CENTRAL UNIVERSITY OF SOUTH BIHAR

Course Structure and Syllabus

for

Master of Science in Life Science

(M.Sc. in Life Science)

(Effective from Academic Session 2022-2023)

Department of Life Science

School of Earth, Biological and Environmental Sciences

About the program: The Department of Life Science is presently offering four semester Masters' degree (M.Sc.) in Life Science based on the Choice Based Credit System (CBCS) model. The curriculum broadly includes theory, practical, skill based, vocational and IKS courses. In addition, the curriculum also provides an opportunity to conduct six month dissertation that can be done within the department or from any other University/Institute of national repute.

The aim of M.Sc. program is to create a highly skilled human resource in the field of Life Science with a sound fundamental knowledge base along with hands on laboratory skill to deal with local/ National and International needs, and provide solutions for a variety of ongoing and emerging issues using scientific interventions.

The faculty members of the Department are highly competitive and experiences in teaching and research. The faculty members opt flexible mode of content delivery such as lectures/tutorials/laboratory work/field work/outreach activities/project work/vocational training/viva/seminars/ term papers/assignments /presentations / self-study work etc., or a combination of some of these.

Objectives:

- To provide in-depth understanding evolution, and structural and functional aspects of ecosystem on the whole.
- To strengthen theoretical basis of biological processes at molecular, cellular and organismal level.
- To offer hands on experience relevant in the field of life science for employment opportunities and societal benefit.

Outcome: After completion of the course students shall be able to fill the lacuna between academics, research and entrepreneurship. They shall attain comprehensive knowledge of all the life sustaining biological processes with direct applicability for socio-economic development.

CBCS Course Structure and Syllabus of Master of Science in Life Science
(M.Sc. in Life Science)
Total Credits: 80 Cr.

Semester – I (Total Credits = 20)		
Course Code	**Name of the Course**	**Credit (L+T+P)**
LSC81DC00104	Cell Biology	3+0+1
LSC81DC00204	Biochemistry	3+0+1
LSC81DC00304	Genetics	3+0+1
LSC81DC00404	Microbiology	3+0+1
	Open Elective Interdisciplinary Course (Elective Basket - II)	4
	Mandatory Elective Non-Credit Course equivalent to 2 credits (Elective Basket - III)	0
Total Credits		**20**

Semester – II (Total Credits = 20)		
Course Code	**Name of the Course**	**Credit (L+T+P)**
LSC82DC00503	Metabolism	2+0+1
LSC82DC00602	Molecular Biology	2+0+0
LSC82DC00702	Recombinant DNA Technology	2+0+0
LSC82DC00802	Enzymology	2+0+0
LSC82DC00904	Research Methodology	4+0+0
LSC82DC01003	Vocational Training of Industrial Application	0+0+3
	Discipline Based Elective Course (Elective Basket - I)	4
	Mandatory Elective Non-Credit Course equivalent to 2 credits (Elective Basket - III)	0
Total Credits		**20**

Semester – III (Total Credits = 20)		
Course Code	**Name of the Course**	**Credit (L+T+P)**
LSC91DC01103	Physiology of Plant System	2+0+1
LSC91DC01203	Physiology of Animal System	2+0+1
LSC91DC01303	Developmental Biology	2+0+1
LSC91DC01403	Biology of Immune System	2+0+1
	Discipline Based Core Elective (Elective Basket - I)	4
	Open Elective Interdisciplinary Course (Elective Basket - II)	4
	Mandatory Elective Non-Credit Course equivalent to 2 credits (Elective Basket - III)	0
Total Credits		**20**

Semester – IV (Total Credits = 20)		
Course Code	**Name of Course**	**Credit (L+T+P)**
LSC92DC01520	Dissertation	20
	Mandatory Elective Non-Credit Course equivalent to 2 credits (Elective Basket – III)	0
Total Credits		**20**

Elective Baskets

Elective Basket – I (Discipline Based Course Elective)		
Course Code	**Name of Course**	**Credit (L+T+P)**
LSC82DE01602 LSC91DE01602	Ecology and Evolution	2+0+0
LSC91DE01702	Cellular Stress Biology	2+0+0
LSC82DE01802	Molecular Plant Pathology	2+0+0
LSC91DE01902	Human Genetics and Genome Analysis	2+0+0
LSC82DE02002	Fundamental of Cancer Biology	2+0+0

LSC82DE02102	Biochemistry of Proteins	2+0+0
LSC82DE02202 LSC91DE02202	Protein Structural Biology	2+0+0
LSC82DE02302 LSC91DE02302	Plant Genetic Engineering	2+0+0
LSC82DE02402 LSC91DE02402	Forms and Functions in Birds: Adaptation perspective	2+0+0

Elective Basket – II (Open Elective Interdisciplinary Course for other departments)		
Course Code	**Name of Course**	**Credit (L+T+P)**
LSC81OE02504	Methods in Biology	4
LSC91OE02604	Fundamentals of Biology	4
LSC91OE02704	Reproductive Health and Population Control	4

Elective Basket – III (Mandatory Elective Non-Credit Course equivalent to 2 credits)		
Course Code	**Name of Course**	**Credit (L+T+P)**
LSC81ME02800 LSC82ME02800 LSC91ME02800	Nutrition and Health	0
LSC81ME02900 LSC82ME02900 LSC91ME02900	Mushroom Farming	0
LSC81ME03000 LSC82ME03000 LSC91ME03000	Post-Harvest Technology for Crop Management	0
LSC81ME03100 LSC82ME03100 LSC91ME03100	Philosophy of Science and Scientific Ethics	0
LSC81SW03200 LSC82SW03200 LSC91SW03200 LSC92SW03200	SWAYAM approved Courses	0
LSC81ME03300 LSC82ME03300 LSC91ME03300	Internship/Field work/ Apprenticeship/Innovation &	0

LSC92ME03300	Entrepreneurship/Co-curricular activities/any other similar course offered by the CUSB under MENC	

Note:

1. *Department Based Core Courses are compulsory for MSc Life Science students.*
2. *Department Based Core Elective are the elective courses for MSc Life Science students.*
3. *Open Elective Interdisciplinary Courses offered by the Life Science Department are for other department students.*
4. *MSc Life Science students shall opt two Open Elective Interdisciplinary Courses from other department to earn 08 credits in two different semesters.*
5. *MSc Life Science students shall opt two Discipline Based Core Elective courses each in the second and third semester.*
6. *Department of Life Science shall provide a list of offered Discipline Based Core Elective courses at the beginning of the second and third semester.*
7. *All Elective courses may not be offered at any given time. An elective will run if opted by 25% ofthe students enrolled in the program.*
8. *The Mandatory Elective Non-Credit Courses (MENC) have no semester boundaries. The students will have full freedom to complete them in any of the semester during the entire duration of the PG program. The MENC courses will require only satisfactory completion and have no grading.*
9. *Department will notify students in the beginning of the semester about offered Internship/Field work based MENCs by the faculty members.*
10. *Dissertation work can be carried within the Life Science Department or outside the department in any Central University/Research Institution within India. The student and concern supervision shall bė responsible for identifying the University/Research Institution for dissertation work outside the department. CUSB will not provide any financial support for dissertation work conducted outside the department.*

Discipline Based Core Courses (First Semester)

Course Title: Cell Biology			
Course Code	LSC81DC00104	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory and Practical		
Special Nature/ Category of the Course (*if applicable*)	A foundational course that is to be compulsorily studied by a student as a core requirement to complete the discipline of study at PG level.		
Methods of Content Interaction	Lecture, Feedback or hand note preparation, group and individual self/laboratory-work and 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 Objective: This course is designed to understand basic structure and function of both pro and eukaryotic cell and their organelles. Also, the fundamentals of cell signaling and cell cycle are explained to students in a very lucid form.

Course Learning Outcomes: The students will learn the role of biomolecules in structural, cellular and functional organization. Illustrate that fundamental structural units define the function of all living things also, gain knowledge about the cross-talk among the various macromolecules and cell cycle checkpoints. Communicate biological concepts and understanding to members of a diverse scientific community as well as to the general public.

Course Content

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% 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 (Chloroplast) and Mitochondria, Vacuole Exocytosis and Endocytosis	Weightage:30% 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, ubiquitination The cytoskeleton, the nature of cytoskeleton, Intermediate filaments, Microtubules, Actin 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% 17
Unit 4: Cell to cell signalling, Overview of extracellular signalling Role of Secondary messenges cAMP. Ca^{2+}, IP_3, Nitric Oxide, H_2S and CO 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% 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=30 Hours	*t of practical* 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 Title: Biochemistry			
Course Code	LSC81DC00204	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory and Practical		
Special Nature/ Category of the Course *(if applicable)*	Skill Based / Vocational Study		
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 presentations.		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative innature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To understand and apply physical and chemical laws that govern biological systems
- To know the specificity of biomolecular structures and their properties and functions in biological systems.
- To appreciate biomolecular hierarchy - simple molecules are the units for building complex structures.
- To be familiar with methods of separation and analysis of biomolecules.

Course Learning Outcomes: 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 biologicalsystems
- To analyse and understand fundamental properties which are utilized by nature during evolution
- To recognize causes and solutions of diseases, daily observations/problems and environmental events in biochemistry.

Course Content

Unit 1: **Physical and Chemical Foundation** Introduction to biochemistry, *Properties of Biomolecules Reflect Their Fitness to the Living Condition*, Stabilizing interactions in biomolecules (covalent, hydrophobic, hydrophilic, van der Waals, electrostatic interaction), *importance of weak forces in Biology* Water as solvent, Acid base and buffer, *Good buffers*, Biological relevance of pH Law of thermodynamics, Gibb's free energy, Chemical equilibria, Redox potential, *High energy biomolecules of biological systems* Colligative properties, diffusion, osmosis Introduction to Spectrophotometry - ultraviolet and visible Fluorescence, Circular dichroism. *Uses in biomolecular*	Weightage: 29 %

analysis	
Unit 2: Carbohydrates Classification, Structure and biological importance, Glycoconjugates - lipopolysaccharides, Glycosaminoglycans, proteoglycans, protein glycosylation, lectin-carbohydrate interactions, *Symbol Nomenclature for Glycans (SNFG), Roles of Glycosylation in Biology, Uses of glycans* Isolation, separation and analysis of carbohydrates	Weightage: 18 %
Unit 3: Lipids *Definition of Lipids*, Storage lipids, Structure and function of fatty acids, Glycerol, Phospholipid, Sphingolipids, Cholesterol and *its derivatives*, Lipoproteins, galactolipid, Waxes, *Terpenes and their relevance to biological systems*. 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 & Nucleic acids Classification and general properties of amino acids, nomenclature of stereoisomers of amino acids, Isolation, separation and analysis of proteins and amino acids Characterization of proteins, sequence determination, massspectrometry, 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 ofproteins, Protein Data bank Structure of hemoglobin, oxygen binding kinetic and its relation to its structure, mechanisms of cooperativity in oxygen binding Glycoproteins, Lipoproteins, Protein modifications and their functional implications. Nitrogenous bases, Nucleosides, Nucleotides, Nucleic acids	Weightage: 33 %

Content Interaction Plan

Contact Hours	Topic
1- 3	**Physical and Chemical Foundation** Introduction to biochemistry, Properties of Biomolecules Reflect Their Fitness to the Living Condition, Stabilizing interactions inbiomolecules (covalent, hydrophobic, hydrophilic, van der Waals, electrostatic interaction), importance of weak forces in Biology
3 – 7	Water as solvent, Acid base and buffer, Good buffers, Biological relevance of pH
8 – 11	Law of thermodynamics, Gibb's free energy, Chemical equilibria, Redox potential, High energy biomolecules of biological systems, Colligative properties, diffusion, osmosis
12 -13	Introduction to Spectrophotometry - ultraviolet and visible Fluorescence, Circular dichroism. Uses in biomolecular analysis
14 – 18	**Carbohydrates** Classification, Structure and biological importance,

19 – 21	Glycoconjugates, lipopolysaccharides, Glycosaminoglycans, proteoglycans, protein glycosylations, lectin-carbohydrate interactions, Symbol Nomenclature for Glycans (SNFG), Roles of Glycosylation in Biology, Uses of glycans, Isolation, separation and analysis of carbohydrates
22- 26	**Lipids** Storage lipids, Structure and function of fatty acids, Glycerol, Classification ofLipids - Phospholipid, Sphingolipids, Lipoproteins, galactolipid Cholesterol and its derivatives, Waxes, Terpenes and their relevance to biological systems
27 -30	Structural lipids in biological membranes, integral membrane proteins, lipoproteins and trafficking through membrane, Lipids as signals, cofactors andpigments, Isolation, separation and analysis of lipids
31 -33	**Proteins** Classification and general properties of amino acids, nomenclature ofstereoisomers of amino acids Isolation, separation and analysis of protein and amino acids
34 – 35	Characterization of proteins, sequence determination, mass spectrometry, oneand 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 structuremechanisms of cooperativity in oxygen binding Glycoproteins, Lipoproteins, Protein modifications and their functional Implications
43 - 45	Nitrogenous bases, Nucleosides, Nucleotides, Nucleic acids
P=30 Hours	*List of practical* Essential Biochemistry Laboratory Techniques 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 Quantitative 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. Fourth 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. **Reginald H. Garrett, Charles M. Grisham.** Biochemistry, Latest Edition. Cengage Learning., Canada.

