Annexure – I

CENTRAL UNIVERSITY OF SOUTH BIHAR

Master of Science in Life Science (M.Sc. in Life Science) Programme Syllabus

(Effective from Academic Session 2018-2019)

Department of Life Science
School of Earth, Biological and Environmental Sciences

CBCS Course Structure of Master of Science in Life Science (M.Sc. in Life Science)

Total Credits: 96 Cr.

Core Credit

First Semester (Total Credits =24Cr.)				
Course Code	**Name of Courses**	**Credits**		
Core Credit (20 Cr.)		**L**	**T**	**P**
MSLSC1001C04	Cell Biology	3	0	1
MSLSC1002C04	Biochemistry	3	0	1
MSLSC1003C04	Genetics	3	0	1
MSLSC1004C04	Methods in Biology	3	0	1
MSLSC1005C04	Microbiology	3	0	1
One Elective Course (4Cr.)				

Second Semester (Total Credits =26Cr.)				
Course Code	**Name of Courses**	**Credits**		
Core Credit (18 Cr.)		**L**	**T**	**P**
MSLSC2001C04	Metabolism	3	0	1
MSLSC2002C04	Molecular Biology	3	0	1
MSLSC2003C04	Recombinant DNA Technology	3	0	1
MSLSC2004C04	Molecular Enzymology	3	0	1
MSLSC2005C02	Summer Internship (External / Internal)	0	0	2
Two Elective Course (4×2=8Cr.)				

Third Semester (Total Credits =24Cr.)				
Course Code	**Name of Courses**	**Credits**		
Core Credit (20 Cr.)		**L**	**T**	**P**
MSLSC3001C04	Developmental Biology	3	0	1
MSLSC3002C04	Physiology of Plant System	3	0	1
MSLSC3003C04	Physiology of Animal System	3	0	1
MSLSC3004C04	Biology of Immune System	3	0	1
MSLSC3005C04	Dissertation	0	0	4
One Elective Course (4Cr.)				

Fourth semester (Total Credits =22 Cr.)				
Course Code	**Name of Courses**	**Credits**		
Core Credit (18 Cr.)		**L**	**T**	**P**
MSLSC4001C18	Dissertation	0	0	18
One Elective Course (4Cr.)				

Elective Baskets

Elective Code	Name of Courses	L	T	P
MSLSC1001E04	Plant Genetic Engineering	2	1	1
MSLSC2001E04	Structural Biology	3	1	0
MSLSC3001E04	Stress Biology	2	1	1
MSLSC4001E04	Biochemistry of proteins	2	1	1
MSLSC4002E04	Human Genetics and Genome Analysis	2	1	1

All Elective courses may not be offered at any given time. An elective will run if opted by 33% of the students enrolled in the programme.

Inter department core/elective course and related practical may be opted by a student from school

Skill Based Courses (Non Credits)

The Life Sciences course includes several excursions. This work finishes in an independent project to study and map an area chosen by the student. Many of the field excursions take place out of term time, so students must be available outside term.

Skill Based Courses	**Name of Courses**	**L**	**T**	**P**
MSLSC4001S00	Experimental Design their own research project	0	0	0
MSLSC4002S00	Health and safety - Laboratory and field (Swachh Bharat Mission)	0	0	0
MSLSC4003S00	Local village fieldwork and farming system	0	0	0

Swayam course (Non Credits)

Swayam course code	**Name of Courses**	**L**	**T**	**P**
MSLSC1001S00	Proteins and Gel-Based Proteomics	0	0	0
MSLSC1002S00	Principles of Downstream techniques in Bioprocess	0	0	0
MSLSC1003S00	Fundamentals of optical and scanning electron microscopy	0	0	0
MSLSC4004S00	Sustainable River Basin Management	0	0	0
MSLSC4005S00	Artificial Intelligence: Search Methods for Problem Solving	0	0	0

Anytime during the entire coursework, Educational/Industrial tour or Excursion may be made to visit institutes/ industries/ laboratories based on availability of funds or otherwise. If excursion takes place, student has to submit a report (10 marks) within a week that will be the part of continuous assessment of a specific course.

** In addition, students are encouraged to take non-credit courses of their specific interests in other Science Centre/Programme of CUSB.*

** The M.Sc. dissertation work should be taken place for one year after allotment of supervisor.*

First Semester

Core Courses

Course Details			
Course Title: Cell Biology			
Course Code	MSLSC1001C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objective of the Course: This course is designed to understand basic structure and function of both pro and eukaryotic cell and their organelles. Also, the fundamentals of cell signalling and cell cycle are explained to students in a very lucid form.

Outcome of the Course: The students will learn the role of biomolecules in structural, cellular and functional organization. Also, gain knowledge about the cross-talk among the various macromolecules and cell cycle checkpoints.

Unit 1 • Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller • The first cell; origin and evolution of prokaryotes of eukaryotic cells • Evolution of unicellular to multicellular eukaryotes; anaerobic and aerobic metabolism.	Weightage:10% L=6
Unit 2 • Ultrastructure of Prokaryotic and Eukaryotic cell • Cell Membrane: Chemical Composition and Fluid Mosaic Model • Membrane transport of micro molecules and macromolecules • Ion Channels and Membrane Potential of neurons • Structure and Functions of Endoplasmic Reticulum, Ribosome, Lysosome, Peroxisomes, Plastids and Mitochondria, Vacuole • Exocytosis and Endocytosis	Weightage:30% L=15

Unit 3 • Protein 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, traffic in the endocytic pathway, exocytosis • The cytoskeleton, the nature of cytoskeleton, Intermediate filaments, Microtubules, Action filaments, Cilia and centrioles, Organization of the cytoskeleton • Cell division (Mitosis and Meiosis) and its control, Cell cycle in mammalian system and its regulation • Cell-cell adhesion, Levels of structural organization: Unicellular, colonial and multicellular forms; levels of organization of tissues, organs and systems; comparative anatomy.	Weightage:40% L=17
Unit 4 • Cell to cell signalling, Overview of extracellular signalling • Role of Secondery messenges cAMP. Ca^{2+}, IP_3 • Cell surface receptors - GPCRs, TGF, Cytokine receptors, Receptor Tyrosine kinases, • Signalling pathways – JAK – STAT, MAP kinase, Activation of Ras, Signaling Pathways that depend on Regulated proteolysis Synthesis and trafficking of neuronal proteins	Weightage:20% L=7

Content Interaction Plan

Contact Hours	Topics
1-2	• Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller
3-4	• The first cell; origin and evolution of prokaryotes of eukaryotic cells
5-6	• Evolution of unicellular to multicellular eukaryotes; anaerobic and aerobic metabolism.
7-8	• Ultrastructure of Prokaryotic and Eukaryotic cell
9-11	• Cell Membrane: Chemical Composition and Fluid Mosaic Model
12-15	• Membrane transport of micro molecules and macromolecules
16-18	• Ion Channels and Membrane Potential of neurons
19-21	• Structure and Functions of Endoplasmic Reticulum, Ribosome, Lysosome, Peroxisomes, Plastids and Mitochondria, Vacuole, Exocytosis and Endocytosis
22-25	• Protein 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, traffic in the endocytic pathway, exocytosis
26-30	• The cytoskeleton, the nature of cytoskeleton, Intermediate filaments, Microtubules, Action filaments, Cilia and centrioles, Organization of the cytoskeleton
31-33	• Cell division (Mitosis and Meiosis) and its control, Cell cycle in mammalian system and its regulation

34-38	• Cell-cell adhesion, Levels of structural organization: Unicellular, colonial and multicellular forms; levels of organization of tissues, organs and systems; comparative anatomy.
39-40	• Cell to cell signalling, Overview of extracellular signalling, Role of Secondery messenges cAMP. Ca^{2+}, IP_3
42-43	• Cell surface receptors - GPCRs, TGF, Cytokine receptors, Receptor Tyrosine kinases,
44-45	• Signalling pathways – JAK – STAT, MAP kinase, Activation of Ras, Signaling Pathways that depend on Regulated proteolysis Synthesis and trafficking of neuronal proteins
P=15 Hours	*List of tentative practicals* ✓ Basic principles of Microscopy ✓ Squash and smear techniques to prepare slides ✓ Sectioning of Plant tissues ✓ Staining of different plant cell types ✓ Pollen viability test by the use of KI_2 solution ✓ To Studies the different stages of Mitosis and Meiosis cell division ✓ Callus Initiation and Plantlet Regeneration

Suggested Readings*:

1. **Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P.** Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA.
2. **Karp, J.G.** Cell and Molecular Biology. John Wiley & Sons, USA.
3. **Kleinsmith, L.J.and Kish, V.M.** Principles of Cell & Molecular Biology. Second Edition. Harper Collins College Publishers, USA.
4. **Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darnell, J.** (Eds). Molecular Cell Biology. Freeman & Co., USA.
5. **Pollard, T.D. and Earnshow, W.C.** Principles of Cell and Molecular Biology, Saunders, USA.

**Please refer to latest editions available.*

Course Details			
Course Title: BIOCHEMISTRY			
Course Code	MSLSC1002C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objective of the Course:

- To understand important principles of physical sciences which run biological systems.
- To explain structures, properties and functions of simple molecules and macromolecules in biological systems.
- To describe biomolecular hierarchy - simple molecules are the units for building complex structures.
- To introduce major methods of separation and analysis of biomolecules.

Outcome of the Course:

Students will be able

- To understand and explain physical laws which govern the structures and important processes in biological systems
- To correlate molecular structures with the higher level of organization in biological systems
- To analyse and understand fundamental properties which are utilized by nature during evolution
- To correlate biochemistry with diseases, daily observations and environment.

Unit 1: Water and thermodynamics • Introduction to biochemistry, Stabilizing interactions in biomolecules (covalent, hydrophobic, hydrophilic, van der Waals, electrostatic interaction) • Water as solvent , Acid base and buffer, Biological relevance of pH • Law of thermodynamics, Gibb's free energy, Chemical equilibria, Redox potential, Colligative properties, diffusion, osmosis.	Weightage : 29 %

• Spectrophotometry - ultraviolet and visible Fluorescence, Circular dichroism.	
Unit 2: Carbohydrates • Classification, Structure and biological importance, Glycoconjugates, lipopolysaccharides, Glycosaminoglycans, proteoglycans, protein glycosylations and its significance, lectin-carbohydrate interactions • Isolation, separation and analysis of carbohydrates	Weightage : 18 %
Unit 3: Lipids • Storage lipids, Structure and function of fatty acids, Glycerol, Phospholipid, Sphingolipids, Cholesterol, Lipoproteins, galactolipid • Structural lipids in biological membranes, integral membrane proteins, lipoproteins and trafficking through membrane, Lipids as signals, cofactors and pigments, Isolation, separation and analysis of lipids	Weightage : 20 %
Unit 4: Proteins • Classification and general properties of amino acids, nomenclature of stereoisomers of amino acids Isolation, separation and analysis of protein and amino acids • Characterization of proteins, sequence determination, mass spectrometry, one and two dimensional gel electrophoresis, Isoelectric focusing gels. • Peptides bonds and Ramachandran Plot, Secondary structure, domain, motif, fold, tertiary and quaternary structure of proteins, methods to determine the secondary and tertiary structure of proteins, Protein Data bank • Structure of haemoglobin, oxygen binding kinetic and its relation to its structure mechanisms of cooperativity in oxygen binding • Glycoproteins, Lipoproteins, Protein modifications and their functional implications.	Weightage : 27 %
Unit 5:Nucleic acids • Nitrogenous bases, Nucleosides, Nucleotides, Nucleic acids	Weightage : 6 %

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1- 3	**Water and thermodynamics** Introduction to biochemistry, Stabilizing interactions in biomolecules (covalent, hydrophobic, hydrophilic, van der Waals, electrostatic interaction)
3 – 7	Water as solvent , Acid, base and buffer, Biological relevance of pH
8 – 11	Law of thermodynamics, Gibb's free energy, Chemical equilibria, Redox potential, Colligative properties, diffusion, osmosis.