   Sheehan, D. Physical Biochemistry: Principles and Applications. John Wiley & SonsLtd., 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 Title: Genetics			
Course Code	LSC81DC00304	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 0(T)+30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory & Practical		
Special Nature/ Category of the Course (*if applicable*)	Fundamental course		
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 naturebut 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 Content

Unit 1: Introduction to Genetic Research Mendelism: Brief overview of Mendel's work, Principle of equivalence of reciprocal hybrids, Application of laws of probability (Product and Sum rule), Chromosomal theory of inheritance, Extensions of Mendelism, Linkage and Crossing Over.	Weightage: 30 %

Model systems in Genetic Analysis: Bacteriophage, *E. coli*, *Neurospora crassa*, yeast, *Arabidopsis*, maize, *Drosophila*, *C. elegans*, Zebra fish, - General outline of life cycle, importance in Genetic analysis.	
Unit 2: Genes & Chromosomes 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, Benzer concept of gene Gene interaction: allelic and gene interactions Structural and numerical changes in chromosome and its implications. 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 in human and its errors.	Weightage: 40%
Unit 3: Nuclear & Organelle genome 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. Mutation; Type, cause & detection. Epigenetics, 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*	Weightage: 15%
Unit 4: Principles of breeding 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, hybrid vigour,Hybrid varieties Population Genetics: General background, Random mating population, Hardy-Weinberg principle	Weightage: 15%

Content Interaction Plan

Contact Hours	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 theory of inheritance
7-9	Extensions of Mendelism
10-12	Linkage and Crossing Over
13-15	Model systems in Genetic Analysis: Bacteriophage, *E. coli*, *Neurospora crassa*, yeast, *Arabidopsis*, maize, *Drosophila*, *C. elegans*, Zebra fish. Outline general features and importance in biological research
16-178	Evolution of gene concept - Definition of factors, alleles, multiple alleles, pseudoalleles, Beadle and Tatum's One gene one enzyme concept, One geneone polypeptide concept, Complementation test, Benzer concept of gene
19-22	Gene interaction: allelic and gene interactions

23-26	Structural and numerical changes in chromosome and its implications.
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 in human and its errors
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	Mutation; Type, cause & detection. Epigenetics, 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 responseto selection, hybrid vigour, and Hybrid varieties, Cultivar: Introduction, mechanism, and importance. Role of induced mutations in crop improvement
P=30 Hours	*List of Practical* Study of morphology of *Drosophila melanogaster* – Wing, Sex comb, Genital plate and Bristles. Study of morphology of a plant model system. Study of stages of mitosis and meiosis by preparing temporary slides of onion root tip andbud. Demonstration of gene -interaction in corn. Karyotyping Slide preparation

Suggested Readings*:

1. Concepts of Genetics, Klug WS & Cummings MR, Prentice – Hall.
2. An Introduction of Genetic Analysis, Griffiths A. Macmillan Learning.
3. Genetics – a conceptual approach, Pierce BA. W H Freeman & Co.
4. Genetics: A Molecular Approach, Peter J. Russel, Pearson.
5. Genetics, Strickburger MW, Prentice – Hall.
6. Genetic Analysis of Genes & Genomics, Hartl, D.L, Jones FW, Jones & Barlett.
7. Advanced Genetics, Miglani, G.S, Alpha Science.
8. Genetics- Classical to Modern, Gupta, P.K, Rastogi Publications.

**Please refer to latest editions available*

Course Title: Microbiology			
Course Code	LSC81DC00404	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Nature of the Course	Discipline Based Core Course (DBCC)		
Special nature/ Category of the Course (if applicable)	Foundational course which is to be compulsorily studied by a student as a core requirement to complete the requirement of M.Sc. Life Science.		
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:

- 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
- To highlight environmental, medicinal and industrial applications of microbes

Course 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
- Understand the basic principles of host microbe interaction and explain the principles of pathogenicity
- Apply the knowledge of microbial systems in diverse fields such as environment maintenance, medicine and industry

Course Content

Unit 1: INTRODUCTION TO MICROBIOLOGY A brief history of microbial world, insight into diversity of microbes, Bergey's manual and bacterial classification (as tutorial) Basic principles of microscopy and staining Ultra-structure of Bacteria, Cyanobacteria, Protozoa Algae and Fungi Ultrastructure of viruses - Replication of Plant and animal viruses, Lytic and lysogenic cycle, Lysogenic conversion and its regulation Cultivation of viruses using embryonated eggs, experimental animals and cell cultures, purification of viruses by adsorption, precipitation, enzymes, serological methods – haemagglutination and ELISA. Assay for viruses.	Weightage: 42 %

Unit 2: GROWTH & NUTRITION **Growth and Nutrition** -Microbial growth and population kinetics, Autotrophs & Prototrophs, methodology for measuring growth and growth regulation, Nutritional requirements of micro-organisms, Mode of nutrition, phototrophy, mixotrophy, saparophytic mode, Chemolithotrophy - oxidation of ammonia, nitrite, molecular hydrogen, Ferrous and sulfur/sulfide symbiosis **Solute Transport** - Primary and Secondary transport, ABC transporters, Phosphotransferase system, Drug export systems **Quorum sensing** - A and C signalling system	Weightage: 18%
Unit 3: BIOCHEMISTRY, PHYSIOLOGY AND GENETICS OF MICROBES **Nitrogen fixation** **Photosynthesis** - Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. **Respiration** - Bacterial aerobic respiration, components of electron transport chain, Bacterial anaerobic respiration: Introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria. **Chemolithotrophy** - Physiological groups of chemolithotrophs, oxidation of ammonia, nitrite, molecular hydrogen, Ferrous and sulfur/sulfide **Sporulation** – characteristics of spores and mechanism of sporulation **Gene transfer** by conjugation, transduction and transformation	Weightage: 13%
Unit 4: MODERN TRENDS IN MICROBIOLOGY **Environmental Microbiology** - Microbial diversity in extreme environments: Occurrence, diversity, adaptations; Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment; **Eutrophication** – algal blooms and toxicity, Physico-chemical and biological measures to control eutrophication, **Microbial degradation** of aliphatic and aromatic hydrocarbons, Bioremediation of Xenobiotics; **Microbes in mineral recovery** - Bioleaching of copper, gold and uranium **Medical Microbiology** - Determinants of infectious diseases: Transmission, Attachment, colonization, Entry, Growth and Multiplication, Toxigenicity; **Physical and chemical control of microbes** - General Characteristic and mode of action, control of viral diseases, **Antimicrobial resistance** - Recent concepts – Multidrug efflux pumps, extended spectrum β-lactamases (ESBL), XMDR M. tuberculosis, Methacillin-resistant S. aureus (MRSA) **Space Microbiology** - Life detection methods -Evidence of metabolism, evidence of photosynthesis (autotrophic and heterotrophic), ATP production, evidences of phosphate and sulphur uptake; **Martian environment** (atmosphere, climate and other details), Antarctica as a model for Mars. Search for life on Mars, Viking mission, Viking landers, and Biology box experiment. **Nanomicrobiology** – nanodiagnosis of infections, role of nanobacteria in human disease, nanotechnology based microbicidal agents	Weightage: 27%

Microbial Technology - Enzyme Engineering - Industrially important microbial enzymes; Immobilization of microbial enzymes – methods, properties and applications; **Microbial strain improvement-** Isolation, selection and improvement of microbial cultures, Screening and isolation of microorganisms, enrichment, strategies of strain improvement for primary, secondary metabolites, Preservation of cultures after strain improvement programme; **Role in production of biofuels and biofertilizer**	

Content Interaction Plan

Contact Hours	Topic
1-3	A brief history of microbial world, insight into diversity of microbes, Bergey's manual and bacterial classification (as tutorial)
4 - 7	Basic principles of microscopy and staining
8-11	Ultra-structure of Bacteria
12	Ultra-structure of Protozoa
13	Ultra-structure of Fungi
14-15	Distinctive properties of viruses; Morphology and Ultrastructure: Icosahedral, Helical, and complex symmetry of viruses
16-17	Viral Genome, Replication of Plant and animal viruses
18-19	Cultivation of viruses using embryonated eggs, experimental animals and cell cultures, purification of viruses by adsorption, precipitation, enzymes, serological methods – haemeagglutination and ELISA. Assay for viruses
20-21	**Growth and Nutrition** -Microbial growth and population kinetics
22	Methodology for measuring growth and growth regulation
23-24	Nutritional requirements of micro-organisms, Auxotrophs & Prototrophs, Mode of nutrition, phototrophy, mixotrophy, saparophytic, symbiosis
25-26	**Chemolithotrophy** - Physiological groups of chemolithotrophs, oxidation of ammonia, nitrite, molecular hydrogen, Ferrous and sulfur/sulfide
27	Solute Transport, **Quorum sensing** - A and C signaling system
28-29	Nitrogen Fixation
30	**Photosynthesis** - Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria.
31	**Respiration** - Bacterial aerobic respiration, components of electron transport chain, Bacterial anaerobic respiration: Introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria.
32	Gene transfer by conjugation
33	Gene transfer by transduction and transformation
34-35	**Environmental Microbiology** - Microbial diversity in extreme environments: Occurrence, diversity, adaptations; Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment
36	**Eutrophication** – algal blooms and toxicity, Physico-chemical and biological measures to control eutrophication, **Microbial degradation** of aliphatic and aromatic hydrocarbons, Bioremediation of Xenobiotics; **Microbes in mineral recovery** - Bioleaching of copper, gold and uranium
37	**Medical Microbiology** - Determinants of infectious diseases: Transmission, Attachment, colonization, Entry, Growth and Multiplication, Toxigenicity

	Physical and chemical control of microbes - General Characteristic and mode of action, control of viral diseases
39 – 40	**Antimicrobial resistance -** Recent concepts – Multidrug efflux pumps, extended spectrum β-lactamases (ESBL), XMDR M. tuberculosis, Methacillin-resistant S. aureus (MRSA)
41	**Space Microbiology**
42	**Nanomicrobiology** - nanodiagnosis of infections, role of nanobacteria in human disease, nanotechnology based microbicidal agents
43	**Microbial Technology - Enzyme Engineering -** Industrially important microbial enzymes; Immobilization of microbial enzymes – methods, properties and applications
44	**Microbial strain improvement-** Isolation, selection and improvement of microbial cultures, Screening and isolation of microorganisms, enrichment, strategies of strain improvement for primary, secondary metabolites, Use of recombinant DNA technology, problems associated with strain improvement programme, Preservation of cultures after strain improvement programme
45	Role in production of biofuels and biofertilizer
P=30 Hours	***List of Practical*** Preparation of defined media for culturing microbes Plating technique and observation of differential microbial flora. Enumeration of CFU of *E. coli*/other microbes by serial dilution. Isolation of pure culture of microbe (streaking and liquid culture transfer techniques) Gram staining for identification of wall type in bacteria. LCB staining for microscopic observation of fungi. Identification of eubacteria by 16s rDNA PCR amplification as a tool. Determination of bacterial growth kinetics. To study the effect of different antibiotics on bacterial culture. Qualitative and quantitative assay for a microbial product (siderophore using CAS/Arnow/Atkin's assay)

Suggested Readings*:

- Prescott, Harlay and Klein: Microbiology. 7th ed. New York : McGraw-Hill Higher Education
- Madigan, Martinko and Parker:Brock Biology of Micro-organism. 11th ed, Pearson
- Alcamo: Fundamentals of Microbiology. 9th ed. Jones & Bartlett Learning
- Talaro K. and Talaro A.: Foundations in Microbiology. 10th ed. McGraw Hill
- Pelczar M. J.,Chan E. C. S. and Krieg N.R.: Microbiology: Concept and Applications. McGraw-Hill College
- Atlas , R. M.: Principles of Microbiology. McGraw Hill Education
- Gornity, G. M.: Bergey's Manual of Systematic Bacteriology (2nd Ed.). Springer

**Please refer to latest editions available.*

Discipline Based Core Courses (Second Semester)

Course Title: Metabolism			
Course Code	LSC82DC00503	**Credits**	3
L + T + P	2 + 0 + 1	**Course Duration**	One Semester
Semester	II	**Contact Hours**	30 (L) + 0 (T) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory and Practical		
Special Nature/ Category of the Course (*if applicable*)	Foundational course which is to be compulsorily studied by a student as a core requirement to complete the study at PG level.		
Methods of Content Interaction	Lecture, Feedback or hand note preparation, 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 to 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 of Carbohydrates, Protein, Lipids and Nucleic acids. Know the importance of the metabolic pathways and related diseases.

Course Content

Unit 1: **Carbon Assimilation:** Light absorption and energy conversion, Photolysis of water and Cyclic and Non-cyclic photophosphorylation, Carbon dioxide uptake and assimilation, Calvin Cycle (C_3), Photorespiration (C_2), Hatch-Slack pathway (C_4); CAM pathway; Sucrose transport, Starch, Cellulose synthesis	Weightage:35% L=10
Unit 2: **Biological Oxidation and Release of Energy:** Glycolysis and Pentose phosphate pathway and its importance in biosynthetic reactions, Gluconeogenesis pathway its regulation and diseases; Cori cycle, Glyoxylate pathway, TCA cycle as amphibolic pathway, High energy compounds; Shuttle systems, Oxidative phosphorylation; Chemiosmotic hypothesis and ATP production.	Weightage:35% L=12
Unit 3: **Metabolism of Macromolecules:** Biosynthesis Glycogen; Biosynthesis and degradation of Fatty acids and Lipids, Synthesis and degradation of steroids, Metabolism of nucleotides, Salvage pathways, its regulation and diseases, amino acids metabolism, Urea cycle, Metabolism and disease	Weightage:25% L=8

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 (C_3); Hatch-Slack pathway (C_4); CAM pathway; Photorespiration (C_2)
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
P=30 Hours	*List of practical* Kranz anatomy and estimation of Starch from C_3 and C_4 plant Observation of starch granules in potato Estimation of Amino acid eg, Proline, Glycine, etc. 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

**Please refer to latest editions available.*

Course Title: Molecular Biology			
Course Code	LSC82DC00602	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Foundational course which is to be compulsorily studied by a student as a core requirement to complete the study at PG level.		
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:

- To develop an understanding of the fundamentals of nucleic acids and their role in information pathways through transcription and translation.

Learning Outcomes: After completion of the course the students shall have an understanding of:

- Prokaryotic and eukaryotic DNA replication, DNA repair and transposition
- RNA synthesis including transcription and post transcriptional modifications.
- RNA stability and degradation
- Genetic code and regulation of protein synthesis in prokaryotes and eukaryotes
- Mechanisms of regulation of genetic expression

Course Contents	
Unit 1: Chromosomal elements, DNA supercoiling, Structure of Chromosomes DNA replication in prokaryotes and eukaryotes, End Replication Problem Homologous and site specific Recombination, DNA damage and repair Transposable elements in bacteria, *Drosophila*, plants and human - LINES, SINES, and retroviruses Prokaryotic and eukaryotic transcription RNA splicing and processing mRNA stability, localization, RNA degradation Gene ~~expression~~ Regulation: Operon and regulon system, ~~Phage strategies,~~ eukaryotic regulation, epigenetic effects, Regulatory RNA	75% Weightage L=23
Unit 2: Genetic code, Wobble hypothesis 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	25% Weightage L=07

Content Interaction Plan:

Contact Hours	Topic
[illegible]	Chromosomal elements, DNA supercoiling, Structure of Chromosomes
[illegible]-5	DNA replication in prokaryotes, DNA replication in eukaryotes
[illegible]	Homologous and site specific Recombination, DNA repair
[illegible]	Transposable elements in bacteria, *Drosophila*, plants and humans- LINES, SINES, retroviruses like elements
12-14	Transcription in Prokaryotes
15 – 16	Transcription in eukaryotes
17-18	RNA splicing and processing
19	mRNA stability, localization
20	RNA degradation
21 – 22	Gene Regulation: Operon system
23	Phage strategies
24	Eukaryotic gene regulation, epigenetic effects, Regulatory RNA
25	Genetic code, wobble base pairing
26 – 27	Translation in prokaryotes
28 – 29	Translation in eukaryotes
30	Translational proof-reading, translational inhibitors. Post-translational modifications, Protein Degradation

Suggested Readings*:

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. Watson J.D., Baker T., Bell S.P., Gann A., Levine M.S., Molecular Biology of The Gene. 7th ed. Pearson Education
4. Watson R.F. Molecular Biology. 5th ed. McGraw-Hill Education

** Please refer to latest editions available.*

Course Title: Recombinant DNA Technology			
Course code	LSC82DC00702	**Credit**	2
L+P+T	2+0+0	**Course duration**	One Semester
Semester	II	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core course (DBCC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Foundation course/Skill Based		
Methods of content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, group and individual self/laboratory-based assignments.		
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 objective: 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 content	
Unit 1: DNA/RNA extraction, purification and their analysis, Gene manipulation basic techniques, Nucleic acid modifying enzymes (viz. restriction enzymes, polymerase, reverse transcriptase, ligase, alkaline phosphatases, terminal transferase, polynucleotidekinase, S1Nuclease and DNAase nuclease), Vectors (viz. Plasmid, Cosmid, Phase, BAC, YAC, PAC, and shuttle vectors), Cloning methods (directional and gateway), Selection screening and analysis of recombinants, Construction of gene libraries, Polymerase chain reaction, Site directed mutagenesis, Vector engineering and codon optimization; protein expression in bacteria, yeast, insect cell, mammalian cell and plant cell; in vitro translation, cell free translation systems, microarray, FISH, in situ PCR, identifying and analysing mRNA, gene silencing, gene knockout in bacterial and eukaryotic system, CRISPR-Cas system, DNA-protein interaction assays, Protein-Protein Interaction Assays, Yeast two hybrid system.	Weightage 70% L=21
Unit 2: DNA sequencing: Maxam-Gilbert and Sanger-Nicolson, Pyrosequencing, Next Generation Sequencing (NGS), Genetic mutation analysis: Amplified Fragment Length Polymorphisms (AFLP) and Restriction Fragment Length Polymorphism (RFLP), SNPs, Protein sequencing methods, Application of RDT (viz. DNA Fingerprinting, diagnosis of genetic diseases, gene therapy, synthesis of Insulin and Hepatitis B vaccine and other advance vaccines, crop improvement, animal husbandry, industrial applications)	Weightage 30% L=9

Content Interaction Plan

Contact Hours	Topic
1-2	DNA/RNA extraction, purification and their analysis
3-5	Gene manipulation basic techniques, Nucleic acid modifying enzymes (viz. restriction enzymes, polymerase, reverse transcriptase, ligase, alkaline phosphatases, terminal transferase, polynucleotidekinase, S1Nuclease and DNAase nuclease),
6-8	Vectors (viz. Plasmid, Phase, Cosmid, Phagemid, BAC, YAC, PAC, and shuttle vectors),
9-11	Cloning methods (directional and gateway), Selection screening and analysis of recombinants, Construction of gene libraries, Polymerase chain reaction, Site directed mutagenesis.
12-13	Vector engineering and codon optimization
14-16	Protein expression in bacteria, yeast, insect cell, mammalian cell and plant cell; in vitro translation, cell free translation systems
17-19	microarray, FISH, in situ PCR, identifying and analysing mRNA, gene silencing, gene knockout in bacterial and eukaryotic system, CRISPR-Cas system
20-22	DNA-protein interaction assays, Protein-Protein Interaction Assays, Yeast two hybrid system.
23-25	DNA sequencing: Maxam-Gilbert and Sanger-Nicolson, Pyrosequencing, Next Generation Sequencing (NGS).
26-28	Genetic mutation analysis: Amplified Fragment Length Polymorphisms (AFLP) and Restriction Fragment Length Polymorphism (RFLP), Protein sequencing methods,
29-30	Application of RDT (viz. DNA Fingerprinting, diagnosis of genetic diseases, gene therapy, synthesis of Insulin and Hepatitis B vaccine other advance vaccines, crop improvement, animal husbandry, industrial applications).

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
7. Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA.

**** Please refer to latest editions available.***

Course Title: Enzymology			
Course Code	LSC82DC00802	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (if applicable)	Skill Based / Concept Based / Application oriented		
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 naturebut also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To understand difference between chemical catalysis and biocatalysis
- To get a knowledge of strategies adopted by enzymes to catalyze a reaction
- To analyze the progress curves of reactions that are catalyzed by enzymes
- To understand the control and regulation of enzyme activity
- To apply the knowledge to solve societal problems

Course Learning Outcomes: The students will be able to:

- Identify and classify chemical reactions to classify enzymes
- Understand kinetics and to analyze the data of enzyme kinetics
- Get knowledge of catalytic mechanisms and strategies that adapted by biocatalyst and further to elucidate structure and their evolution
- Understand the regulation and control of enzymatic activity and their mechanistic details
- Apply the knowledge of Enzymology in solving problems of the society like therapeutic uses of enzymes and their inhibitors, Industrial uses of enzymes etc.

Course Contents	
Unit 1: *Rate of Reaction, Activation energy, Catalysis and catalytic power,* Thermodynamics and Equilibrium *History of Enzymes and Enzyme commission*, Enzyme nomenclature and Classification Enzyme activity, Specific activity and Units; Factor affecting enzyme activity and catalysis, Effect of pH and temperature. Role of metal ions in enzyme catalysis Active site and its importance, Isozymes; Ribozymes; Zymogens; Abzymes Enzyme assays: Types, Continuous and discontinuous assays; Optimization of enzyme assays.	Weightage: 24%
Unit 2:	Weightage:

Kinetics: Significance; *Velocity Measurements, Progress Curves,* Rapid Equilibrium, Steady state; state, equilibrium kinetics, Michaelis and Menten Equation and its Lineweaver – Burk plot, *Hanes plot and Eadie–Hofstee plot* ficance of Km, Catalytic efficiency, and turnover number; Order of kinetics ient kinetics, flow techniques (continuous, stopped, quenched), Enzyme ition, Models and types of inhibition; Multi-substrate enzymes; Multisite and steric enzymes; Models and examples	27%
UNIT III: Basic Catalytic Mechanisms, 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	Weightage: 25%
UNIT IV: 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	Weightage: 24%

Content Interaction Plan:

Contact Hours	Topic
1-2	*Rate of Reaction, Activation energy, Catalysis and catalytic power,* Thermodynamics and Equilibrium
3-4	*History of Enzymes and Enzyme commission*, Enzyme nomenclature and Classification
5-6	Enzyme activity, Specific activity and Units; Factor affecting enzyme activity and catalysis, Effect of pH and temperature. Role of metal ions in enzyme catalysis Active site and its importance
7	Enzyme assays: Types, Continuous and discontinuous assays; Optimization of enzyme assays.
8-10	*Initial Velocity Measurements, Progress Curves*, Rapid Equilibrium, Steady state, pre-steady state, equilibrium kinetics, Michaelis and Menten Equation and its derivation, Lineweaver – Burk plot, *Hanes plot and Eadie–Hofstee plot*
11-12	Significance of Km, Catalytic efficiency, and turnover number; Order of kinetics, Transient kinetics, flow techniques (continuous, stopped, quenched)
13- 16	Enzyme Inhibition, Models and types of inhibition; multi-substrate enzymes; Multisite and allosteric enzymes; Models and examples
17 – 20	Basic Catalytic principles, catalytic strategies of enzymes – Chymotrypsin, Protease, carbonic anhydrase, lysozyme, Restriction enzymes
21- 24	Regulatory Strategies of allosteric enzymes-Aspartate transcarbamoylase, Kinases, Phosphatase, isozymes, proteolysis, Integration of kinetic, chemical and structural data to describe enzyme action

25 - 27	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
28 - 30	Enzymes used in biotransformation, drug synthesis, biosensors, Therapeutic enzymes, industrial enzymes

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.*

Course Title: Research Methodology			
Course Code	LSC82DC00904	Credits	4
L + T + P	4 + 0 + 0	Course Duration	One Semester
Semester	II	Contact Hours	60 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory and Hands-on training		
Special Nature/ Category of the Course (*if applicable*)	Research foundation course/Skill-based course		
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 presentations.		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative innature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives: The course aims to

- Acquaint the students with fundamental knowledge of Research methodology and methods in biology.
- It will provide an understanding of scientific terms, the scope of research, experimental design and interpretation of results, scientific communication, and ethics.
- Develops an understanding of the concept and importance of research, raising questions, planning methodology, documentation, and presentation.
- The biophysical methods and advanced methods will help students in learning the basic and new technologies.