12 -13	Spectrophotometry - ultraviolet and visible Fluorescence, Circular dichroism.
14 – 18	**Carbohydrates** Classification, Structure and biological importance,
19 - 21	Glycoconjugates, lipopolysaccharides, Glycosaminoglycans, proteoglycans, protein glycosylations and its significance, lectin-carbohydrate interactions, Isolation, separation and analysis of carbohydrates
22- 26	**Lipids** Storage lipids, Structure and function of fatty acids, Glycerol, Classification of Lipids - Phospholipid, Sphingolipids, Waxes, Terpenes, Steroids
27 -30	Lipoproteins, galactolipid Structural lipids in biological membranes, integral membrane proteins, lipoproteins and trafficking through membrane, Lipids as signals, cofactors and pigments, Isolation, separation and analysis of lipids
31 -33	**Proteins** Classification and general properties of amino acids, nomenclature of stereoisomers of amino acids Isolation, separation and analysis of protein and amino acids
34 – 35	Characterization of proteins, sequence determination, mass spectrometry, one and two dimensional gel electrophoresis, Isoelectric focusing gels
36 – 38	Peptides bonds and Ramachandran Plot, Secondary structure, domain, motif, fold, tertiary and quaternary structure of proteins, methods to determine the secondary and tertiary structure of proteins.
39 – 42	Structure of haemoglobin, oxygen binding kinetic and its relation to its structure mechanisms of cooperativity in oxygen binding Glycoproteins, Lipoproteins, Protein modifications and their functional implications
43 - 45	Nitrogenous bases, Nucleosides, Nucleotides, Nucleic acids
30 Hours	*List of practicals (tentative)* • Preparation of phosphate buffer and verification of Henderson Halsselblach equation. • Verification of Beer's law • Determination of PI of Glycine by titration • Estimation of protein content in a solution • Determination of molecular mass using SDS PAGE • Qualitative tests of carbohydrates • Quantitive test of carbohydrate

Suggested Readings*:

1. **Creighton, T.E.** Proteins: Structures and Molecular Properties. W.H. Freeman & Co., USA.
2. **Donald Voet, Judith G Voet**: Biochemistry. Foruth edition, John Wiley & Sons , Inc
3. Nelson D.L. and Cox, M.M. 2008. Principles of Biochemistry. 5th Edition. W H Freeman & Co., USA.
4. **Sheehan, D.** Physical Biochemistry: Principles and Applications. John Wiley & Sons Ltd., UK.
5. **Lesk, A. M.** Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK.
6. **Fasman, G.D.** Circular Dichroism and the Conformational Analysis of Biomolecules. Plenum Publishing Corporation, USA.
7. **Clark, R.J.H. and Hester, R.E.** Biomolecular Spectroscopy (Advances in Spectroscopy) Part A and B. John Wiley & Sons, USA.
8. **Branden, C. I. and Tooze, T.** Introduction to Protein Structure. Garland Publishing, USA.

* *Please refer to latest editions available*

Course Details			
Course Title: GENETICS			
Course Code	MSLSC1003C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills,		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - Summative Assessment in the form of End Term Examination		

Course Objectives

This course deals with basic understanding of genetic constitution and laws of genetics; organization of genes in prokaryotes and eukaryotes and their role in governing the phenotypic traits. Emphasis is laid on development of overall concept of genetic composition of living world and mode of its inheritance.

Learning Outcomes

After completion of the course the learners will be able to:

- Identify Mendelian and non-Mendelian inheritance patterns such as incomplete dominance, codominance, multiple alleles, and sex linkage from the results of crosses
- Explain the relationship between genotypes and phenotypes
- Use a Punnett square and probability method to calculate the expected proportions of genotypes and phenotypes in a cross
- Explain Mendel's law of segregation and independent assortment in terms of genetics and the events of meiosis
- Explain the effect of linkage and recombination on gamete genotypes
- Calculate distance between genes using 3 – point cross
- Explain the phenotypic outcomes of epistatic effects among genes and polygenic inheritance
- Understand the importance of specific model organisms
- Analyze the implication of structural rearrangements and special features in chromosomes
- Understand the basic principles of sex determination
- Explain the organization of nuclear and organelle genomes

Course Contents

UNIT I: Introduction to Genetic Research (Weightage : 30 %)

- Mendelism: Brief overview of Mendel's work, Principle of equivalence of reciprocal hybrids, Application of laws of probability (Product and Sum rule), Chromosomal Basis of Mendelism, Extensions of Mendelism, Linkage and Recombination
- Model systems in Genetic Analysis: Bacteriophage, *E. coli*, *Neurospora crassa*, yeast, *Arabidopsis*, maize, *Drosophila, C. elegans*, Zebra fish, *Homo sapiens* - General outline of life cycle, importance in Genetic analysis.

UNIT II: Genes & Chromosomes (Weightage : 40 %)

- Evolution of gene concept - Definition of factors, alleles, multiple alleles, pseudoalleles, Beadle and Tatum's One gene one enzyme concept, One gene one polypeptide concept, Complementation test, Intragenic complementation, Cistron, Recon and Muton
- Gene interaction: allelic and gene interactions
- Chromosomal structural rearrangements: (a) Cytogenetic implications of Deletions, Duplications, Inversions, Translocations, Centric fusion and Centric fission, ; numerical chromosomal abnormalities
- Special chromosomes: (a) B Chromosomes (b) Structural organization and significance of Polytene chromosomes (c) Lampbrush chromosomes and implications of their study in genetic research; Fragile X – chromosome, heterochromatin and Lyon's hypothesis; somatic cell hybridization and use of somatic cell hybrids in gene mapping
- Sex differentiation and its errors, Genomic imprinting

UNIT III: Nuclear & Organelle genome (Weightage : 15 %)

- Concept of gene: Conventional and modern views. Fine structure of gene, split genes, pseudogenes, coding and non-coding genes, overlapping genes and multi-gene families.
- Organization of nuclear and organelle genomes; C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs
- Extra nuclear inheritance: Maternal effect- Shell coiling in Limnaea, Organelle heredity: Chloroplast in *Chlamydomonas*; Mitochondria-Poky in *Neurospora*, Petite in *Saccharomyces*

UNIT IV: Principles of breeding **(Weightage : 15 %)**

- Breeding methods in self-pollinated plants: Pure line theory and pure line method, Pedigree method, Bulk population method, Back cross method
- Breeding methods in cross pollinated plants: Theory of selection and response to selection, Mating systems and their consequences, basis of inbreeding and hybrid vigour, Hybrid varieties, Recurrent selection, Role of induced mutations in crop improvement

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-4	Mendelism: Brief overview of Mendel's work, Principle of equivalence of reciprocal hybrids, Application of laws of probability (Product and Sum rule),
5 - 6	Chromosomal Basis of Mendelism
7-9	Extensions of Mendelism
10-12	Linkage and Recombination
13-15	Model systems in Genetic Analysis: Bacteriophage, *E. coli*, *Neurospora crassa*, yeast, *Arabidopsis*, maize, *Drosophila*, *C. elegans*, Zebra fish, *Homo sapiens* - General outline of life cycle, importance in Genetic analysis.
Formative assessment 1	
16-178	Evolution of gene concept - Definition of factors, alleles, multiple alleles, pseudoalleles, Beadle and Tatum's One gene one enzyme concept, One gene one polypeptide concept, Complementation test, Intragenic complementation, Cistron, Recon and Muton
19-22	Gene interaction: allelic and gene interactions
Formative assessment 2	
23-26	Chromosomal structural rearrangements: (a) Cytogenetic implications of Deletions, Duplications, Inversions, Translocations, Centric fusion and Centric fission, numerical chromosomal abnormalities
27-28	Special chromosomes: (a) B Chromosomes (b) Structural organization and significance of Polytene chromosomes (c) Lampbrush chromosomes and implications of their study in genetic research;
29 - 30	Fragile X – chromosome, heterochromatin and Lyon's hypothesis
31	Somatic cell hybridization and use of somatic cell hybrids in gene mapping
32 - 33	Sex differentiation and its errors, Genomic imprinting
Formative assessment 3	
34 - 35	Concept of gene: Conventional and modern views. Fine structure of gene, split genes, pseudogenes, coding and non-coding genes, overlapping genes and multi-gene families.
36 – 37	Organization of nuclear and organelle genomes; C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs
38 - 39	Extra nuclear inheritance: Maternal effect- Shell coiling in Limnaea, Organelle heredity: Chloroplast in *Chlamydomonas*; Mitochondria-Poky in *Neurospora*, Petite in *Saccharomyces*
40 – 42	Breeding methods in self-pollinated plants: Pure line theory and pure line method, Pedigree method, Bulk population method, Back cross method

43 – 45	Breeding methods in cross pollinated plants: Theory of selection and response to selection, Mating systems and their consequences, basis of inbreeding and hybrid vigour, Hybrid varieties, Recurrent selection, Role of induced mutations in crop improvement
Formative assessment 4	

- Suggested References:
- Anastasi A. (1976). *Psychological testing* (4th ed.). New York: McMillan Pub Co.
- Bloom, B. S., Hastings, J. H., & Madaus, G. F. (1971). *Handbook on formative and summative evaluation of student learning*. New York: McGraw Hill.
- Cronbach, L. J. (1950). *Essentials of psychological testing* (3rd ed.). New York: Harper & Row publishers.
- Ebel, R. L., & Frisbei, D. A. (1986). *Essentials of educational measurement.* New Delhi: Prentice Hall.
- Freeman, F. S. (1976). *Theory and practice of psychological testing,* (3rd ed.). New Delhi: Oxford & IBH Pub. Co.
- Guilford, J. P. (1954). *Psychometric methods*. New York: McGraw Hill.
- Miller, M. D., Linn, R. L., & Gronlund, N. E. (2009). *Measurement and assessment in teaching* (10th ed.). New Jersey: Pearson Education Inc.
- Singh, A. K. (1986). *Tests, measurement and research methods in behavioural sciences.* New Delhi: McGraw Hill.

Tentative List of Practicals

1. Study of morphology of *Drosophila melanogaster* – Wing, Sex comb, Genital plate and Bristles.
2. Study of morphology of a plant model system.
3. Study of stages of mitosis and meiosis by preparing temporary slides of onion root tip and bud.
4. Pedigree Analysis, analysis of inheritance pattern using blood types
5. Karyotyping
6. Basic principles of agarose gel electrophoresis, isolation of DNA and visualization by electrophoresis.
7. Visit to a plant breeding center.

Course Details			
Course Title: Methods in Biology			
Course Code	MSLSC1004C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- To acquaint the students with the basic concepts, practices and relationship between theory and experimental methods in laboratory.
- To orient the students with various techniques including bioinformatics, biostatistics, biophysics and radiolabeling.
- To provide knowledge supporting the theoretical subjects and comprehensive understanding of the principles and techniques being used for the purpose.
- To learn techniques and developing skills in designing an experiment and logical interpretation of the results.