Course Learning Outcomes: After completion of the course, the students shall have an understanding of:

- The students will be able to gather scientific information from reliable sources, formulate a scientific question, design a hypothesis, collect and discuss the results that answer the question, making effective scientific communication, along with the ethics and regulations related to the research.

Course Contents

Unit 1: Perspectives of scientific research, Experimental design and interpretation of results Science and technology, Importance of scientific research, Scientific aptitude and temper, skills for being a research scientist, Scientific question and social responsibility, Qualities of a good researcher, Changes faced in research, Contribution of Indian scientists in global research, Literature review, and analysis, Literature databases including hands-on assignments on literature search, Identification of relevant gap areas in the area of interest, generate a hypothesis, Research Plan, define objectives, Plan of Work, select methods to address the problem, Collect data, Sampling methods, evaluation of data, documentation and presentation of findings.	Weightage: 25%

Unit 2: Regulatory guidelines and Scientific writing, presentation, and publishing Ethical issues and guidelines related to research involving recombinant DNA technology, transgenic plants, genetically modified crops, use of small and large animals. Ethical issues related to the use of human - subjects, embryos, tissues, and stem cells - for research. Communication of results, Poster presentation, formal publication, Essentials of effective scientific writing; hands-on training on making posters, documenting formal research articles, Citations and indices; journal Impact factor, H-index, Journal Matrics, Ethics in scientific publishing, and Intellectual property rights.	Weightage: 25%
Unit 3: Methods in Biology Biological databases: Meta databases, Databases of DNA, Model organisms, Gene expression, Proteins, protein structure, and metabolic pathways. Introduction to Biophysical methods, Fluorescence, Intrinsic and extrinsic Fluorescence, Quenching, Circular Dichroism, Dynamic light scattering (DLS), Mass spectrometry and surface plasma resonance, applications of techniques in life sciences.	Weightage: 25%
Unit 4: Advanced Methods in Biology Artificial Intelligence (AI) in Life Science and Healthcare: Biological Intelligence Vs Artificial Intelligence, Basic concepts and terminology, Application of AI in: pharmaceutical industry, drug design, lead optimization and clinical trial, Biomarker discovery, precision medicine, health diagnostics, and Agriculture. Ethical concerns of AI in biology, Omics and its applications in Life Science.	Weightage: 25%

Content Interaction Plan

Contact Hours	Topic
1-7	Science and technology, Importance of scientific research, Scientific aptitude and temper, skills for being a research scientist, Scientific question and social responsibility, Qualities of a good researcher, Changes faced in research, Contribution of Indian scientists in global research, Literature review and analysis.
8-15	Literature databases including hands-on assignments on literature search, Identification of relevant gap areas in the area of interest, generate hypothesis, Research Plan, define objectives, Plan of Work, select methods to address the problem, Collect data, evaluation of data, documentation and presentation of findings.
16-22	Ethical issues and guidelines related to research involving recombinant DNA technology, transgenic plants, genetically modified crops, use of small and large animals. Ethical issues related to the use of human - subjects, embryos, tissues, and stem cells - for research.
23-30	Communication of results, Poster presentation, formal publication, Essentials of effective scientific writing; hands-on training on making posters, documenting formal research article, Citations and indices; journal Impact factor, H-index, Ethics in scientific publishing, and Intellectual property rights.
31-37	Biological databases: Meta databases, Databases of DNA, Sampling methods, Model organisms, Gene expression, Proteins, protein structure, and metabolic pathways.
38-45	Introduction to Biophysical methods, Fluorescence, Intrinsic and extrinsic

	Fluorescence, Quenching, Circular Dichroism, Dynamic light scattering (DLS), Mass spectrometry and surface plasma resonance, applications of techniques in life sciences.
41-52	Artificial Intelligence (AI) in Life Science and Healthcare: Biological Intelligence Vs Artificial Intelligence, Basic concepts and terminology,
53-60	Application of AI in: pharmaceutical industry, drug design, lead optimization and clinical trial, Biomarker discovery, precision medicine, health diagnostics, and Agriculture. Ethical concerns of AI in biology, Omics and its applications in Life Science.

Suggested Readings*:

- C R Kothari, Research Methodology, Methods and techniques
- Ronald B Corley, A guide to methods in biomedical sciences
- Principles and Techniques of Biochemistry and Molecular Biology 14 July 2010 by Wilson/Walker
- Russell and Norvig. 2020. Artificial Intelligence: A Modern Approach 3rd Edition
- Thomas Marshall, Tiffiany Champagne-Langabeer, Darla Castelli, Deanna Hoelscher 2017. Cognitive computing and eScience in health and life science research: artificial intelligence and obesity intervention programs Health Inf Sci Syst, Nov 1;5(1):13.
- Garay and Gray. 2012. Omics and therapy - a basis for precision medicine. Mol Oncology. Apr;6(2):128-39
- Frederick L Kiechle, Xinbo Zhang, Carol A Holland-Staley. 2004. The -omics era and its impact, Arch Pathol Lab Med. Dec;128(12):1337-45

**Refer to latest editions available.*

Course Title: Vocational training of Industrial applications			
Course Code	LSC82DC01003	**Credits**	3
L + T + P	0+0+3	**Course Duration**	One Semester
Semester	II	**Contact Hours**	0 (L) + 0 (T) + 90 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Laboratory Work		
Special Nature/ Category of the Course (*if applicable*)	Vocational/Skill Based		
Methods of Content Interaction	Protocol instruction by Lecture and Laboratory demonstration/hands-on training		
Assessment and Evaluation	30% - Continuous Internal Assessment 10% Internal Assessment by faculty member 20% - Record keeping + Bench skill 70% - End Term External Examination (University Examination) Overall Record Book Viva Activity performed in examination		

Course Objectives:

- To give an exposure of standard procedures of a recombinant DNA laboratory.
- To run enzyme assays and its data analyses.

Course Learning Outcomes: This course is to provide students with hands-on experience with tools and techniques used in the Life Science laboratory, with a focus on the production and downstream processing of recombinant proteins. This training will help students to develop the necessary skills required for placement in research laboratories and biotech industries.

Course Contents (include operon expression)	
Laboratory 1: Cloning and Expression of desired gene from a biological source *Protocol of RNA isolation and cDNA synthesis:* Material required for total RNA isolation Quality and Quantification of RNA Synthesis of complementary cDNA *Amplification of desired DNA segment from cDNA:* Primer designing Material required for Polymerase chain reaction Handling of enzymes Cleaning and maintenance of Thermocycler Preparing a polymerase chain reaction Design of Program in thermocycler Initiate the reaction in thermocycler *Verification of amplified product:* • Verification of amplification of the desired DNA fragment by agarose gel electrophoresis. Use of standard DNA length markers	Weightage: 33%

Purification of DNA fragment from agarose gel Ligation of PCR amplified DNA fragment in TA / blunt end cloning vector	
Laboratory 2: Expression of desired gene Prokaryotic System from a biological source *Transformation of E. coli by constructs:* Preparation of Competent *E. coli* cell Transformation of E. coli cells with construct Screening of transformed cells by colony PCR Purification of plasmid from positive colonies Release of insert by Double digestion from the purified constructs Double digestion from the purified expression vector Purification of digested insert and digested expression vector from agarose gel Ligation and transformation of Expression host by construct. Screening of colonies by colony PCR *Expression and Purification of Expressed Protein:* Induction of protein expression in transformed *E. coli* Verification of expression by SDS PAGE. Purification of Expressed protein by chromatography	Weightage: 33%
Laboratory 3: Enzyme Assays Extraction of Acid phosphatase enzyme from potato Ammonium Sulphate precipitation technique for enzyme purification Storage and Handling of enzymes Taking Control and blanks in Enzyme Assay Assessing the stability of an enzyme Measurement of initial velocity Acid phosphatase Effect of enzyme concentration on Acid phosphatase OR Determination of working dilution of Acid phosphatase Effect of substrate concentration on Acid phosphatase activity and data analysis. Effect of pH on Acid phosphatase activity Effect of temperature on Acid phosphatase activity Chymotrypsin / trypsin assay	Weightage: 33%

Content Interaction Plan

Contact Hours	Topic
30	**Laboratory 1: Cloning and Expression of desired gene from a biological source**
	Protocol of RNA isolation and cDNA synthesis: Material required for total RNA isolation Quality and Quantification of RNA Synthesis of complementary cDNA *Amplification of desired DNA segment from cDNA:* Primer designing Material required for Polymerase chain reaction Handling of enzymes Cleaning and maintenance of Thermocycler Preparing a polymerase chain reaction

	Design of Program in thermocycler Initiate the reaction in thermocycler *Verification of amplified product:* Verification of amplification of the desired DNA fragment by agarose gel electrophoresis. Use of standard DNA length markers Purification of DNA fragment from agarose gel *Vector Construct formation and Transformation of E. coli by constructs:* Ligation of PCR amplified DNA fragment in TA / blunt end cloning vector
30	**Laboratory 1: Cloning and Expression of desired gene from a biological source**
	Protocol of RNA isolation and cDNA synthesis: Material required for total RNA isolation Quality and Quantification of RNA Synthesis of complementary cDNA *Amplification of desired DNA segment from cDNA:* Primer designing Material required for Polymerase chain reaction Handling of enzymes Cleaning and maintenance of Thermocycler Preparing a polymerase chain reaction Design of Program in thermocycler Initiate the reaction in thermocycler *Verification of amplified product:* Verification of amplification of the desired DNA fragment by agarose gel electrophoresis. Use of standard DNA length markers Purification of DNA fragment from agarose gel *Vector Construct formation and Transformation of E. coli by constructs:* Ligation of PCR amplified DNA fragment in TA / blunt end cloning vector
61 - 90	**Laboratory 3: Enzyme Assays**
	Extraction of Acid phosphatase enzyme from potato Ammonium Sulphate precipitation technique for enzyme purification Storage and Handling of enzymes Taking Control and blanks in Enzyme Assay Assessing the stability of an enzyme Measurement of initial velocity Acid phosphatase Effect of enzyme concentration on Acid phosphatase OR Determination of working dilution of Acid phosphatase Effect of substrate concentration on Acid phosphatase activity and data analysis. Effect of pH on Acid phosphatase activity Effect of temperature on Acid phosphatase activity Chymotrypsin / trypsin assay

Suggested Readings*:

- Michael R Green and Joseph Sambrook et al. 2012 Molecular Cloning A LABORATORY MANUAL
- Enzyme Assays: A Practical Approach (Practical Approach Series, 257) 2nd Edition by Robert Eisenthal (Editor), Michael Danson (Editor) Oxford University Press.

**Refer to latest editions available.*

Discipline Based Core Courses (Third Semester)

Course Title: Physiology of Plant System			
Course Code	LSC91DC01103	**Credits**	3
L + T + P	2 + 0 + 1	**Course Duration**	One Semester
Semester	III	**Contact Hours**	30 (L) + 0 (T) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory and Practical		
Special Nature/ Category of the Course (*if applicable*)	Foundational course which is to be compulsorily studied by a student as a core requirement to complete the study at PG level.		
Methods of Content Interaction	Lecture, Feedback or hand note preparation, 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. Explain assimilation of different mineral nutrients in plants. Will be explaining the relations between secondary metabolites and plant defence. They will grasp the mechanisms of action light harvesting complex and also response of plant towards abiotic and biotic stress. Explain the plant hormones and their roles in plant development. Explain physiological responses produced by plants against environmental stresses.

Course Content

Unit 1: • **Transport and Translocation: Fundamentals** **Classical and quantitative method of taxonomy of plants,** nonvascular 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 legume-*Rhizobium* system: perception and signalling, nitrate and ammonium assimilation; amino acid biosynthesis.	Weightage :20% L=8
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=12
Unit-3	Weightage:25%

• **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.	L=4
Unit-4 • **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 signalling pathways, ABA as stress hormone • Responses of plants towards biotic factors: plant defence system, systemic plant defence responses	Weightage:20% L=6

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

	Responses of plants towards biotic factors: plant defence system, systemic plant defence responses
	List of Practical (Tentative) 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 Title: Physiology of Animal System			
Course Code	LSC91DC01203	**Credits**	3
L + T + P	2 + 0 + 1	**Course Duration**	One Semester
Semester	III	**Contact Hours**	30 (L) + 0 (T) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of Course	Theory & Practical		
Special Nature/ Category of the course *(if applicable)*	Fundamental as well as skill based		
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual research paper-based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in naturebut also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To understand basic physiological processes of life in 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.