Learning Outcomes

After completion of the course the learners will be able to:

- Use computational tools to make literature search for any topic of study
- Use bioinformatics tools for preliminary analysis of DNA or protein in question.
- Devise a methodology to study the DNA or protein based upon various biophysical, bio statistical or radiolabeling detection methods.

Course Contents

UNIT I: Computational techniques (Weightage : 24 %, Lectures: 11)

Introduction to Bioinformatics, Biological databases, nucleic acid databases (NCBI, EMBL, DDBJ), protein databases (SWISS Prot, PIR), structural databases (PDB, CATH, SCOP), specialized databases (KEGG, OMIM, Pubmed, submission and retrieval of data, Sequence similarity search: BLAST and its types, Multiple Sequence alignment: CLUSTALW, phylogenetic analysis, Domain analysis of protein sequences, Application of computational methods in experimental design of genetic manipulations.

UNIT II: Biophysical Methods (Weightage : 27 %, Lectures: 12)

Introduction to Biophysical methods, Molecular analysis using Fluorescence recovery after photobleaching (FRAP), Fluorescence resonance energy transfer (FRET); Nuclear magnetic Resonance (NMR); Electron spin resonance (ESR) spectroscopy, Dynamic light scattering (DLS), Mass spectrometry and surface plasma resonance methods, applications of all techniques in life sciences.

UNIT III: Biostatistical methods (Weightage : 24 %, Lectures: 11)

Introduction to biostatistics, concept of variables in biological systems, types of variables; Measures of central tendency and dispersal, concept of probability distributions (Binomial, poission and normal), Sampling distribution; Difference between parametric and non-parametric statistics; confidence interval; Errors; Levels of significance; Regression and correlation; t-test; Inferential aspects of analysis of variance

UNIT IV: Radiolabeling techniques (Weightage : 25 %, Lectures: 11)

Introduction to radiolabeling, Detection and measurement of different types of radioisotopes in biology, instruments for measurement of radiation like G.M. counters, liquid scintillation counters, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, Methods of adding radioactive labels to nucleic acids and proteins, detection methods, Generation of probes, Northern blotting, southern blotting, western blotting, Screening recombinant DNA library, safety guidelines, disadvantages, other than radiolabeling techniques of Direct or indirect labelling, Biotin, Alkaline phosphatase, Horse radish peroxidase, Detection methods

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Introduction to Bioinformatics, Biological databases, nucleic acid databases (NCBI, EMBL, DDBJ)
3-5	Protein databases (SWISS Prot, PIR), structural databases (PDB, CATH, SCOP), specialized databases (KEGG, OMIM, Pubmed, submission and retrieval of data.
6-7	Sequence similarity search: BLAST and its types, Multiple Sequence alignment: CLUSTALW
8-11	Phylogenetic analysis, Domain analysis of protein sequences, Application of computational methods in experimental design of genetic manipulations.
12-13	Introduction to Biophysical methods, Florescence and advanced methods based upon fluorescence, Molecular analysis using Fluorescence recovery after photobleaching (FRAP)
14-16	Fluorescence resonance energy transfer (FRET), Nuclear magnetic Resonance (NMR)
17-19	Electron spin resonance (ESR) spectroscopy, Dynamic light scattering (DLS)
20-23	Mass spectrometry and surface plasma resonance methods, applications of all techniques in life sciences.
24-25	Introduction to biostatistics, concept of variables in biological systems, types of variables; Measures of central tendency and dispersal,
26-28	Concept of probability distributions (Binomial, poission and normal), Sampling distribution
29-31	Difference between parametric and non-parametric statistics; confidence interval; Errors;
32-34	Levels of significance; Regression and correlation; t-test; Inferential aspects of analysis of variance
35-36	Introduction to radiolabelling, Detection and measurement of different types of radioisotopes in biology, instruments for measurement of radiation like G.M. counters
37-39	Liquid scintillation counters, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material
40-42	Methods of adding radioactive labels to nucleic acids and proteins, detection methods, Generation of probes, Northern blotting, southern blotting, western blotting, Screening recombinant DNA library, safety guidelines, disadvantages
42-45	Other than radiolabelling techniques of Direct or indirect labelling, Biotin, Alkaline phosphatase, Horse radish peroxidase, Detection methods
30 Hours	Tentative list of Practicals:

	• DNA and protein sequence retrieval from NCBI and swiss prot database • Similarity search using BLAST • Multiple sequence alignment using CLUSTALW • Examining the distribution of a test dataset • Calculating probabilities and p-values • One and two sample test • Generating good quality plots: scattered plot, bar plot, histogram, pi-chart, density plots and box plots

Suggested References:

- **David Mount**: Bioinformatics: Sequence and Genome Analysis, Second Edition (2004)
- **Arthur Lesk**: Introduction to Bioinformatics, 3rd Edition (2008)
- **Teresa Attwood and David Parry-Smith**: Introduction to Bioinformatics (2001)
- **Stephen A. Krawetz and David D. Womble**: Introduction to Bioinformatics: A Theoretical and Practical Approach, 1st Edition (2003)
- **Abhilash M (Author):** Introduction to Bioinformatics and Microarray Technology (2010)
- **Andreas D. Baxevanis (Editor), B. F. Francis Ouellette (Editor):** Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition (2004)
- **Steen Knudsen**: Guide to Analysis of DNA Microarray Data, 2nd Edition by (2004)
- **Mark Schena**: Microarray Analysis, 1st Edition (2002)
- **Arun Jagota**: Microarray Data Analysis and Visualization by (2001)
- **Sharma V, Munjal A, Shanker A** A Text Book of Bioinformatics. Rastogi Publications (2016)
- **Daniel W. W. (9th Edition).** Biostatistics: A Foundation for Analysis in the Health Sciences. Wiley.
- **Sokal R. R. & Rholf F. J. :** Biometry W.H. Freeman, San Francisco, USA.
- Zar H: Biostatistical Analysis Pearson Edu publication
- **Principles and Techniques of Biochemistry and Molecular Biology** 14 July 2010
  by Wilson/Walker
- **The Cell**: A Molecular Approach; Cooper GM.; Sunderland (MA): Sinauer Associates; 2000.

*Please refer to latest editions available

Course Details			
Course Title: MICROBIOLOGY			
Course Code	MSLSC1005C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills,		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - Summative Assessment in the form of End Term Examination		

Course Objectives

This course is designed to understand and appreciate the structural and functional diversity of microbes and the extent of their involvement in shaping the sustenance of life on Earth. This course also highlights the interaction of microbes with humans and methods required for their study.

Learning Outcomes

After completion of the course the learners will be able to:

- Appreciate the enormous diversity of microbes in nature
- Apprehend the principles of microscopy
- Understand the basics of microbial cell structures
- Get acquainted with techniques of microbial culture
- Explain growth patterns and constrains on microbial growth
- Differentiate between nutritional types and classification of microbes based on nutritional requirement
- Understand the means of genetic transfer among microbes
- Explain the basic structure and ways of replication prevalent among viruses
- Understand the basic principles of host microbe interaction
- Explain the principles of pathogenicity
- Get acquainted with life cycles of some significant pathogens

Course Contents

UNIT I: Introduction to Microbiology (Weightage : 37 %)

- A brief history of microbial World, Bergey's manual and bacterial classification
- Methods in microbiology: microscopy and staining; isolation, identification and pure culture techniques; culture dependent analysis, FISH, measuring microbial activities in nature
- Ultra-structure of Bacteria, Structure and function of bacterial cell wall, Archaeobacteria, Protozoa and Fungi.

UNIT II: Growth & Genetics (Weightage : 24 %)

- Microbial growth and population kinetics, methodology for measuring growth and growth regulation, Physical and chemical control of microbes: General Characteristic and mode of action
- Nutritional requirements of micro-organisms, Mode of nutrition, phototrophy, mixotrophy, saparophytic, symbiotic (nitrogen fixation, mycorrhiza) , Auxotrophs & Prototrophs
- Genetics of Bacteria: Gene transfer by conjugation, transduction and transformation

UNIT III: Virology (Weightage : 18 %)

- Discovery and distinctive properties of viruses
- Morphology and Ultrastructure: Icosahedral, Helical, and complex symmetry of viruses
- Viral Genome, Replication of Plant and animal viruses, Control of viral diseases

UNIT IV: Microbe – Human Interactions (Weightage : 21 %)

- Normal microflora of human body: skin, Eye, Respiratory tract, Intestinal tract, Genitourinary tract, Germ free (Gnotobiotic) animal
- Determinants of infectious diseases: Transmission, Attachment, colonization, Entry, Growth and Multiplication, Toxigenicity
- Basic concepts, action of pathogens, Life cycle of some important diseases causing pathogens like- Malaria, hepatitis, filaria, Kalazar and AIDS

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-3	A brief history of microbial World, Bergey's manual and bacterial classification
4 - 7	Methods in microbiology: microscopy and staining
8-9	Isolation, identification and pure culture techniques; culture dependent analysis
10-11	FISH, measuring microbial activities in nature
12-17	Ultra-structure of Bacteria, Structure and function of bacterial cell wall, Archaeobacteria, Protozoa and Fungi
Formative Assessment 1	
18-19	Microbial growth and population kinetics
20-21	Methodology for measuring growth and growth regulation
22 - 24	Physical and chemical control of microbes: General Characteristic and mode of action
25 - 28	Nutritional requirements of micro-organisms, Mode of nutrition, phototrophy, mixotrophy, saparophytic, symbiotic (nitrogen fixation, mycorrhiza) , Auxotrophs & Prototrophs
29	Genetics of Bacteria: Gene transfer by conjugation
30	Transduction and transformation
Formative assessment 2	
31	Discovery and distinctive properties of viruses
32	Morphology and Ultrastructure: Icosahedral, Helical, and complex symmetry of viruses
33 - 37	Viral Genome, Replication of Plant and animal viruses
38	Control of viral diseases
Formative assessment 3	
39 - 40	Normal microflora of human body: skin, Eye, Respiratory tract, Intestinal tract, Genitourinary tract, Germ free (Gnotobiotic) animal
41 - 42	Determinants of infectious diseases: Transmission, Attachment, colonization, Entry, Growth and Multiplication, Toxigenicity
43 – 44	Basic concepts, action of pathogens, Life cycle of some important diseases causing pathogens like- Malaria, hepatitis,
45	Filaria, Kalazar and AIDS
Formative assessment 4	

***Suggested References:**

1. **Prescott, Harlay and Klein:** Microbiology
2. **Madigan, Martinko and Parker:** Biology of Micro-organism:
3. **Alcano:** Fundamentals of Microbiology
4. **Talaro K. and Talaro A.:** Foundations in Microbiology
5. **Pelczar M. J.,Chan E. C. S. and Krieg N.R.:** Microbiology: Concept and Applications
6. **Atlas , R. M.:** Principles of Microbiology
7. **Gornity, G. M.:** Bergey's Manual of Systematic Bacteriology (2nd Ed.)

*Please refer to latest editions available.

Tentative List of Practicals

1. Preparation of defined media for culturing microbes
2. Plating technique and observation of differential microbial flora.
3. Enumeration of CFU of *E. coli*/other microbes by serial dilution.
4. Isolation of pure culture of microbe (streaking and liquid culture transfer techniques)
5. Gram staining for identification of wall type in bacteria.
6. LCB staining for microscopic observation of fungi.
7. Identification of eubacteria by 16s rDNA PCR amplification as a tool.
8. Microbial characterization employing whole cell protein isolation and study of proteome using 2D – PAGE.
9. Determination of optimum pH and temperature on growth of isolated culture.
10. Determination of bacterial growth kinetics.
11. To study the effect of different antibiotics on bacterial culture.
12. Assessment of viability/proliferation in cultured cells by Trypan Blue staining and MTT assay.
13. Qualitative and quantitative assay for a microbial product (siderophore using CAS/Arnow/Atkin's assay)
14. Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, helminths and arthropods.

Second Semester

Course Details			
Course Title: METABOLISM			
Course Code	MSLSC2001C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objective of the Course: In addition the role of enzymes in metabolism of carbohydrate, fats, amino acid, and nucleotides will be discussed. All catabolic and anabolic pathways describe in animal and plant system

Outcome of the Course: Students will understand the core metabolic pathways of biological system that will allow lucid comprehension of integrated catabolic and anabolic pathways.

Unit 1 • **Carbon Assimilation:** Light absorption and energy conversion, Photolysis of water and photophosphorylation, Carbon dioxide uptake and assimilation, Calvin Cycle (C_3); Hatch-Slack pathway (C_4); CAM pathway; Photorespiration (C_2)	Weightage:25% L=11
Unit 2 • **Biological Oxidation and Release of Energy:** Glycolysis and Gluconeogenesis pathway; Cori cycle, Pentose phosphate pathway and its importance in biosynthetic reactions, Kreb's cycle; Glyoxylate pathway, High energy compounds; Oxidative phosphorylation; Chemiosmotic hypothesis	Weightage:35% L=15
Unit 3 • **Metabolism of Macromolecules:** Biosynthesis of carbohydrates eg Starch, Cellulose and Glycogen; Biosynthesis and degradation of Lipids, Synthesis and degradation of steroids, Metabolism of nucleotides, salvage pathways, its regulation and diseases, amino acids metabolism, Urea cycle	Weightage:35% L=15
Unit 4 • **Energy Metabolism:** Integration and organ specialization • **Metabolism and disease**	Weightage:5% L=4

Content Interaction Plan

Contact Hours	Topics
1-5	• Light absorption and energy conversion, Photolysis of water and photophosphorylation
6-11	• Carbon dioxide uptake and assimilation, Calvin Cycle (C3); Hatch-Slack pathway (C4); CAM pathway; Photorespiration (C2)
12-16	• Glycolysis and Gluconeogenesis pathway
17-20	• Pentose phosphate pathway and its importance in biosynthetic reactions, Cori cycle
21-23	• Kreb's cycle; Glyoxylate pathway and its regulation
24-26	• High energy compounds; Oxidative phosphorylation; Chemiosmosis hypothesis
27-30	• Biosynthesis carbohydrates eg Starch, Cellulose and Glycogen
31-34	• Biosynthesis and degradation of Lipids
35-36	• Synthesis and degradation of steroids
37-39	• Metabolism of nucleotides, salvage pathways, its regulation and diseases
40-41	• Amino acids metabolism, Urea cycle
42-43	• Energy Metabolism: Integration and organ specialization
44-45	• Metabolism and disease
30 Hours	Tentative list of practicals: • Estimation of Starch from C3 and C4 plant • Observation of starch granules in potato • Estimation of Amino acid • Extraction of Lipid from egg yolk

Suggested Readings*:

1. **Buchanan, B., Gruissem, W. and Jones, R.** (Eds.) 2000. *Biochemistry & Molecular Biology of Plants*. American Society of Plant Physiologists, USA.
2. **Dey, P.M. and Harborne, J.B.** (Eds.) 1997. Plant Biochemistry. Academic Press, USA.
3. **Metzler, D.E.** 2000. Biochemistry. Second Edition. Academic Press, USA.
4. **Nelson D.L. and Cox, M.M.** 2008. Principles of Biochemistry. 5th Edition. W H Freeman & Co., USA.
5. **Stryer L., Berg, J.M. and Tymoczko, J.L.**2006. Biochemistry.Sixth Edition.W.H. Freeman & Co., USA.
6. **Donald Voet, Judith G Voet**: Biochemistry. Foruth edition, John Wiley & Sons , Inc

Course Details			
Course Title: MOLECULAR BIOLOGY			
Course Code	MSLSC2002C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills,		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - Summative Assessment in the form of End Term Examination		

Course Objectives

The objective of this course is to have an understanding of fundamentals of nucleic acids and their role in information pathways through transcription and translation. During these processes.; and to compare the mechanisms of bacterial and eukaryotic DNA replication, DNA repair, transcription, and translation; to explain the molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes at both pre- and posttranscriptional levels

Learning Outcomes

The course will enable the student to understand the importance and functions of nucleic acids, to appreciate that the genetic material stores the information for the regulated function of cell, to grasp the protein-nucleic acid interaction modulation in DNA, RNA and protein metabolism.

Course Contents

UNIT I: DNA Replication & Transposition (Weightage : 37 %)

- Chromosomal elements, DNA supercoiling, Structure of Chromosomes
- DNA replication in prokaryotes and eukaryotes, Extrachromosomal replicons
- Homologous and site specific Recombination, DNA mutations and repair
- Transposable elements in bacteria, *Drosophila*, plants and human - LINES, SINES,and retroviruses

UNIT II: Transcription and RNA Processing (Weightage : 24 %)

- Prokaryotic and eukaryotic transcription, catalytic RNA
- RNA splicing and processing
- mRNA stability, localization, RNA degradation
- Gene Regulation: Operon system, Phage strategies, eukaryotic regulation, epigenetic effects, Regulatory RNA

UNIT III: Protein Metabolism (Weightage : 18 %)

- Genetic code, wobble base pairing
- Translation in prokaryotes and eukaryotes - amino acylation of tRNA, tRNA-identity, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination

- Translational proof-reading, translational inhibitors, Post-translational modifications, Protein Degradation

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Chromosomal elements, DNA supercoiling, Structure of Chromosomes
3 - 5	DNA replication in prokaryotes
6 – 7	DNA replication in eukaryotes
8	Extrachromosomal replicons
9	Homologous and site specific Recombination
10 – 12	DNA mutations and repair
13	Transposable elements in bacteria, *Drosophila*
14	Transposable elements in plants
15	Transposable elements in humans- LINES, SINES, retroviruses like elements
Formative Assessment 1	
16-18	Transcription in Prokaryotes
19 – 21	Transcription in eukaryotes
22	catalytic RNA
23 - 24	RNA splicing and processing
25	mRNA stability, localization
26 - 27	RNA degradation
28 - 30	Gene Regulation: Operon system
31 - 32	Phage strategies
33 - 34	Eukaryotic gene regulation, epigenetic effects, Regulatory RNA
Formative assessment 2	
35	Genetic code, wobble base pairing
36 - 39	Translation in prokaryotes
40 - 42	Translation in eukaryotes
43	Translational proof-reading, translational inhibitors
44	Post-translational modifications
45	Protein Degradation
Formative assessment 3	

Suggested References:

1. **Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick**: Lewin's genes XI
2. **H. Lodish, A. Berk, S L.Zipursky, P. Matsudaira, D. Baltimore, and J. Darnell:** Molecular Cell Biology, 4th edition.
3. **Nelson D.L. and Cox, M.M. 2008**. Principles of Biochemistry. 5th Edition. W H Freeman & Co., USA.

** Please refer to latest editions available.*

Tentative List of Practicals

- Project on making DNA Model
- Plasmid DNA isolation, quantification and Agarose Gel Electrophoresis
- Isolation of RNA
- Competent Cell Preparation
- Transformation of *E.coli* cells
- Induction of enzyme activity in bacteria: The lac operon
- Effect of antibiotics like actinomycin and chloramphenicol on transcription and translation.

Course Details			
Course Title: RECOMBINANT DNA TECHNOLOGY			
Course Code	MSLSC2003C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

The course aims to acquaint the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology. It will help in understanding the principle and applications of molecular biology methods with an emphasis on the application of recombinant DNA technology to medicine, crop, animals, and industry.

Learning Outcomes

The students will understand the basic and advance techniques for DNA manipulations and protein expression in various organisms. They will understand the applications of recombinant DNA technology to therapeutics and medicine. A scientific temperament for reasoning and planning of experiment design will be promoted.

Course Contents

UNIT I: Nucleic acid manipulations (Weightage : 24 %, Lectures: 11)

Isolation and purification of RNA and DNA, Analysis of nucleic acids by one and two dimensional gel electrophoresis, Molecular analysis of nucleic acid sequences, Gene manipulation Basic techniques, Cutting and joining DNA molecules, Constructing Gene Libraries, Genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors, Selection, screening and analysis of recombinants. Polymerase chain reaction, random amplified polymorphic DNA (RAPD), site directed mutagenesis, Cloning vectors: plasmid and phage vectors, Cosmids, phasmids and other advanced vectors

UNIT II: Protein Expression **(Weightage : 27 %, Lectures: 12)**

Method of Transformations, Vector Engineering and codon optimization; expression in bacteria, yeast, insects and insect cells, mammalian cells, plants; in vitro translation, cell-free translation systems, microarray, FISH, in situ PCR, Identifying and analysing mRNA, gene silencing, gene knock out in bacterial and eukaryotic organisms, Crispr-cas technique, Reporter Gene Assays, DNA-Protein Interaction Assays, Protein-Protein Interaction Assays, yeast two hybrid assay

UNIT III: **(Weightage : 27 %, Lectures: 12)**

DNA sequencing: Maxam-Gilbert and Sanger- Nicolson, Pyrosequencing, Automated gene sequencing, strategies for genome sequencing, Next generation Sequencing (NGS) , Genetic mutation analysis: Amplified Fragment Length Polymorphism (AFLP) and restriction fragment length polymorphism (RFLP), Markers and their applications, Protein sequencing methods, detection of post translational modification of proteins

UNIT IV: Applications of RDT **(Weightage : 22 %, Lectures: 10)**

Medicine: Diagnosis of Genetic Diseases, DNA Fingerprinting, Gene Therapy- somatic and germ line, Synthesis of Human Insulin and Hepatitis B Vaccine; Applications in crop improvement, Animal Husbandry, Industrial Applications, applications of Crispr-cas technique, Bioethical issues.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Isolation and purification of RNA and DNA, Analysis of nucleic acids by one and two dimensional gel electrophoresis,
3-5	Molecular analysis of nucleic acid sequences Gene manipulation Basic techniques, Cutting and joining DNA molecules
6-7	Constructing Gene Libraries Genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors, Selection, screening and analysis of recombinants.
8-11	Polymerase chain reaction, random amplified polymorphic DNA (RAPD), site directed mutagenesis, Cloning vectors: plasmid and phage vectors, Cosmids, phasmids and other advanced vectors
12-13	Method of Transformations, Vector Engineering and codon optimization expression in bacteria, yeast, insects and insect cells, mammalian cells, plants
14-16	in vitro translation, cell-free translation systems, microarray, FISH, in situ PCR
17-19	Identifying and analysing mRNA, gene silencing, gene knock out in bacterial and eukaryotic organisms, Crispr-cas technique,
20-23	Reporter Gene Assays, DNA-Protein Interaction Assays, Protein-Protein

	Interaction Assays, yeast two hybrid assay
24-26	DNA sequencing: Maxam-Gilbert and Sanger- Nicolson, Pyrosequencing,
27-29	Automated gene sequencing, strategies for genome sequencing, Next generation Sequencing (NGS)
30-33	Genetic mutation analysis: Amplified Fragment Length Polymorphism (AFLP) and restriction fragment length polymorphism (RFLP), Markers and their applications
34-35	Protein sequencing methods, detection of post translational modification of proteins
36-38	Medicine: Diagnosis of Genetic Diseases, DNA Fingerprinting, Gene Therapy- somatic and germ line
39-41	Synthesis of Human Insulin and Hepatitis B Vaccine; Applications in crop improvement
42-45	Animal Husbandry, Industrial Applications, applications of Crispr-cas technique, Bioethical issues
30 Hours	*Practicals (Tentative list of practicals is below)* • Amplification of gene through Polymerase chain reaction (PCR) • Restriction digestion of genomic/plasmid DNA • Ligation of vector and insert • Overexpression of protein in *E.coli* cells • Characterization of over-expressed protein on SDS PAGE gel

Suggested Readings*:

1. **Brown, T. (2010).** Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
2. **Primrose, S. B., & Twyman, R. (2009).** Principles of gene manipulation and genomics. Wiley. com.
3. **Howe, C. J. (2007).** Gene cloning and manipulation. Cambridge University Press.
4. **Nelson D.L. and Cox, M.M.** 2008. Principles of Biochemistry. 5th Edition. W H Freeman & Co., USA.
5. **Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darnell, J.** (Eds). Molecular Cell Biology. Freeman & Co., USA.
6. **Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P.** Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA.