Course Learning Outcomes: 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 forthe adaption of organisms.
- To perform hematological tests in the pathology or other laboratories.

Course Content	Weightage: 20% L=06
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 -** Anatomy of heart structure, myogenic heart, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.	

Unit 2: **Respiratory System** – Anatomy of respiratory system, Respiration in vertebrates, 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. Senses -Vision, hearing and balance, olfaction, taste, ouch and temperature. **Excretory System** - Physiology of excretion in vertebrates, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid- base balance.	Weightage: 40% L=12
Unit 3: **Digestive System** - Introduction to evolution of digestive system, digestion, absorption, neuronal and endocrine regulation of digestive processes, energy balance, BMR. **Thermoregulation** - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization, stress and adaptation. **Endocrinology and Reproduction** - Endocrine glands in vertebrates, basic mechanism of hormone action, hormones and diseases, reproductive processes, gametogenesis, ovulation, neuroendocrine regulation	Weightage: 40% L-12

Content Interaction Plan

Contact Hour	Topic
1 - 2	**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.
3 - 6	**Cardiovascular System** - 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.
7 - 10	**Respiratory System** – Respiration in vertebrates, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.
11 - 14	**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. Senses -Vision, hearing and balance, olfaction, taste, ouch and temperature.
13 - 17	**Excretory System** - Physiology of excretion in vertebrates, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance.
18 - 20	**Thermoregulation** - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization, stress and adaptation.
21 - 24	**Digestive System** – Introduction to evolution of digestive system, digestion, absorption, neuronal and endocrine regulation of digestive processes, energy balance, BMR.

25 - 30	**Endocrinology and Reproduction -** Endocrine glands in vertebrates, basic mechanism of hormone action, hormones and diseases, reproductive processes, gametogenesis, ovulation, neuroendocrine regulation.
P=30 Hours	**List of practical:** Introduction to the laboratory and Lab safety Do's & Don'ts. To count the total RBC in blood. 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. Virtual dissection. Observations on Endocrine Glands.

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.
5. **Martini H, Nath JL, Bartholomew EF**: Fundamentals of Anatomy Physiology. Pearson, 2017.

** Please refer to latest editions available.*

Course Title: Developmental Biology			
Course Code	LSC91DC01303	**Credits**	3
L + T + P	2+0+1	**Course Duration**	One Semester
Semester	III	**Contact Hours**	30 (L) + 0 (T) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory & Practical		
Special Nature/ Category of the Course (*if applicable*)	Fundamental course/Skill Based/Laboratory skills		
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)		

Course Objectives: The course aims to:

1. Acquaint the students with fundamental knowledge of developmental biology
2. Learn the basic concepts of animal and plant development,
3. Make the students aware of various modes of regeneration and therapeutic interventions to treat diseases.

Course Learning Outcomes: After completion of the course the students shall have an understanding of:

- It will enable students to capture the advantages of using different model organisms.
- The knowledge of the developmental process in detail will broaden the analysis of principles underlying morphogenesis in plants and animals.
- The application of studying developmental processes in health, diseases, and development of therapies.

Course Contents

Unit 1: Approaches to developmental biology Anatomical, genetic, evolutionary, mathematical modelling, and experimental approaches; Model organisms: *Dictyostelium, C. elegans, Chick, Xenopus, mouse, Arabidopsis;* 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	Weightage: 27%
Unit 2: Developmental process in animals 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 the vulva in *C. elegans*, induction of development of the compound eye in *xenopus*, development of tetrapod limbs, Hox Gene Specification of Limb Skeleton Identity, Environmental regulation of animal development	Weightage: 27%
Unit 3: Developmental process in plants	Weightage:

Gametophyte development and fertilization, embryogenesis, 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.	24%
Unit 4: Regeneration, Aging, Health and Disease Introduction to regeneration, Different ways to rebuild, Hydra: Stem Cell-Mediated Regeneration, Morphallaxis, and Epimorphosis, Stem Cell-Mediated Regeneration in Flatworms, Stem cells and aging, Teratogenesis, Cancer as a disease of development, developmental therapies for cancer.	Weightage: 22%

Content Interaction Plan

Contact Hours	Topic
1-5	Anatomical, genetic, evolutionary, mathematical modelling, and experimental approaches; Model organisms: *Dictyostelium, C. elegans, Chick, Xenopus, mouse, Arabidopsis;*
6-12	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
13-18	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 the vulva in *C. elegans*,
19-24	induction of development of the compound eye in *xenopus*, development of tetrapod limbs, Hox Gene Specification of Limb Skeleton Identity, Environmental regulation of animal development
25-30	Gametophyte development and fertilization, post-fertilization changes, organization of shoot and root apical meristem, shoot and root development; leaf development and phyllotaxy
30-35	transition to flowering, floral meristems and floral development in Arabidopsis and Rice.
36-40	Introduction to regeneration, Different ways to rebuild, Hydra: Stem Cell-Mediated Regeneration, Morphallaxis, and Epimorphosis, Stem Cell-Mediated Regeneration in Flatworms,
41-45	Stem cells and aging, Teratogenesis, Cancer as a disease of development, developmental therapies for cancer.
P=30 Hours	*List of practical* Study of *Xenopus* 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: Gilbert, S.F. 2000. Developmental Biology. Sixth edition. INC Publishers, USA. Westhoff, P. 1998. Molecular Plant Development: from gene to plant. The Bath Press, UK.	

L. 2001. Principles of Development. Second Edition. Oxford Univ. Press, UK.
G.N. (Ed.) 2005. Plant Architecture and its Manipulation, ARPN Rev. Vol.17, Blackwell Publ. CRC Press, USA.
Buchanan, B.B., Gruissem, W. and Jones, R.L. (Eds.) 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, USA.
Heldt, H.W. 2005. Plant Biochemistry. Third Edition. Academic Press, USA.
Hopkins, W.G. and Huner, N.P.A. 2004. Introduction to Plant Physiology. Third Edition. John Wiley, UK.
Taiz, L. and Zeiger, E. (Eds.) 2006. Plant Physiology. Fourth Edition. Sinauer Associates Inc. Publishers, USA.

James M Wells, Fiona M Watt. 2018. Diverse mechanisms for endogenous regeneration and repair in mammalian organs. Nature, May;557(7705):322-328. doi: 10.1038/s41586-018-0073-7
Halfon N, Forrest CB, Lerner RM, et al., editors. Cham (CH): Springer; 2018. Handbook of Life Course Health Development [Internet].
*Please refer to latest editions available.

Course Title: Biology of Immune system			
Course Code	LSC91DC01403	**Credits**	3
L + T + P	2 + 0 + 1	**Course Duration**	One Semester
Semester	III	**Contact Hours**	30 (L) + + 0 (T) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory and Practical		
Special Nature/ Category of the Course (if applicable)	Skill Based / Vocational Study		
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 naturebut also contributing to the final grades) 70% - End Term External Examination (University ation)		

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 Innate Immunity Introduction and Overview of the immune system. Origin ofimmunology and its evolution, Types of immunity-Innate and acquired, active and passive, humoral andcell mediated, Clonal selection theory Cells, Organs, and Microenvironments of the Immune System Recognition and Response Innate Immunity The Complement System	Weightage: 22%

Unit 2: Adaptive Immunity: **Antigen Receptors and MHC** The Organization and Expression of Lymphocyte Receptor Genes The Major Histocompatibility Complex and Antigen Presentation **Development** T-Cell Development B-Cell Development **Effector Responses** T-Cell Activation, Helper Subset Differentiation, and Memory B-Cell Activation, Differentiation, and Memory Generation Effector Responses: Antibody- and Cell-Mediated Immunity Barrier Immunity: The Immunology of Mucosa and Skin The Adaptive Immune Response in Space and Time	Weightage: 44%
Unit 3: Experimental Methods Antibody Generation Immunoprecipitation- and Agglutination-Based Techniques Antibody Assays Based on Molecules Bound to Solid-Phase Supports Antibody-Mediated Microscopic Visualization of Cells and Subcellular Structures Immunofluorescence-Based Imaging Techniques Flow Cytometry and Cell Sorting Cell Cycle Analysis Assays of Cell Death	Weightage: 11%
Unit 4: The Immune System in Health and Disease Allergy, Hypersensitivities, and Chronic Inflammation Tolerance, Autoimmunity, and Transplantation Infectious Diseases and Vaccines Immunodeficiency Diseases Cancer and the Immune System	Weightage: 23%

Content Interaction Plan

Contact Hours	Topic
1- 2	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
3 – 6	Cells, Organs, and Microenvironments of the Immune System
7 – 10	Recognition and Response Innate Immunity The Complement System
11 – 13	**Antigen Receptors and MHC** The Organization and Expression of Lymphocyte Receptor Genes The Major Histocompatibility Complex and Antigen Presentation

14 – 17	**Development** T-Cell Development B-Cell Development
18	**Effector Responses** T-Cell Activation, Helper Subset Differentiation, and Memory
19 – 20	B-Cell Activation, Differentiation, and Memory Generation
21 – 24	Effector Responses: Antibody- and Cell-Mediated Immunity Barrier Immunity: The Immunology of Mucosa and Skin The Adaptive Immune Response in Space and Time
24 – 26	**Experimental Methods** Antibody Generation Immunoprecipitation- and Agglutination-Based Techniques Antibody Assays Based on Molecules Bound to Solid-Phase Supports Antibody-Mediated Microscopic Visualization of Cells and Subcellular Structures Immunofluorescence-Based Imaging Techniques Flow Cytometry and Cell Sorting Cell Cycle Analysis Assays of Cell Death
27 – 30	**The Immune System in Health and Disease** Allergy, Hypersensitivities, and Chronic Inflammation Tolerance, Autoimmunity, and Transplantation Infectious Diseases and Vaccines Immunodeficiency Diseases Cancer and the Immune System
P=30 Hours	*List of Practical* 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

**latest editions of the textbooks should be referred*

Discipline Based Core Courses (Fourth Semester)

Course Title: Dissertation			
Course code	LSC92DC01520	**Credit**	20
L+T+P	0+0+20	**Course duration**	One Semester
Semester	IV	**Contact Hours**	0 (L)+ 0 (T) + 600 (P) Hours
Course Type	Discipline Based Core Courses (DBCC)		
Nature of the Course	Research work		
Special Nature/ Category of the Course (*if applicable*)	Project-work/Laboratory-work/Hands-on learning/Skill Development/Entrepreneurship		
Methods of Interaction	One to one interaction, presentation, lab work and field work		
Assessment and Evaluation	70% Dissertation report evaluated by the Dissertation supervisor (internal and external both) 30% Power Point Presentation of the dissertation research work evaluated jointly by Departmental Committee or special evaluation committee constituted by the HoD		

Course objectives:

- To develop analytical, critical thinking, problem-solving, and decision-making skills
- To acquire and develop autonomous skills
- To develop scientific communication and public speaking skills
- To develop abilities to independently learn new knowledge and methods
- To learn scientific writing skills.

Learning outcomes: Upon successful completion of this course, the students will be able to grasp the fundamental concepts and requirements of laboratory-oriented work which is essential to becoming a professional researcher. The student will be equipped with laboratory basics and various techniques that enable them to either enter a Life Science related industry or pursue higher studies.

Course Content: Any potential research problem relevant to local/national/international needs.

Elective Baskets

Elective Basket – I (Discipline Based Core Elective)

Course Title: Ecology and Evolution			
Course code	LSC82DE01602 LSC91DE01602	**Credit**	2
L+T+P	2+0+0	**Course duration**	One Semester
Semester	II/III	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory & Field Work		
Special Nature/ Category of the Course (*if applicable*)	Environment related course		
Methods of content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students.		
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 develop understanding of ecological relationships between organisms and their environment.
- To give detailed outline of biological diversity, threat to biodiversity, and impact of environmental pollution.
- To provide an overview of concept of molecular evolution.
- To provide glimpse of Phylogenetic Trees and highlight their construction along with interpretation
- To give detailed explanation of key concepts of Population Genetics in terms of Hardy-Weinberg Law, Genetic Drift, Natural Selection, Adaption and Speciation.