* *Please refer to latest editions available.*

Course Details			
Course Title: Molecular Enzymology			
Course Code	MSLSC2004C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

This course will cover in detail the nomenclature and classification of enzymes, Principles of catalysis, enzyme kinetics, and structural as well as chemical basis of catalytic mechanisms of enzyme reaction with an emphasis on kinetics, specificity and regulation of various types of reaction.

Learning Outcomes

The course will provide the knowledge about role of - classification of enzymes, catalyst in a chemical reaction, various factors affecting catalysis. It will help in understanding the kinetics of reaction, effect of inhibitors on kinetics, catalytic mechanism explained by structure-function relationships and regulatory strategies of various enzymes. Also, the students learn the rational design, directed evolution and applications of enzymology in therapeutics and industry.

Course Contents

UNIT I **(Weightage : 24 %, Lectures: 11)**

- Enzyme nomenclature and Classification
- Activation energy, Active site and its importance, Thermodynamics and Equilibrium; Enzyme activity; Enzyme activity, Specific activity and Units; Factor affecting enzyme activity and catalysis, Effect of pH and temperature. Role of metal ions in enzyme catalysis
- Isozymes; Ribozymes; Zymogens; Abzymes
- Enzyme assays: Types, Continuous and discontinuous assays; Optimization of enzyme assays.

UNIT II **(Weightage : 27 %, Lectures: 12)**

- Enzyme Kinetics: Significance; Rapid Equilibrium, Steady state, pre-steady state, equilibrium kinetics, Michaelis and Menten Equation and its derivation, Lineweaver – Burk plot,
- Significance of Km, Catalytic efficiency, and turnover number; Order of kinetics
- Transient kinetics, flow techniques (continuous, stopped, quenched), Enzyme Inhibition, Models and types of inhibition; Multi-substrate enzymes; Multisite and allosteric enzymes; Models and examples

UNIT III **(Weightage : 25 %, Lectures: 11)**

- Basic Catalytic principles, catalytic strategies of enzymes - Chymotrypsin**,** Protease, carbonic anhydrase, lysozyme, Restriction enzymes
- Regulatory Strategies of allosteric enzymes-Aspartate transcarbamoylase, Kinases, Phosphatase, isozymes, proteolysis, Integration of kinetic, chemical and structural data to describe enzyme action

UNIT IV **(Weightage : 24 %, Lectures: 11)**

- Frontiers in enzymology: Rational design of an enzyme catalyst, directed evolution, selection, screening, Structural basis of enzyme action and characterization of active site residues; structure guided active site (re)design, design of inhibitors
- Enzymes used in biotransformation, drug synthesis, biosensors, Therapeutic enzymes, industrial enzymes

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Enzyme nomenclature and Classification
3-5	Activation energy, Active site and its importance, Thermodynamics and Equilibrium; Enzyme activity; Enzyme activity, Specific activity and Units; Factor affecting enzyme activity and catalysis, Effect of pH and temperature. Role of metal ions in enzyme catalysis
6-7	Isozymes; Ribozymes; Zymogens; Abzymes
8-11	Enzyme assays: Types, Continuous and discontinuous assays; Optimization of enzyme assays.
12-15	Enzyme Kinetics: Significance; Rapid Equilibrium, Steady state, pre-steady state, equilibrium kinetics, Michaelis and Menten Equation and its derivation, Lineweaver – Burk plot,
16-19	Significance of Km, Catalytic efficiency, and turnover number; Order of kinetics, Transient kinetics, flow techniques (continuous, stopped, quenched)
20-23	Enzyme Inhibition, Models and types of inhibition; Multi-substrate enzymes; Multisite and allosteric enzymes; Models and examples

24-29	Basic Catalytic principles, catalytic strategies of enzymes – Chymotrypsin**,** Protease, carbonic anhydrase, lysozyme, Restriction enzymes
30-34	Regulatory Strategies of allosteric enzymes-Aspartate transcarbamoylase, Kinases, Phosphatase, isozymes, proteolysis, Integration of kinetic, chemical and structural data to describe enzyme action
35-40	Frontiers in enzymology: Rational design of an enzyme catalyst, directed evolution, selection, screening, Structural basis of enzyme action and characterization of active site residues; structure guided active site (re)design, design of inhibitors
41-45	Enzymes used in biotransformation, drug synthesis, biosensors, Therapeutic enzymes, industrial enzymes
30 hours	Tentative list of Practical's: • Extraction of Acid phosphatase enzyme from potato • Ammonium Sulphate precipitation technique for enzyme purification • Determination of Acid phosphatase activity • Effect of pH on Acid phosphatase activity • Effect of tempreture on Acid phosphatase activity • Effect of substrate concentration on Acid phosphatase activity • Effect of enzyme concentration on Acid phosphatase

Suggested Readings*:

1. **Dixon W. B.**: Enzyme kinetics.
2. IUPAC Enzyme nomenclature series.
3. **J. Raymond:** Enzyme Assays.
4. **Nelson D.L. and Cox, M.M.** 2008. Principles of Biochemistry. 5th Edition. W H Freeman & Co., USA.
5. **Palmer:** Enzyme Kinetics (1995).
6. **Richard A. Harvey and Denise R. Ferrier**: Lippincott's Illustrated Reviews: Biochemistry Fifth Edition.
7. **Stryer L., Berg, J.M. and Tymoczko, J. L.** 2006. Biochemistry. Sixth Edition. W.H. Freeman & Co., USA.
8. **N.C. Price, L. Stevens.** 2000. Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins, Oxford University Press, USA.
9. **D. Purich.** 2010. Enzyme Kinetics: Catalysis and Control, Academic Press, San Diego, USA.

*Refer to latest editions available.

MSLSC2005C02 -- Summer Internship (Internal /External)

Third Semester

Course Details			
Course Title: Developmental Biology			
Course Code	MSLSC3001C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

The course will cover basic concepts of animal and plant development, gametogenesis, fertilization in early development of plants and animals. This will also cover organogenesis, and sex determination, programmed cell death and aging of plants and animals

Learning Outcomes

It will enable students to capture advantages of using different model organisms. The knowledge of developmental process in detail will broaden the analysis of principles underlying morphogenesis in plants and animals.

Course Contents

UNIT I: Approaches to developmental biology (Weightage : 24 %, Lectures: 11)

Anatomical, genetic, evolutionary, teratology, mathematical modelling, and experimental approaches; Model organisms: *Dictyostelium, C. elegans, Drosophila, Zebrafish, Xenopus, Chick, Mouse, Arabidopsis*

UNIT II: Basic concepts of development (Weightage : 27 %, Lectures: 12)

Potency, commitment, specification, induction, competence, determination and differentiation, morphogenetic gradients, pattern formation, cell fate, cell lineages, mosaic vs regulative development, genomic equivalence and the cytoplasmic determinants, imprinting

UNIT III: Developmental process in animals (Weightage : 27 %, Lectures: 12)

Cleavage, gastrulation, cell specification; axis and pattern formation with examples from *C. elegans*, *Drosophila*, amphibians, chick and mammals, Cell aggregation and differentiation in *Dictyostelium*, formation of vulva in *C. elegans*, induction of development of compound eye in *Drosophila*, limb development and regeneration in vertebrates. Environmental regulation of animal development

UNIT IV: Developmental process in plants (Weightage : 22 %, Lectures: 10)

Gametophyte development and fertilization, post-fertilization changes, organization of shoot and root apical meristem, shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Rice.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-2	Anatomical, genetic, evolutionary Approaches to developmental biology
3-5	Teratology, mathematical modelling, and experimental approaches
6-7	Model organisms: *Dictyostelium, C. elegans, Drosophila,*
8-11	Model organisms: *Zebrafish, Xenopus, Chick, Mouse, Arabidopsis*
12-13	Potency, commitment, specification, induction, competence,
14-16	Determination and differentiation, morphogenetic gradients, pattern formation
17-19	Cell fate, cell lineages, mosaic vs regulative development
20-23	Genomic equivalence and the cytoplasmic determinants, imprinting
24-26	Cleavage, gastrulation, cell specification; axis and pattern formation with examples from *C. elegans*, *Drosophila*, amphibians, chick and mammals
27-29	Cell aggregation and differentiation in *Dictyostelium*, formation of vulva in *C. elegans*,
30-33	Induction of development of compound eye in *Drosophila*, limb development and regeneration in vertebrates.
34-35	Environmental regulation of animal development
36-38	Gametophyte development and fertilization, post-fertilization changes
39-41	Organization of shoot and root apical meristem, shoot and root development; leaf development and phyllotaxy
42-45	Transition to flowering, floral meristems and floral development in Arabidopsis and Rice.

30 Hours	*Practicals (Tentative)* • Study of frog, hen and/ rat development through prepared permanent slides. • Study of different developmental stages of angiosperms. • Genetic analysis of flower development in Arabidopsis thaliana. • The ABC model of floral organ identity determination • Various stages of *Caenorhabditis elegans* development. • Growth and maintenance of Hydra culture to display regeneration in Hydra.

Suggested Readings*:

1. **Gilbert, S.F.** 2000. Developmental Biology. Sixth edition. INC Publishers, USA.
2. **Westhoff, P**. 1998. Molecular Plant Development: from gene to plant. The Bath Press, UK.
3. **Wolpert, L.** 2001. Principles of Development. Second Edition. Oxford Univ. Press, UK.
4. **Turnbill, G.N.** (Ed.) 2005. Plant Architecture and its Manipulation, ARPP Rev. Vol.17, Blackwell Publ. CRC Press, USA.
5. **Buchanan, B.B., Gruissem, W. and Jones, R.L.** (Eds.) 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, USA.
6. **Heldt, H.W.** 2005. Plant Biochemistry. Third Edition. Academic Press, USA.
7. **Hopkins, W.G. and Huner, N.P.A.** 2004. Introduction to Plant Physiology. Third Edition. John Wiley, UK.
8. **Srivastava, L.M.** 2002**.** Plant Growth and Development: Hormones and Environment. Academic Press, USA.
9. **Taiz, L. and Zeiger, E.** (Eds.) 2006. Plant Physiology. Fourth Edition. Sinauer Associates Inc. Publishers, USA.

**Please refer to latest editions available.*

Course Details			
Course Title: Physiology of Plant System			
Course Code	MSLSC3002C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objective of the Course: This course will cover the harvesting of light energy, oxidation of biomolecules for generation of energy, nitrate assimilation, role of plant hormones, photo morphogenesis, movement of ions, and responses of plant under biotic and abiotic stresses.

Outcome of the Course: This course will allow students to understand the Nitrogen Metabolism and effect of plant hormones on different cellular processes of plants. They will grasp the mechanisms of action light harvesting complex and also response of plant towards abiotic and biotic stress.

Unit-1 • **Transport and Translocation: Fundamentals** **Classical and quantitative method of taxonomy of plants,** non-vascular and vascular plants, 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 photo assimilates. • **Nitrogen Metabolism** Biological Nitrogen fixation in rhizobium and leguminous plants, Nitrate and ammonium assimilation; amino acid biosynthesis.	Weightage :20% L=12
Unit-2 • **Secondary Metabolites** Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles. • **Plant Hormones** Growth: general aspects of phytohormones, auxins, cytokine, gibberellins,ABA, and ethylene: action and their application; photoperiodisin and vernalization, Germination, growth movements, parthenocarpy, abscission and senescence.	Weightage:35% L=18
Unit-3 • **Sensory Photobiology** Primary processes of photosynthesis, Light Harvesting Complex, Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement and their role in photo morphogenesis; photoperiodism and biological clocks.	Weightage:25% L=10

Unit-4	Weightage:20% L=10
• **Stress Physiology:** Responses towards abiotic factors: stresses involving water deficit, high and low temperature stress, salinity stress, drought stress, anoxia and heavy metal stress, role of osmotic adjustments towards tolerance, understanding of genetic basis. • Understanding signalosome under stress conditions: Perception, transduction and response trigger, induction of specific gene expression, stress proteins, convergence and divergence of signaling pathways, ABA as stress hormone • Responses of plants towards biotic factors: plant defence system, systemic plant defence responses	

Content Interaction Plan

Contact Hours	Topics
1-2	• Classical and quantitative method of taxonomy of plants, non-vascular and vascular plants
3-5	• 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 photo assimilates.
6-10	• Nitrogen Metabolism: Biological Nitrogen fixation in rhizobium and leguminous plants, Nitrate and ammonium assimilation; amino acid biosynthesis.
11-13	• Secondary Metabolites: Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.
14-16	• Plant Hormones: Growth: general aspects of phytohormones
17-23	• Auxins, cytokine, gibberellins, ABA and ethylene: action and their application
24-25	• Photoperiodisin and vernalization, Germination, growth movements, parthenocarpy, abscission and senescence
26-28	• Sensory Photobiology: Primary processes of photosynthesis, Light Harvesting Complex
29-33	• Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins;
34-35	• Stomatal movement and their role in photo morphogenesis; photoperiodism and biological clocks.
36-40	• Stress Physiology: Responses towards abiotic factors: stresses involving water deficit, high and low temperature stress, salinity stress, drought stress, anoxia and heavy metal stress, role of osmotic adjustments towards tolerance, understanding of genetic basis.
41-43	• Understanding signalosome under stress conditions: Perception, transduction and response trigger, induction of specific gene expression, stress proteins, convergence and divergence of signalling pathways, ABA as stress hormone
44-45	• Responses of plants towards biotic factors: plant defence system, systemic plant defence responses
	Practicals (Tentative)

P=30 Hours	• Spectrophotometric analysis of photosynthetic pigment. • Separation of different plant pigment through paper chromatography. • Basic steps of Plant Tissue Culture • Inoculation of Brassica seeds for tissue culture to check the effect of phytohormones. • Estimation of Osmolytes from plant tissues under stress. • Estimation of ROS from plants systems. • To study totipotency of plant cell by preparing regenerative media.

Suggested Readings*:

1. **Hopkins, W.G. and Huner, N.P.A.**: Introduction to Plant Physiology. John Wiley, UK.
2. **Taiz, L. and Zeiger, E:**. Plant Physiology.Fourth Edition.Sinauer Associates Inc. Publishers, USA.
3. **Bob B. Buchanan, Wilhelm Gruissem, Russell L. Jones:** Biochemistry & Molecular Biology of Plants
4. **Frank Salisbury, Cleon Ross**: Plant Physiology
5. **Robert M. Devlin**: Plant Physiology

* *Please refer to latest editions available.*

Course Details			
Course Title: PHYSIOLOGY OF ANIMAL SYSTEM			
Course Code	MSLSC3003C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objective of the Course:

- To understand basic physiological processes of life in multicellular animals
- To focus on structures and processes of organs and organ systems in an organism.
- To understand mechanisms of homeostasis.
- To integrate the molecular and cellular processes with tissue, organ and organ system levels and their coordination.

Unit-1 • **Blood and Circulation** – Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin and other respiratory pigments, immunity, haemostasis, open and closed circulation • **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.	**Weightage: 18%**
Unit-2 • **Respiratory System –** Comparison of respiration in invertebrates and vertebrates, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration. • **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.	**Weightage: 27%**
Unit-3 • **Excretory System** - Comparative physiology of excretion in invertebrates and vertebrates, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of waterbalance, blood volume, blood pressure, electrolyte balance, acid-base balance**.** • **Thermoregulation** - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization, homeotherm, poikiotherm, endotherm Stress and Adaptation	**Weightage: 20%**
Unit-4	**Weightage: 33%**

• **Digestive System -** Introduction to evolution of digestive system Digestion, absorption, neuronal and endocrine regulation of digestive processes, energy balance, BMR. • **Endocrinology and Reproduction -** Endocrine glands in invertebrates and vertebrates, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation	

Outcome of the Course:

Students will be able

- To correlate life processes with daily activities like breathing and respiration, nutrition or digestion, seeing and its neural connections etc.
- To connect variations in physiological conditions and their cause like nutritional, environmental or psychological etc.
- To understand pathological conditions of certain disorders.
- To compare and understand evolution of structures to perform physiological functions for the adaption of organisms.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1 - 3	**Blood and Circulation** – Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin and other respiratory pigments, haemostasis, open and closed circulation
4 - 8	**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.
9 - 13	**Respiratory System –** Comparison of respiration in invertebrates and vertebrates, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.
14 - 21	**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.
22 - 27	**Excretory System -** Comparative physiology of excretion in invertebrates and vertebrates, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of waterbalance, blood volume, blood pressure, electrolyte balance, acid-base balance**.**
28 - 30	**Thermoregulation -** Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization, homeotherm, poikiotherm, endotherm Stress and Adaptation
31 - 36	**Digestive System –** Introduction to evolution of digestive system Digestion, absorption, neuronal and endocrine regulation of digestive processes, energy balance, BMR.
37 - 45	**Endocrinology and Reproduction -** Endocrine glands in invertebrates and

	vertebrates, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation
30 hrs Practicals	**Tentative list of practicals:** • To stain cheek epithelial cells with methylene blue. • To count the total RBC in blood using heamocytometer. • To determine of heamoglobin content. • To measure the sugar level in blood. • To measure blood pressure by sphygmomanometer. • To find the blind spot of eye and related phenomena. • To determine amylase activity in saliva. • To determine the Body Mass Index.

Suggested Readings*:

1. **Guyton and Hall** textbook of medical physiology by Hall, John E. and Guyton, Arthur C. Published by : Elsevier (Philadelophia), 2011.
2. **Barrett, Kim E**.: Gangong's review of medical physiology by Publication Tata McGraw Hill, 2012.
3. **David Randall, Warren Burggren, and Kathleen French., WH Freeman**: Eckert Animal Physiology: Mechanisms and Adaptations, Fifth Edition.
4. **Kandel ER, Schwartz JH, Jessell TH**: Principles of neural science 2000, 4th edition. New York: McGraw-Hill.

* *Please refer to latest editions available.*

Course Details

Course Title: BIOLOGY OF IMMUNE SYSTEM			
Course Code	MSLSC3004C04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objective of the Course:

- To understand the defense mechanism of animals.
- To identify the various components of immune system with their functions
- To acquaint with and explain the processes like inflammation, allergy, transplantation, autoimmune diseases etc
- To utilize antibody for applications in different fields

Outcome of the Course:

Students will be able to:

- Identify and explain components of defense system of animals.
- Correlate observations in the surrounding environments with the immune system.
- Use techniques important for diagnostic and experimental purposes.
- Explain mechanisms, at molecular and cellular level, of different pathological conditions.

Course Contents

Unit 1 • Introduction and Overview of the immune system. Origin of immunology and its evolution, Infection and immunity, • Types of immunity-Innate and acquired, active and passive, humoral and cell mediated, Clonal selection theory • Organ and cells of the immune system: structure and function. • Hematopoiesis, Lymphocyte traffic, Antigens and immunogens, Adjuvants	**Weightage : 22%**
Unit 2 • Structure and function of immunoglobulins • Antibody variants-isotypes, allotypes, and idiotypes • Theories and genetic basis of antibody diversity, • Monoclonal antibody, Hybridoma technology, Organization of immunoglobulin genes. • Major histocompatibility complex. MHC genes and Histocompatibility antigens. Role of MHC in T cell selection. • Complement system: Mechanism of its fixation, complement activation and its biological activities, Classical, alternative and lectin pathways, Regulation of complement	**Weightage : 44%**
Unit 3 • Antigen-antibody interactions, Antibody-antigen binding: affinity,	**Weightage : 11%**

avidity, cross reactivity, agglutination, hemagglutination • Precipitation reactions in solution and in gels, • Immunoassays: Radioimmunoassay, ELISA, ELISPOT, immunoflourescence assays • Fluorescence activated cell sorting. Western blotting	
Unit 4 • Cytokines and their role in immune regulation. • Allergy and hypersensitivity, Autoimmunity: factor contributing to autoimmunity and diagnosis, • Immunodeficiencies; primary and secondary, Transplantation immunology • Immunological tolerance to self and to antigens; its induction and features • Immunosuppression-specific and non-specific, Effector mechanism and examples of each type of hypersensitivity, Tumor immunology • Immunization and vaccines	**Weightage : 23%**

Course Plan

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
2 - 3	Introduction and Overview of the immune system. Origin of immunology and its evolution, Infection and immunity, Types of immunity-Innate and acquired, active and passive, humoral and cell mediated, Clonal selection theory
4 - 8	Organ and cells of the immune system: structure and function. Hematopoiesis, Lymphocyte traffic
8 - 10	Antigens and immunogens, Adjuvants
11 - 14	Structure and function of immunoglobulins Antibody variants-isotypes, allotypes, and idiotypes Hybridoma technology, Monoclonal antibody,
15 - 21	Theories and genetic basis of antibody diversity, Organization of immunoglobulin genes.
22 - 26	Major histocompatibility complex. MHC genes and Histocompatibility antigens. Role of MHC in T cell selection.
26 - 29	Complement system: Mechanism of its fixation, complement activation and its biological activities, Classical, alternative and lectin pathways, Regulation of complement
29 - 34	Antigen-antibody interactions, Antibody-antigen binding: affinity, avidity, cross reactivity, agglutination, hemagglutination Precipitation reactions in solution and in gels, Immunoassays: Radioimmunoassay, ELISA, ELISPOT, immunoflourescence assays Fluorescence activated cell sorting. Western blotting
35 – 36	Cytokines and their role in immune regulation.
37 – 45	Allergy and hypersensitivity, Autoimmunity: factor contributing to autoimmunity and diagnosis, Immunodeficiencies; primary and secondary, Transplantation immunology

	Immunological tolerance to self and to antigens; its induction and features Immunosuppression-specific and non-specific, Effector mechanism and examples of each type of hypersensitivity, Tumor immunology Immunization and vaccines
Practicals 30 hrs	Tentative list of Practicals: • To determine viability of blood cells using Trypan blue. • To determine the blood group of your own blood. • To measure total WBC count. • To Prepare blood smear and to fix blood cells on glass slide • Differential staining of WBCs • Use of immunoassay for estimation.