Learning outcomes: Upon successful completion of this course, the students will have a deepened knowledge of the fundamental concepts of ecology and evolutionary biology, which will help them acquire a better understanding of the subject.

Course content

	Weightage 40%
Unit 1: Introduction to ecology-Aim and scope of Ecology. Environmental concept-Physical environment; biotic environment; biotic and abiotic interaction. Autecology and population concept- characteristics of population, population size and exponential growth, population dynamics, fertility rate and age structure, limits of population growth. Competition and coexistence, intra-specific interactions, interspecific interactions, mutualism and commensalism, Concepts of community and continuum; community coefficients, interspecific associations, ordination; ecological niche; species diversity (α, β, γ). Ecological succession: Models	

and mechanisms of ecological succession; changes in ecosystem properties during succession. Ecosystem organization: Structure and functions, primary production, energy dynamics.	
Unit 2: Biological diversity: Concept and levels; distribution and global patterns; terrestrial biodiversity hot spots; role of biodiversity in ecosystem functions; IUCN categories of threat; inventory; conservation, protected area network. Global change: Greenhouse gases, consequences of climate change. Molecular evolution (neutral theory, punctuated equilibrium); Molecular clock; Molecular evolution and Phylogenetic tree: Development of Phylogenetic tree; Amino acid sequence and phylogeny; DNA-based phylogenetic trees; Nucleotide sequence comparison and homologies; Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift	Weightage 60%

Content Interaction Plan

Contact Hours	Topic
1-2	Introduction to ecology-Aim and scope of Ecology, Environmental concept-Physical environment; biotic environment; biotic and abiotic interaction
3-4	Autecology and population concept- characteristics of population, population size and exponential growth
5-6	Population dynamics, fertility rate and age structure, limits of population growth, Competition and coexistence, intra-specific interactions, interspecific interactions, mutualism and **commensalism**.
7-8	ncepts of community and continuum; community coefficients, interspecific associations, ordination; ecological niche; species diversity (α, β, γ).
9-10	Ecological succession: Models and mechanisms of ecological succession; changes in ecosystem properties during succession.
11-12	Ecosystem organization: Structure and functions, primary production, energy dynamics
13-14	Biological diversity: Concept and levels; distribution and global patterns; terrestrial biodiversity hot spots; role of biodiversity in ecosystem functions
15-18	IUCN categories of threat; inventory; conservation, protected area network. Global change: Greenhouse gases, consequences of climate change
19-20	Molecular evolution (neutral theory, punctuated equilibrium); Molecular clock.
21-25	Molecular evolution and Phylogenetic tree: Development of Phylogenetic tree; Amino acid sequence and phylogeny; DNA-based phylogenetic trees; Nucleotide sequence comparison and homologies.
26-28	Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration

	and random genetic drift; Adaptive radiation
29-30	Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution;

Suggested Readings*:

Fundamentals of Ecology, EP Odum (2017), Natraj Publishers, Dehradun
A Text Book of Plant Ecology, RS Ambasht (1990), Students Friends Publishers, Varanasi
A Textbook on Ecology & Environmental Science, PP Mahendran, P Rajan (2008), Agrotech Publishing Academy
Ecology, M Begon, JL Harper, CR Townsend (1996), Blackwell Science, Cambridge, USA.
Ecology and Environment, PD Sharma (2020), Rastogi Publications, Meerut

Please refer to latest editions available

Course Title: Cellular Stress Biology			
Course code	LSC91DE01702	**Credit**	2
L+T+P	2+0+0	**Course duration**	One Semester
Semester	III	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory & Field Work		
Special Nature/ Category of the Course (*if applicable*)	Fundamental/Skill based		
Methods of content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students.		
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 students with all aspects of stress and develop an understanding of stress research and scientific studies in general
- To enable the students to appreciate both, the evolutionary conserved aspects of cell stress responses (e.g. heat shock proteins and chaperones) and individual signaling pathways and molecules controlling the action of specific stress stimuli.

Course 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
- Get acquainted with techniques of analyzing effects of stress and response towards them
- Explain various mechanisms of cell survival and cell death

Course Contents

Unit 1: Stress mediated Signaling Cascades Introduction to the concept of stress and stimulus perception Signaling cascade active during osmotic stress, hypoxia, salinity Temperature sensing through DNA, RNA thermometers and proteins; membrane modulations in perception and mitigation of temperature stress Reactive Oxygen Species in Stress Perception – detection and mitigation Iron – the universal stress determinant, production of siderophore as a stress adaptation Designing of experiments to study stress responses	Weightage: 50%
Unit 2: Cellular Stress Responses – Adaptations and Cell Death DNA Damage Response, Unfolded Protein Response – mitochondrial and endoplamic reticulum based UPR, Heat Shock Response; Linking cellular stress to systemic homeostasis Accidental and Programmed Cell Death: Apoptosis, Ferroptosis, Autophagy, MPT – driven necrosis, Necroptosis, , Pyroptosis, Parthanatos, Entotic cell death, Immunogenic Cell death, Cellular Senescence, phytaspase induced	Weightage: 50%

programmed cell death in plants Implications of cell death in human diseases Assays for analysis of stress responses in microbes, plants, cell lines and animal models; result interpretation	

Content Interaction Plan

Contact Hours	Topic
1	Introduction to the concept of stress and stimulus perception
2	Signaling cascade active during osmotic stress
3-4	Signaling cascade active during hypoxia, salinity
5 – 6	Temperature sensing through DNA, RNA thermometers and proteins
7	Membrane modulations in perception and mitigation of temperature stress
8-10	Reactive Oxygen Species in Stress Perception – detection and mitigation
11-12	Iron – the universal stress determinant, production of siderophore as a stress adaptation
13-14	Designing experiments to study stress responses
15	DNA Damage Response, Unfolded Protein Response – mitochondrial and endoplamic reticulum based UPR
16	Heat Shock Response, Linking cellular stress to systemic homeostasis
17-18	Apoptosis
19	Ferroptosis
20	Autophagy
21-22	MPT – driven necrosis, Necroptosis, , Pyroptosis, Parthanatos, Entotic cell death, Immunogenic Cell death
23	Cellular Senescence, phytaspase induced programmed cell death in plants
24-25	Implications of cell death in human diseases
26	Assays for analysis of stress responses in microbes
27	Assays for analysis of stress responses in plants
28	Assays for analysis of stress responses in cell lines
29	Assays for analysis of stress responses in animal models
30	Interpretation of experimental results

Suggested Readings*:

Prescott, Harlay and Klein: Microbiology, 7th ed. New York : McGraw-Hill Higher Education

Madigan, Martinko and Parker: Brock Biology of Micro-organism, 11th ed, Pearson

Lodish, H., Berk, A., Zipursky, S.L., Matsudaria, P., Baltimore, D. and Darnell, J. (Eds). Molecular Cell Biology. 9th ed. Freeman & Co., USA.

Karp, J.G. Cell and Molecular Biology. 9th ed. John Wiley & Sons, USA.

Taiz, L. and Zeiger, E. (Eds.) 2006. Plant Physiology. 5th ed. Sinauer Associates Inc. Publishers, USA.

**Please refer to latest editions available*

Course Title: Molecular Plant Pathology			
Course code	LSC82DE01802	**Credit**	2
L-T-P	2+0+0	**Course duration**	One Semester
Semester	II	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Skill based		
Methods of content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, group and individual self/laboratory-based assignments.		
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 objective: The goal is to develop the critical and analytical skills of students to understand scientific developments in the field of molecular plant pathology. The course will focus on basic concepts of plant-pathogen interactions and research approaches required for addressing open questions in plant pathology.

Learning outcomes: It is expected that at the end of the course the student will be able to gain the knowledge necessary to understand, plan, and carry out research in molecular plant pathology.

Course content

Unit 1: An overview of nature of pathogens and pests, pathogen penetration, establishment, colonization in host, genetic and molecular basis for disease resistance, Flor's hypothesis, Koch postulates. Preformed plant defences, induced host defences, biochemical and physiological responses, host-pathogen interaction mechanisms, hypersensitive cell death, Physiology and biochemistry of plant disease, role of cell wall in plant defense, Molecular determinants of pathogenicity, effectors, elicitors, defensins, phytoalexins, common phenolics, plant cell wall degrading enzymes, host specific toxins, host nonspecific toxins. Plant disease resistance, classes of resistance genes, adapted host resistance, nonadapted host resistance, Systemic acquired resistance, Induce Systemic acquired resistance, Pathogenesis-related (PR)-proteins.	Weightage 65%
Unit 2: Genetic engineering approach to develop disease resistance in plants: Pathogen-Derived Resistance and RNAi, modifying susceptibility genes to attenuate pathogenicity, enriching the known repertoire of immune receptors, deploying resistance genes for broad-spectrum resistance, Genome editing	Weightage 35%

tools for disease resistance: Zinc Finger Nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs), Oligonucleotide-Directed Mutagenesis (ODM), CRISPR-Cas9, CRISPR/Cpf1; DNA-free genome editing systems.	

Content Interaction Plan

Contact Hours	Topic
1-2	An overview of nature of pathogens and pests, pathogen penetration, establishment, colonization in host
3-4	Genetic and molecular basis for disease resistance, Flor's hypothesis, Koch postulates
5-9	Preformed plant defences, induced host defences, biochemical and physiological responses, host-pathogen interaction mechanisms, hypersensitive cell death, Physiology and biochemistry of plant disease, role of cell wall in plant defence.
10-15	Molecular determinants of pathogenicity, effectors, elicitors, defensins, phytoalexins, common phenolics, plant cell wall degrading enzymes, host specific toxins, host nonspecific toxins
16-20	Plant disease resistance, classes of resistance genes, adapted host resistance, Nonadapted host resistance, Systemic acquired resistance, Induce Systemic acquired resistance, Pathogenesis-related (PR)-proteins.
21-22	Genetic engineering approach to develop disease resistance in plants: Pathogen-Derived Resistance and RNAi
23-26	Modifying susceptibility genes to attenuate pathogenicity, Enriching the known repertoire of immune receptors, deploying resistance genes for broad-spectrum and durable resistance
27-30	Genome editing tools for disease resistance: Zinc Finger Nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs), Oligonucleotide-Directed Mutagenesis (ODM), CRISPR-Cas9, CRISPR/Cpf1, DNA-free genome editing systems.

Suggested Readings*:

Plant Pathology, T.N. Agrios, Academic Press, 2001
Introduction to Plant Pathology, Richard N Strange, 2003, Springer publication
Host Pathogen Interactions, Lucas, 2001, Blackwell publication
Annual Review of Phytopathology (Journal)
Annual Review of Plant Biology (Journal)
Current Opinion in Plant Biology (Journal)
Other subject related Reviews
**Please refer to latest editions available*

Course Title: Human Genetics and Genome Analysis			
Course Code	LSC91DE01902	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory		
Special Nature/ Category of the Course *(if applicable)*	Fundamental/Skill Based		
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 E n d Term Examination		

Course Objectives:

- To introduce the concept of inheritance as it occurs in human beings including the field of genetics concerned with structural and functional studies of the genome.
- To provide a comprehensive understanding of genome study and its practical applications.