Suggested Readings:

1. **Judith A. Owen:** Kuby Immunology
2. **Roitt** : Roitt's Essential Immunology
3. Kenneth Murphy: Janeway's Immunobiology

MSLSC3005C04—Dissertation

Fourth Semester

MSLSC4001C18—Dissertation

Elective Courses

Course Details			
Course Title: PLANT GENETIC ENGINEERING			
Course Code	MSLSC1001E04	**Credits**	4
L + T + P	2 + 1 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	30 (L) + 15 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objective of the Course: To provide the students' knowledge of main engines of implementation and transmission of a genetic material at molecular and cellular levels, and also methods of change of a genetic material and construction of transgene organisms with the given properties.

Outcome of the Course: The course will enable the students to understand the advanced recombinant DNA techniques in the field of plant genetic engineering and prepare them for PhD in the field of plant system.

Course Contents

Unit-I • Introduction to some important components – Plant tissue culture, genetic engineering. • Introduction to cell and tissue culture techniques: basic techniques, culture requirements, totipotency, haploids, micro propagation, protoplast isolation and fusion, somatic hybrids.	Weightage:20% L=9
Unit-II • Isolate the gene of interest for genetic engineering of plants for improved stress tolerance • Basis of tumor formation; Features of Ti and Ri plasmids; Methods and Mechanisms of DNA transfer to plant cell; Co-integrate vector and Binary vectors; Transgene stability and gene silencing. • Transgenic plants *Agrobacterium* mediated DNA transformation, Chloroplast transformation, mutant approach, wild relatives approach, contrasting genotypes approach etc.	Weightage:30% L=15
Unit-III • Production of novel plant genotypes with improved tolerance towards abiotic stresses: success of plant breeding vs modern genetic modifications • Rising of stress tolerant genotypes through genetic engineering.	Weightage:25% L=11

Unit-IV • Application of plant transformation for productivity and performance • Control of plant pests and pathogens by genetic engineering: insect, nematodes, virus, bacteria and fungus resistant plants, Ethical Issues related to GMO.	Weightage:25% L=10

Content Interaction Plan

Contact Hours	Topics
1-2	• Introduction to some important components – Plant tissue culture, genetic engineering
3-5	• Introduction to cell and tissue culture techniques: basic techniques, culture requirements, totipotency, haploids, micro propagation,
6-9	• Protoplast isolation and fusion, somatic hybrids.
10-13	• Isolate the gene of interest for genetic engineering of plants for improved stress tolerance
14-17	• Basis of tumor formation; Features of Ti and Ri plasmids
18-20	• Methods and Mechanisms of DNA transfer to plant cell; Co-integrate vector and Binary vectors
16-18	• Transgene stability and gene silencing.
19-24	• Transgenic plants *Agrobacterium* mediated DNA transformation, Chloroplast transformation, mutant approach, wild relatives approach, contrasting genotypes approach etc.
25-32	• Production of novel plant genotypes with improved tolerance towards abiotic stresses: success of plant breeding vs modern genetic modifications
33-35	• Rising of stress tolerant genotypes through genetic engineering.
36-38	• Application of plant transformation for productivity and performance
39-45	• Control of plant pests and pathogens by genetic engineering: insect, nematodes, virus, bacteria and fungus resistant plants, Ethical Issues related to GMO.
15 Hours	Tutorials
	List of Practicals 1. Steps of media preparation for PTC: Preparation of media, pouring of plates, preparation of slant and stab 2. Plant Tissue culture: Seed surface sterilization, Seed inoculation, and Regeneration of plants 3. Plant regeneration and sub-culturing 4. Callus induction and sub-culturing 5. Haploid culture 6. Primary and secondary inoculation of *Agrobacterium* 7. Transformation of plant: Co-infection and co-incubation 8. Methods for crossing of plants

Suggested Readings*:

1. **George Acquaah**: Principle of Plant Genetics and Breeding; Willy-Blackwell
2. **Maarten J. Chrispeels and David E. Sadava**: Plants, Genes and Crop Biotechnology; American Society of Plant Biologists.
3. **H.S. Chawla**: Introduction of Plant Biotechnology; Oxford and IBH Publishing
4. **M.K. Razdan:** Introduction of Plant Tissue Culture; Science publishers

Course Details			
Course Title: Structural Biology			
Course Code	MSLSC2001E04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) + 0 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual self/laboratory based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

The course aims to understand the structure and dynamics of macromolecules and their complexes at atomic or near atomic resolution, and subsequently to explain the in vivo functions and interactions. It is a growing field based on advanced methodologies of X-ray crystallography, Nuclear magnetic resonance and electron microscopy. The course also details the applications of computational biology for data analysis and for construction of 3D models.

Learning Outcomes

The students will learn fundamental techniques like X-ray diffraction, NMR, and electron microscopy to determine the structure of protein and analysis of structure to understand the structure-function relationship of protein.

Course Contents

UNIT I **(Weightage : 24 %, Lectures: 10)**

Protein sequences, sequence alignment; Basic polypeptide stereochemistry, hierarchy in protein folds, Motifs and domains of Protein Structure, Alpha domain structures, Alpha/Beta structures, Beta structures, Structural classification of proteins, Protein families, structure-function relationships of proteins, convergent evolution, divergent evolution, structural genomics

UNIT II **(Weightage : 27 %, Lectures: 12)**

Protein structure determination by computational methods, Homology/comparative modeling, Fold recognition (threading), Ab initio (de novo, new folds) methods; protein structure determination by experimental methods, X-ray crystallography, NMR spectroscopy- Multidimensional Solid and solution state NMR, Electron microscopy- Sample preparation (Negative stain, cryo-EM), Type of samples: Single particle, Fibres, Filaments, 2D crystals, tubular crystals, Advantages and disadvantages of various methods, Databases: Coordinate files, Protein data bank.

UNIT III **(Weightage : 29%, Lectures: 13)**

Principles of protein purification for crystallization, Methods of crystallization, structure determination; Structure validation, X-ray sources and area detectors, waves and their properties, X-ray diffraction, Bragg's law, reciprocal lattice and Ewald-sphere construction, Diffraction Data collection, Symmetry and unit cells, Structure factor and Phase problem, Solving the crystallographic phase problem: Patterson maps and Molecular replacement, Multiple Isomorphous replacement (MIR), Multi-wavelength anomalous diffraction (MAD), R-factors, validation and Analysis

UNIT IV **(Weightage : 20 %, Lectures: 10)**

Time resolved crystallography- visualization of reaction in four dimensions, pump-probe, diffusion-trapping, study of haemoglobin oxygenated and deoxygenated states, Applications of techniques: Structure based drug design, carbonic anhydrase inhibitor dorzolamide, tyrosine kinase inhibitor Imatinib

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1-3	Protein sequences, sequence alignment; Basic polypeptide stereochemistry, hierarchy in protein folds, Motifs and domains
4-7	Protein Structure, Alpha domain structures, Alpha/Beta structures, Beta structures
8-10	Structural classification of proteins, Protein families, structure-function relationships of proteins, convergent evolution, divergent evolution, structural genomics
11-13	Protein structure determination by computational methods, Homology/comparative modeling, Fold recognition (threading), Ab initio (de novo, new folds) methods;
14-18	protein structure determination by experimental methods, X-ray crystallography, NMR spectroscopy- Multidimensional Solid and solution state NMR,

19-22	Electron microscopy- Sample preparation (Negative stain, cryo-EM), Type of samples: Single particle, Fibres, Filaments, 2D crystals, tubular crystals, Advantages and disadvantages of various methods, Databases: Coordinate files, Protein data bank.
23-30	Principles of protein purification for crystallization, Methods of crystallization, structure determination; Structure validation, X-ray sources and area detectors, waves and their properties, X-ray diffraction, Bragg's law, reciprocal lattice and Ewald-sphere construction, Diffraction Data collection, Symmetry and unit cells, Structure factor and Phase problem, Solving the crystallographic phase problem: Patterson maps and Molecular replacement, Multiple Isomorphous replacement (MIR), Multi-wavelength anomalous diffraction (MAD), R-factors, validation and Analysis,
31-35	Bragg's law, reciprocal lattice and Ewald-sphere construction, Diffraction Data collection, Symmetry and unit cells, Structure factor and Phase problem, Solving the crystallographic phase problem: Patterson maps and Molecular replacement, Multiple Isomorphous replacement (MIR), Multi-wavelength anomalous diffraction (MAD), R-factors, validation and Analysis,
35-40	Time resolved crystallography- visualization of reaction in four dimensions, pump-probe, diffusion-trapping, study of haemoglobin oxygenated and deoxygenated states,
41-45	Applications of techniques: Structure based drug design, carbonic anhydrase inhibitor dorzolamide, tyrosine kinase inhibitor Imatinib,
15 Hours	Tutorials

Suggested Readings*:

1. **Alexander McPherson**; Introduction to Macromolecular Crystallography, 2nd Edition
2. **Bernhard Rupp**; Biomolecular Crystallography: Principles, Practice, and Application to Structural Biology
3. **Branden and Tooze** ; Introduction to protein structure
4. **Cedric Notredame and Jean-Michel Claverie**; Bioinformatics for Dummies
5. **Gale Rhodes**, Crystallography Made Crystal Clear (Third Edition).
6. **James Keeler;** Understanding NMR spectroscopy. John wiley & sons, England. ISBN: 978-0-470-74609-7
7. **U. Valdre (Editor), Peter W Hawks (Editor):** Biophysical electron microscopy: Basic concepts and modern techniques
8. **Joachim Frank:** Three dimensional electron microscopy of Macromolecular of Macromolecular assemblies by

Reviews:

1. Macromolecular structure determination by electron microscopy: new advances and recent results. Curr Opin Struct Biol 8, 595-600 (1998)

Links

1. Bernhard Rupp's Interactive Crystallography Course

Course Details			
Course Title: STRESS BIOLOGY			
Course Code	MSLSC3001E04	**Credits**	4
L + T + P	2 + 1 + 1	**Course Duration**	One Semester
Semester	3rd	**Contact Hours**	30 (L) + 15 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, assignments, seminar, presentations by students, individual and group drills,		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - Summative Assessment in the form of End Term Examination		

Course Objectives

The goal of the course is to approach all aspects of stress and develop an understanding of stress research and scientific studies in general. The focus is on both the evolutionary conserved aspects of cell stress responses (e.g. heat shock proteins and chaperones) and on individual signalling pathways and molecules controlling the action of specific stress stimuli.

Learning Outcomes

After completion of the course the learners will be able to:

- Understand the basic mechanism of stress perception
- Explain stress responses at cellular level
- Apprehend the role of microRNA in stress response
- Get acquainted with techniques of analyzing effects of stress and response towards them
- Explain the basic structure and ways of replication prevalent among viruses
- Understand the basic principles of host microbe interaction
- Explain the mechanisms of apoptosis and autophagy

Course Contents

UNIT I: Signalling during stress (26% Weightage)

- Abiotic and Biotic Stress Response Crosstalk
- Reactive Oxygen in Stress Perception – detection and mitigation
- Perception of salt and osmotic stresses, Heavy metal sensing

UNIT II: Cellular Stress Responses (37% Weightage)

- The Heat Shock Response, The Response to Oxidative Stress
- The Unfolded Protein Response (UPR), The DNA Damage Response
- Stress Responses in Disease States – Diabetes, Parkinson's disease, Myocardial Infarction
- microRNA in stress response: Recognition of microRNA target sites, MicroRNA regulation during stress adaptation

UNIT III: Stress-Induced Cell Death (17% Weightage)

- Apoptosis, Autophagic Cell Death, Necrosis
- Aspartate-specific proteases in programmed cell death
- Involvement of phytaspase in the abiotic stress response – Phytaspase localization and processing, Retrograde trafficking of phytaspase during the programmed cell death

UNIT IV: Study of stress response (20% Weightage)

- Basis of detection for alterations at biochemical and physiological level
- Analysis of DNA damage
- Detection of alterations in transcriptome
- Proteomic approaches for analysis of stress

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1	Abiotic and Biotic Stress – introduction and response
2	Co – relation between abiotic and biotic stress response
3 - 4	Reactive Oxygen in Stress Perception – detection and mitigation
5 - 6	Perception of salt and osmotic stresses
7	Heavy metal sensing
Formative Assessment 1	
8 – 10	The Heat Shock Response, The Response to Oxidative Stress
11	The Unfolded Protein Response (UPR)
12 – 13	The DNA Damage Response
14	Stress Responses in Disease States – Diabetes
15 – 16	Parkinson's disease, Myocardial Infarction

17 – 18	microRNA in stress response: Recognition of microRNA target sites
19	MicroRNA regulation during stress adaptation
Formative assessment 2	
20	Apoptosis, Autophagic Cell Death, Necrosis
21 – 22	Aspartate-specific proteases in programmed cell death
23 – 24	Involvement of phytaspase in the abiotic stress response – Phytaspase localization and processing
25	Retrograde trafficking of phytaspase during the programmed cell death
Formative assessment 3	
26 - 27	Basis of detection for alterations at biochemical and physiological level
28	Analysis of DNA damage
29	Detection of alterations in transcriptome
30	Proteomic approaches for analysis of stress
15 contact hours	Tutorial
Formative assessment 4	
30 hrs laboratory practical	• Setting up stress exposure experiment and stress influenced growth analysis • Heavy metal/salt detection using Atomic Absorption Spectrophotometry • Estimation of antioxidative enzymes • Assessment of stress induced membrane damage by lipid peroxidation • Visualizing stress influenced proteins by SDS and 2D – PAGE

Suggested References:

1. **Prescott, Harlay and Klein:** Microbiology
2. **Madigan, Martinko and Parker:** Biology of Micro-organism
3. **Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darnell, J.** (Eds). Molecular Cell Biology. Freeman & Co., USA.
4. **Karp, J.G.** Cell and Molecular Biology. John Wiley & Sons, USA.
5. **Taiz, L. and Zeiger, E.** (Eds.) 2006. Plant Physiology. Fourth Edition. Sinauer Associates Inc. Publishers, USA.

*Please refer to latest editions available.

Course Details			
Course Title: Biochemistry of Proteins			
Course Code	MSLSC4001E04	**Credits**	4
L + T + P	2 + 1 + 1	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	30 (L) + 15 (T) + 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Objectives of the course:

- To understand protein structure and function as a part of cellular physiology.
- To understand the protein synthesis, its life and degradation in a cell and extracellular environment.
- To acquaint with chemical modification of amino acid residues of proteins and their uses.
- To learn how to study protein structure, folding and unfolding.
- To learn how to study interactions of protein with other macromolecules or simple molecules.

Outcome of the course:

The students will be able

- To design experiments for protein purification and characterization.
- To explain thermodynamics of folding of protein and formation of supramolecular assemblies.
- To design experiments for protein protein interaction related problems.
- To solve questions related cellular localization protein and further confirmation with various techniques.

Content Interaction Plan:

Unit-1 **(Weightage : 51 %)**
Chemical properties of polypeptides and advance methods of their modification and applications, Extraction and Isolation of proteins from different biological materials, advanced methods of purification of proteins. Anfinsen experiments and Levinthal paradox, the folded conformation of globular proteins, Chemical and physical methods of unfolding, Interaction of proteins with other molecules, Methods to study protein-protein interactions, supramolecular complexes and their assemblies.

Unit-2 **(Weightage : 49 %)**

Biosynthesis of proteins, some selective Post-translational modifications of polypeptides, Secretory proteins and import of proteins into other organelles, Nuclear transport of proteins by importins and exportins, methods to study localization and co-localization
Protein misfolding, Protein degradation by different pathways in cell and extracellular fluids, defects of protein degradation pathways.

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1- 13 (13)	Chemical properties of amino acids and polypeptides, advance methods of their modification and applications, Extraction and Isolation of proteins from different biological materials, advanced methods of purification of proteins. Anfinsen experiments and Levinthal paradox, the folded conformation of globular proteins,
14 - 23 (10)	Chemical and physical methods of unfolding, Interaction of proteins with other molecules, Methods to study protein-protein interactions, supramolecular complexes and their assemblies.
24- 35 (12)	Biosynthesis of proteins, some selective Post-translational modifications of polypeptides, Secretory proteins and import of proteins into other organelles, Nuclear transport of proteins by importins and exportins, methods to study localization and co-localization
36 – 45 (10)	Protein misfolding, Protein degradation by different pathways in cell and extracellular fluids, defects of protein degradation pathways.
	Tutorial 15 hours
	Practical: Steps of Protein purification including precipitation, desalting methods, column chromatography, analysis of purification steps by SDS PAGE and related techaniques, characterization of purified protein by either immunological, biochemical or biological activity.* *All experiments will done by available material in the Laboratory

Suggested Readings*:

1. T.E. Creighton: Protein
2. Voet & Voet: Biochemistry
3. Scope: Protein Purification
4. Tanford: Nature's Robot
5. Garrett & Grisham: Biochemistry
6. Subject related Reviews

Course Details			
Course Title: HUMAN GENETICS AND GENOME ANALYSIS			
Course Code		**Credits**	4
L + T + P	2 + 1 + 1	**Course Duration**	One Semester
Semester	4th	**Contact Hours**	30 (L) + 15 (T) 30 (P) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills,		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - Summative Assessment in the form of End Term Examination		

Course Objectives

This course deals with study of inheritance as it occurs in human beings including the field of genetics concerned with structural and functional studies of the genome. The objective is to provide a comprehensive understanding and integrated view of a variety of overlapping fields including cytogenetics, molecular genetics, genomics, behavioral genetics and clinical genetics along with means of genome study and its practical applications.

Learning Outcomes

After completion of the course the learners will be able to:

- Understand the course of human evolution and get an idea of various tine scales relevant to human decent
- Apply Hardy – Weinberg law for calculating allelic and genetic variation.
- Interrelate several aspects of human behavior with genetic makeup
- Identify unique and signature components of human genome
- Understand the mechanism and role of epigenetic modifications in creating variations
- Identify cellular and genetic changes leading to development of cancer
- Explain the method of genome mapping
- Appreciate the medical and forensic applications of knowledge of human genetics

Course Contents

UNIT I: Human Evolution and Population genetics (27% Weightage)

- Rates of evolution and origin of new genes, comparison of humans with chimpanzees
- Time scale of evolution, tracing human history with different markers, genetic adaptations unique to humans
- ***Genetic variation*** - application of Hardy – Weinberg law to human population, fitness and selection
- ***Behavioural genetics*** – application of behavior first approach and gene first approach, genetic component of human behavior with examples of Huntington's disease and Schizophrenia

UNIT II: Organization of Human Genome (27% Weightage)

- ***Organization***, size and banding, rRNA, mRNA and snRNA coding genes, unique and repetitive DNA, interrupted genes, gene families, overlapping and truncated genes
- ***Epigenetics***: mode of genome alterations and its implications; Inheritance of fear as a case study
- ***Cell cycle & Cancer:*** genetics of cell cycle progression, chromosomes in neoplasias, cancer as a genetic disorder, loss of cell cycle control; Inherited versus sporadic cancers. Oncogenes: Retroviral oncogenes, proto-oncogenes, functions of oncogene products; Tumor suppressor genes, Cancer therapy: early detection and prevention, molecular diagnosis, treatment.

UNIT III: Genome analysis (27% Weightage)

- DNA sequencing, bio chips, DNA micro arrays, gene annotation, gene structure predictions, gene ontology consortium recommendations, structural and functional genomics.
- ***Human genome project***; mapping strategies, current status of various maps; human genome diversity
- Rise of variation and its extent in populations (e.g. HapMap)

UNIT IV: Applied Genetics (19% Weightage)

- ***Prenatal screening methods***- Amniocentesis- Chronic Villous sampling, Ultrasonography, fetoscopy, maternal blood sampling.
- ***Gene Therapy***- classification of gene therapy- class I, II, and III. Types of gene therapy, germ line gene therapy and somatic gene therapy
- ***Personalized medicine***: pharmacogenomics and disease diagnosis
- ***DNA Forensics*** – profiling methods based on VNTR, autosomal STR, Y chromosome, mitochondrial DNA, SNPs

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	**Unit/Topic/Sub-Topic**
1 – 2	Rates of evolution and origin of new genes, comparison of humans with chimpanzees
3 – 4	Time scale of evolution, tracing human history with different markers, genetic adaptations unique to humans
5 – 6	***Genetic variation*** - application of Hardy – Weinberg law to human population, fitness and selection
7 – 8	***Behavioural genetics*** – application of behavior first approach and gene first approach, genetic component of human behavior with examples of Huntington's disease and Schizophrenia
9 - 10	***Organization***, size and banding, rRNA, mRNA and snRNA coding genes, unique and repetitive DNA, interrupted genes, gene families, overlapping and truncated genes
11 – 12	***Epigenetics***: mode of genome alterations and its implications, Inheritance of fear as a case study
13 – 16	***Cell cycle & Cancer:*** genetics of cell cycle progression, chromosomes in neoplasias, cancer as a genetic disorder, loss of cell cycle control
17 – 18	Inherited versus sporadic cancers. Oncogenes: Retroviral oncogenes, proto-oncogenes; functions of oncogene products
19	Tumor suppressor genes, Cancer therapy: early detection and prevention, molecular diagnosis, treatment
20 – 22	DNA sequencing, bio chips, DNA micro arrays, gene annotation, gene structure predictions
23 – 25	Gene ontology consortium recommendations, structural and functional genomics
26	***Human genome project***; mapping strategies, current status of various maps; human genome diversity
27	How variation arises and its extent in populations (e.g. HapMap)
28	***Prenatal screening methods***- Amniocentesis- Chronic Villous sampling, Ultrasonography, fetoscopy, maternal blood sampling.
28	***Gene Therapy***- classification of gene therapy- class I, II, and III. Types of gene therapy
29	Germ line gene therapy and somatic gene therapy, ***Personalized medicine***: pharmacogenomics and disease diagnosis
30	***DNA Forensics*** – profiling methods based on VNTR, autosomal STR, Y chromosome, mitochondrial DNA, SNPs

Suggested References:

6. **Genetics:** Snustad and Simmons. John Wiley & Sons
7. **Genetics – A conceptual approach**: Benjamin A. Pierce. W. H. Freeman and Company
8. **Concepts of Genetics:** William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. Pearson

List of Practicals

1. Calculation of allelic and genotypic frequencies
2. Report preparation and presentation of any inherited human character
3. Human karyotyping
4. Culture of cancerous cell lines and its comparison with normal cell lines
5. Assessment of viability/proliferation in cultured cells by Trypan Blue staining and MTT assay
6. Gene annotation and gene structure predictions