Learning Outcomes:

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

- Apply Hardy – Weinberg law for calculating allelic and genetic variation.
- Identify unique and signature components of human genome
- Understand the mechanism and role of epigenetic modifications in creating variations
- Explain the method of genome mapping
- Appreciate the medical and forensic applications of knowledge of human genetics

Course Contents

Unit 1: ***Genome Organization***, size and banding, rRNA, mRNA and snRNA coding genes, unique and repetitive DNA, interrupted genes, overlapping and truncated genes ***Epigenetics***: mode of genome alterations and its implications **Pedigree Analysis** – Application of Mendelian Genetics for prediction of traits ***Genetic variations in population*** Application of Hardy – Weinberg law to human population, concepts and calculation of rate of change in allele and gene frequencies, fitness and selection DNA sequencing – short and long read, comparison with Sanger sequencing; bio chips, DNA micro arrays	Weightage: 47 %
Unit 2: Gene annotation, gene structure predictions, gene ontology consortium recommendations, structural and functional genomics	Weightage: 53%

Human genome project; mapping strategies, current status of various maps; human genome diversity ***Genome India Project*** Disease diagnosis, ***Gene Therapy*** and Genome editing, germ line gene therapy and somatic gene therapy, Stem-Cell-Based Gene Therapy, RNA Therapy, ***Personalized medicine***: pharmacogenomics ***DNA Forensics*** – profiling methods based on VNTR, autosomal STR, Y chromosome, mitochondrial DNA, SNPs	

Content Interaction Plan

Contact Hours	Topic
1 – 2	***Organization***, size and banding, rRNA, mRNA and snRNA coding genes, unique and repetitive DNA, interrupted genes, overlapping and truncated genes
3 – 4	***Epigenetics***: mode of genome alterations and its implications
5 – 6	**Pedigree Analysis** - Applying Mendelian Genetics for prediction of traits
7 – 9	***Genetic variations in population:*** Application of Hardy – Weinberg law to human population, concepts and calculation of rate of change in allele and gene frequencies
10 - 11	Fitness and selection
12	DNA sequencing – short and long read
13	Comparison with Sanger sequencing
14	Bio-chips, DNA micro arrays
15-17	Gene annotation, gene structure predictions
18	Gene ontology consortium recommendations
19 – 22	Structural and functional genomics
23 – 24	***Human genome project***; mapping strategies, current status of various maps; human genome diversity, ***Genome India Project***
25-26	Disease diagnosis, ***Gene Therapy*** and Genome editing, germ line gene therapy and somatic gene therapy
27	Stem-Cell-Based Gene Therapy, RNA Therapy
28	***Personalized medicine***
29-30	***DNA Forensics*** – profiling methods based on VNTR, autosomal STR, Y chromosome, mitochondrial DNA, SNPs

Suggested Readings*:

Snustad D.P., Simmons M.J. 2015. Principles of Genetics. 7th ed. John Wiley & Sons
Pierce B. 2019. Genetics – A conceptual approach 7th edW. H. Freeman and Company
Klug W.S., Cummings M.R., Spencer C.A., Palladino M.A. 2019. Concepts of Genetics12th ed Pearson

**Please refer to latest editions available*

Course Title: Fundamentals of Cancer Biology			
Course Code	LSC82DE02002	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	24 (L) + 6 (T) + 0 (P) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Special Nature of the Course	Fundamental/Skill based		
Methods of Content Interaction	Lecture, Tutorials, Group discussion; video comments, self-study, seminar, presentations by students, individual and group drills, group and Self-assignments.		
Assessment and Evaluation	30% - Continuous Internal Assessment (Formative in naturebut also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objective: The course objective to provide the students brief overview about cancer biology, prognosis, and possible prevention strategy. They learn molecular and cellular events associated with cancer cells growth, proliferation, and death. Students may understand advance techniques of cancer prevention using different model.

Course Learning Outcome: The course would help the students to understand cancer biology, advance cellular, molecular and imaging techniques that beneficial them for choosing PhD in cancer or other human disease.

Course Contents

Unit 1: Introduction of cancer: overview of cancer, types of cancer and tumor formation, prognosis, and possible available treatment strategy. Proto-oncogenes: introduction, role in cancer cells growth and proliferation; factors responsible for changed protooncogenes as a cancer-causing agent. Microenvironment: introduction, components, regulated growth and development of cancer. Growth and proliferation; factors responsible for growth and proliferation of cancer cells such as transcriptional factors, E2F1& retinoblastoma (Rb), and signaling molecules. Genome integrity: introduction, mechanism of cancer cells genome modification through methylation and acetylation. Cell cycle and apoptosis: introduction, mechanism of cancer cell cycle progression mediated by cyclins, cyclin dependent kinases (cdks), and tumor suppressor proteins; mechanism of apoptosis, types of apoptosis in cancer cells.	Weightage:40% L=10

Unit 2: Cancer metabolism: introduction, functional characterization of genes, transcriptional factors, involved in cancer research using gene knockdown and imaging techniques. Cancer genes knock down through RNA interference (RNAi) by siRNA, shRNA, microRNA and CRISPR -Cas9 techniques. Localization and characterization of cancer genes by confocal and fluorescent techniques. Signaling cascade in cancer: introduction, proteins involve in cancer cells signaling for instance, serine/threonine kinases (e.g., Raf and Akt), lipid kinases (e.g., phosphoinositide 3-kinases, PI3Ks), stress signaling pathways involves in cancer cells for examples, P38MAPK. Cancer model: introduction, cell lines, xenograft, transgenic mice model for cancer studies; brief overview of transgenic and nude mice and its important in cancer research program. Success stories of cancer therapeutics	Weightage:60% L=14

Content Interaction Plan

Contact Hours	Topic
1-2	Introduction of cancer – overview, type of cancer, tumor formation and available cancer treatment options.
3-4	Introduction proto-oncogenes: introduction, possible role in changing normal cells to cancer cells.
5-6	Microenvironment: introduction, components, regulated growth and development of cancer.
7-8	Cancer cells growth & proliferation: factors responsible for growth and proliferation of cancer cells such as E2F1, pRb and signaling molecules
9-10	Genome integrity: epigenetic modification of genome in cancer
10-12	Cell cycle and apoptosis: introduction, cell cycle and apoptosis in cancer cells
13-18	Cancer metabolism: introduction, functional characterization of genes/transcriptional factors involved in cancer. Discussion gene knock-down techniques using RNAi and CRISPR-Cas9 techniques. Brief overview of protein localization in cancer cells using fluorescent tag labelling and imaging
19-21	Signaling cascade in Cancer: introduction and overview of various type of signaling pathway involved in cancer cells.
22-24	Cancer model: Brief introduction of cell lines, xenograft, and transgenic model of cancer biology and its relevance.
6 Hours	Tutorials

Readings*:

Weinberg: The biology of Cancer second edition.
GS Garland Science, Taylor & Francis Group.

Arthur Schulz: Molecular biology of human cancers, An advanced student's
Springer.

Siddhartha Mukherjee: The Emperor of All Maladies: A Biography of Cancer, textbook,
Scribner.

**Please refer to latest editions available*

Course Title: Biochemistry of Proteins			
Course Code	LSC82DE02102	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Fundamental/Skill based		
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 naturebut 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.

Course Content

Unit 1: 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, Protein unfolding: physical and chemical methods ~~of unfolding~~, Interaction of	Weightage: 51%

with other molecules, Methods to study protein-protein interactions, *supramolecular structures, cooperativity, Network motif.*	
Biosynthesis of proteins, some selective Post-translational modifications polypeptides, Secretoryproteins and import of proteins into other organelles, Nuclear transport of proteins by importins andexportins, *Markers and inhibitors*, methods to study localization and co-localization Protein misfolding, Protein degradation by different pathways in cell and extracellular fluids, defects of protein degradation pathways.	Weightage: 49%

Content Interaction Plan

Contact Hours	Topic
1-09 (09)	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,
10 - 16 (07)	Chemical and physical methods of unfolding, Interaction of proteins with othermolecules, Methods to study protein-protein interactions, *supramolecular complexes* *cooperativity, Network motif.*
17- 26 (10)	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, *Markers and inhibitors* methods to study localization and co- localization
27 - 30 (04)	Protein misfolding, Protein degradation by different pathways in cell and extracellular fluids, defects of protein degradation pathways.

Suggested Readings*:

T.E. Creighton: Protein
Voet & Voet: Biochemistry
Scope: Protein Purification
Tanford: Nature's Robot
Garrett & Grisham: Biochemistry
An Introduction to Systems Biology by Uri Alon
Subject related Reviews
**Please refer to latest editions available*

Course Title: Biochemistry of Proteins			
Course Code	LSC82DE02102	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Fundamental/Skill based		
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 naturebut 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.

Course Content

Unit 1: 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, Protein unfolding: physical and chemical methods ~~of unfolding~~, Interaction of	Weightage: 51%

proteins with other molecules, Methods to study protein-protein interactions, *supramolecular structures, cooperativity, Network motif.*	
Unit 2: Biosynthesis of proteins, some selective Post-translational modifications of polypeptides, Secretoryproteins and import of proteins into other organelles, Nuclear transport of proteins by importins andexportins, *Markers and inhibitors*, methods to study localization and co-localization Protein misfolding, Protein degradation by different pathways in cell and extracellular fluids, defects of protein degradation pathways.	Weightage: 49%

Content Interaction Plan

Contact Hours	Topic
1-09 (09)	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,
10 - 16 (07)	Chemical and physical methods of unfolding, Interaction of proteins with othermolecules, Methods to study protein-protein interactions, *supramolecular complexes* *cooperativity, Network motif.*
17- 26 (10)	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, *Markers and inhibitors* methods to study localization and co- localization
27 - 30 (04)	Protein misfolding, Protein degradation by different pathways in cell and extracellular fluids, defects of protein degradation pathways.

Suggested Readings*:

T.E. Creighton: Protein
Voet & Voet: Biochemistry
Scope: Protein Purification
Tanford: Nature's Robot
Garrett & Grisham: Biochemistry
An Introduction to Systems Biology by Uri Alon
Subject related Reviews
**Please refer to latest editions available*

Course Title: Protein Structural Biology			
Course Code	LSC82DE02202 LSC91DE02202	**Credits**	2
L + T + P	2+0+0	**Course Duration**	One Semester
Semester	II/III	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hours
Course Type	Department-Based Core Elective		
Nature of the Course	Theory & Hands-on training course		
Special Nature/ Category of the Course (*if applicable*)	Skill Based/Computational Skill enhancement/*in-silico* methods hands-on training		
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)		

Course Objectives: The course aims to

- Acquaint the students with fundamental knowledge about structural biology.
- 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 emphasizing protein structure-function relationship.
- Gain insights into the field of X-ray crystallography from making the protein to structure solution.

Course Learning Outcomes: After completion of the course the students shall have understanding of:

- The students will learn fundamental techniques for structure prediction and determination like computational methods, 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.
- Using the computational tools for preliminary analysis of proteins
- Applications of structural details of macromolecules in drug synthesis through Structure guided drug design.

Course Contents

Unit 1: Protein sequences, sequence alignment; Basic polypeptide stereochemistry, hierarchy in protein folds, Structural classification of proteins, Structure-function relationship of proteins, 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, Electron microscopy- Sample preparation (Negative stain, cryo-EM), Types of samples, Advantages and	Weightage: 50%, 15 Lectures

advantages of various methods, Databases: SCOP, CATH and PDB database.	
Unit 2: 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, 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, 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	**Weightage: 50%, 15 Lectures**

Content Interaction Plan

Contact Hours	Topic
1-5	Protein sequences, sequence alignment; Basic polypeptide stereochemistry, hierarchy in protein folds, Structural classification of proteins, Structure-function relationship of proteins, Protein structure determination by computational methods, Homology/comparative modeling
6-10	Fold recognition (threading), Ab initio (de novo, new folds) methods; protein structure determination by experimental methods, X-ray crystallography, NMR spectroscopy
11-15	Electron microscopy- Sample preparation (Negative stain, cryo-EM), Types of samples, Advantages and disadvantages of various methods, Databases: SCOP, CATH and PDB database.
16-20	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, Symmetry and unit cells
21-25	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
26-30	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

Suggested Readings*:

Alexander McPherson; Introduction to Macromolecular Crystallography, 2nd Edition
Bernhard Rupp; Biomolecular Crystallography: Principles, Practice, and Application to Structural Biology
Branden and Tooze; Introduction to protein structure
Cedric Notredame and Jean-Michel Claverie; Bioinformatics for Dummies
Gale Rhodes, Crystallography Made Crystal Clear (Third Edition).

James Keeler; Understanding NMR spectroscopy. John wiley & sons, England. ISBN: 978-0-470-74609-7

U. Valdre (Editor), Peter W Hawks (Editor): Biophysical electron microscopy: Basic concepts and modern techniques

Joachim Frank: Three-dimensional electron microscopy of Macromolecular assemblies

Reviews: M H Stowell 1, A Miyazawa, N Unwin. 1998. Macromolecular structure determination by electron microscopy: new advances and recent results. Curr Opin Struct Biol 8, 595-600

Links: Bernhard Rupp's Interactive Crystallography Course

**Please refer to latest editions available*

Course Title: Plant Genetic Engineering			
Course Code	LSC82DE02302 LSC91DE02302	**Credits**	2
L + T + P	2 + 0+ 0	**Course Duration**	One Semester
Semester	II/III	**Contact Hours**	30 (L) + 0 (T) + 0(P) Hours
Course Type	Department Based Core Elective (DBCE)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Elective foundational course, aimed to expand the understanding in a specific area, emerged from the foundational knowledge.		
Methods of Content Interaction	Lecture, Feedback or hand note preparation, 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 Objective: 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.

Course Learning Outcome: 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 1: 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. 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:60% L=20
Unit 2: 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. Application of plant transformation for productivity and performance	Weightage:40% L=10

Control of plant pests and pathogens by genetic engineering: insect, nematodes, virus, bacteria and fungus resistant plants, Ethical Issues related to GMO.	

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.
19-20	Transgenic plants *Agrobacterium* mediated DNA transformation, Chloroplast transformation, mutant approach, wild relatives approach, contrasting genotypes approach etc.
21-23	Production of novel plant genotypes with improved tolerance towards abiotic stresses: success of plant breeding vs modern genetic modifications
24-25	Rising of stress tolerant genotypes through genetic engineering.
26-28	Application of plant transformation for productivity and performance
29-30	Control of plant pests and pathogens by genetic engineering: insect, nematodes, virus, bacteria and fungus resistant plants, Ethical Issues related to GMO.

Suggested Readings*:

George Acquaah: Principle of Plant Genetics and Breeding; Willy-Blackwell

Maarten J. Chrispeels and David E. Sadava: Plants, Genes and Crop Biotechnology; American Society of Plant Biologists.

H.S. Chawla: Introduction of Plant Biotechnology; Oxford and IBH Publishing

M.K. Razdan: Introduction of Plant Tissue Culture; Science publishers

**Please refer to latest editions available*

Course Title: Forms and Functions in Birds			
Course Code	LSC82DE02402 LSC91DE02402	**Credits**	2
L + T + P	2+0+0	**Course Duration**	One Semester
Semester	II/III	**Contact Hours**	24 (L)+6(T)+0(P) Hours
Course Type	Department Based Core Elective (DBCE)		
Nature of the Course	Theory & Field work		
Special Nature/ Category of the Course (*if applicable*)	Skill Based/Biodiversity & Conservation/Indian Knowledge System (IKS)		
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)		

Course Objectives:

- To acquaint the students with fundamental knowledge about birds, and their importance to the ecosystem and modern science.
- To create a pool of trained human resource to take up high end research on birds in India subcontinent.

Course Learning Outcomes: After completion of the course the students shall have understanding of:

- Birds and their importance to the ecosystem.
- Birds in Indian culture and Indian Knowledge System.
- The importance of birds as an experimental model in modern science.
- The bird taxonomy, morphology, physiology and adaptive strategies.
- Bird identification and conservation of birds.

Course Contents

Unit 1: Comparative account of birds & reptiles with respect to origin of birds, Hypotheses on avian origin, Evolution of flight in birds, Knowledge and importance of birds in Indian culture – Past and present scenario. Bird diversity, distribution and conservation. Body plan in birds, feather morphology, Moults and plumage, Feather maintenance & oil gland, Avian flight: forms, mechanisms, & energetics. Avian anatomy – Skeletal system, Muscular system: pelvic and wing musculature, Respiratory system and mechanism, Circulatory system, Digestive system, Urogenital system, Functional structure & adaptations in avian sperms and eggs.	Weightage: 70 %

Different senses & nervous system in birds, Cognition & intelligence in birds, Echolocation in birds, Thermoregulation in birds, Vocalization in birds. Unique functional adaptations in birds: temperature regulation of mound-nests in megapodes, salt excretion in seabirds, milk secretion in pigeons, torpor in nightjars, saliva-nests of swifts.	
Unit 2: The pineal gland & melatonin, Circadian rhythms and photoperiodism in birds, Hormonal regulation of songs in birds. Functional roles of Gonadotropins, thyrotropins, & growth hormones, Functions of parathyroids, calcitonin, & vitamin D, Hormonal responses of birds to environmental and physiological stress. Unique adaptations to their environment: beaks (bills), feet, and plumage (feathers). Temperature regulation of mound-nests in megapodes, salt excretion in seabirds, milk secretion in pigeons, torpor in nightjars, saliva-nests of swifts.	Weightage: 30 %

Content Interaction Plan

Contact Hours	Topics
1-3	Evolution of birds, Birds in Indian culture
	Bird diversity and classification
	Distribution and conservation of birds
4-21	Body plan in birds, feather morphology, Moults and plumage, Feather maintenance & oil gland, Avian flight: forms, mechanisms, & energetics.
	Avian anatomy – Skeletal system, Muscular system: pelvic and wing musculature, Respiratory system and mechanism, Circulatory system, Digestive system, Urogenital system, Functional structure & adaptations in avian sperms and eggs.
	Different senses & nervous system in birds, Cognition & intelligence in birds, Echolocation in birds, Thermoregulation in birds, Vocalization in birds.
	Unique functional adaptations in birds: temperature regulation of mound-nests in megapodes, salt excretion in seabirds, milk secretion in pigeons, torpor in nightjars, saliva-nests of swifts.
22-27	The pineal gland & melatonin, Circadian rhythms and photoperiodism in birds, Hormonal regulation of songs in birds.
	Functional roles of Gonadotropins, thyrotropins, & growth hormones, Functions of parathyroids, calcitonin, & vitamin D, Hormonal responses of birds to environmental and physiological stress.
28-30	Unique adaptations to their environment: beaks (bills), feet, and plumage (feathers).
	Temperature regulation of mound-nests in megapodes, salt excretion in seabirds, milk secretion in pigeons, torpor in nightjars, saliva-nests of swifts.
6 hours	Tutorials
Suggested Readings*:	

Scanes GC and Dridi S. 2021. Sturkie's Avian Physiology, 7th ed. Elsevier.
Lovette, I.J and Fitzpatrick, J.W. 2016. Handbook of Bird Biology, 3rd ed. Wiley.
Gill, F.B, and Prum, R.O. 2019. Ornithology, 4th ed. Macmillan.
Birkhead, T., Wimpenny, J., and Montgomerie, B. 2014. Ten Thousand Birds: Ornithology since Darwin. Princeton University Press, Princeton, NJ.
Birkhead, T. 2013. Bird Sense: What it's like to be a bird? Bloomsbury, NY.
Kaiser G. 2007. The Inner Bird: Anatomy and Evolution. UBC Press.
Scot G. 2020. Essential Ornithology. 2nd ed. Oxford press.
Proctor NS, Lynchm PJ. 1993.Manual of Ornithology: Avian Structure and Function
Please refer to latest editions available

Elective Basket – II

Open Elective Interdisciplinary Courses for other Departments

Course Title: Methods in Biology			
Course Code	LSC81OE02504	**Credits**	4
L + T + P	3+0+1	**Course Duration**	One Semester
Semester	I	**Contact Hours**	45 (L) + 0 (T) + 30 (P) Hours
Course Type	Open Elective Interdisciplinary Course (OEIC)		
Nature of the Course	Theory and Practical		
Special Nature/ Category of the Course (*if applicable*)	Basic methods applied in Biology/computational methods hands-on training/ Skill enhancement/Interdisciplinary		
Methods of Content Interaction	Lectures, 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)		

Course Objectives: The course aims to:

1. To orient the students with various techniques including bioinformatics, biostatistics, biophysics and radiolabeling.
2. To provide knowledge supporting the theoretical subjects and comprehensive understanding of the principles and techniques being used for the purpose.
3. To learn techniques and developing skills in designing an experiment and logical interpretation of the results.

Course Learning Outcomes: After completion of the course, the students shall have an understanding of:

- 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 1: Computational techniques 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.	24% Weightage, lectures: 11
Unit 2: Biophysical Methods Introduction to Biophysical methods, **Microscopy,** Molecular analysis using Fluorescence recovery after photobleaching (FRAP), Fluorescence resonance	26% Weightage, lectures: 12

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 3: Biostatistical methods Introduction to biostatistics, concept of variables in biological systems, types of variables; Measures of central tendency and dispersal, concept of probability distributions (Binomial, Poisson 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	(24% Weightage, lectures: 11)
Unit 4: Radio-labelling techniques Introduction to radioactivity 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 radiolabelling techniques of Direct or indirect labelling, Biotin, Alkaline phosphatase, Horse radish peroxidase, Detection methods	24% Weightage, lectures: 11

Content Interaction Plan

Contact Hours	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, position 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
P=30 Hours	*List of Practical* 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 Readings*:

David Mount (2004): Bioinformatics: Sequence and Genome Analysis, Second Edition

Arthur Lesk (2008): Introduction to Bioinformatics, 3rd Edition

Teresa Attwood and David Parry-Smith (2001): Introduction to Bioinformatics

Stephen A. Krawetz and David D. Womble (2003): Introduction to Bioinformatics: A Theoretical and Practical Approach, 1st Edition

Andreas D. Baxevanis (Editor), B. F. Francis Ouellette (Editor): (2004) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition

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.

**latest editions of the textbooks should be referred*

Course Title: Fundamentals of Biology			
Course Code	LSC91OE02604	**Credits**	4
L + T + P	4 + 0 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	60 Hours (L)
Course Type	Open Elective Interdisciplinary Course (OEIC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	General course can be opted by student of any stream to know the biological principles/ Interdisciplinary		
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 Examination		

Course Objectives:

- To introduce the concept of life.
- To acquaint students with concepts of advent of life and biological diversity.
- To develop an understanding towards maintenance of individual life forms and their interactions towards formation of a stable community.

Course Learning Outcomes:

After completion of the course the learners shall have basic understanding of:

- Origin and evolution of Life
- Cellular organization of plant and animal
- Morphology and physiology of flowering plants and humans
- Diversity of life forms

Course Contents

Unit 1: Origin and evolution of life Origin of life – definition of life and its advent, RNA world hypothesis, tree of life Advent of Evolutionary ideas Human Evolutionary history	10% Weightage
Unit 2 - Biomolecules and cell biology Carbohydrates, Lipids, Proteins and Nucleic Acid Structure of plant and animal cell – membranes and cell compartments Cell division - Mitosis and meiosis Basic principles of inheritance	23% Weightage
Unit 3 - Structural organization and physiology • Overview of morphology and anatomy of flowering plants • Physiology of plants - Respiration, transpiration, photosynthesis and reproduction • Anatomy and physiology of humans - Homeostasis, Respiration, Digestion, Circulation, Excretion, Nervous system and Reproduction	42% Weightage
Unit 4 - Population and diversity	25%

Diversity of plants and animals Speciation - Concept of species and population Inter and Intraspecific interaction	Weightage

Content Interaction Plan

Contact Hours	Topic
1-6	**UNIT 1: Origin and evolution of life**
	Origin of life – definition of life and its advent, RNA world hypothesis, tree of life
	Advent of Evolutionary Ideas
	Human Evolutionary history
7-20	**UNIT 2: Biomolecules and cell biology**
	Carbohydrates, Lipids, Proteins and Nucleic Acid
	Structure of plant and animal cell – membranes and cell compartments
	Cell division - Mitosis and meiosis
	Basic principles of inheritance
21-45	**UNIT 3: Structural organization and physiology**
	Overview of morphology and anatomy of flowering plants
	Physiology of plants - Respiration, transpiration, photosynthesis and reproduction
	Anatomy and physiology of humans - Homeostasis, Respiration, Digestion, Circulation, Excretion, Nervous system and Reproduction
46-60	**UNIT 4: Population and diversity**
	Diversity of plants and animals
	Speciation - Concept of species and population
	Inter and Intraspecific interaction

Suggested Readings*:

Urry L, Cain M, Wasserman S, Minorsky P, Reece. Campbell Biology, 12th ed. Pearson Education, Inc.

Raven P., Johnson G., Mason K., Losos J., Duncon D. Biology 12th ed. McGraw-Hill

Mader S. Concepts of biology, 3rd ed. New York : McGraw-Hill

NCERT Textbook for Biology – Class XI and XII

**latest editions of the textbooks should be referred*

Course Title: Reproductive Health and Population Control			
Course Code	LSC91OE02704	**Credits**	4
L + T + P	3+1+0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) + 0 (P) Hours
Course Type	Open Elective Interdisciplinary Course (OEIC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Interdisciplinary/ Life Skills		
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)		

Course Objectives: The course aims to:

- Acquaint the students with fundamental knowledge of Reproductive health, new reproductive techniques, and population control measures as per SDG target 3.7.
- Develops an understanding of the concept and importance of population education.
- Various terminologies connected with population studies and factors responsible for population growth are introduced along with issues raised increase in population. The government-endorsed plans for population control.

Course Learning Outcomes: After completion of the course, the students shall have an understanding of:

- It will enable students to understand reproduction and reproductive technologies.
- The knowledge of the various population control measures will aware the students to disseminate the knowledge to society.

Course Contents:

Unit 1: Reproduction Development of reproductive system, Anatomical and hormonal consideration. Spermatogenesis- Sperm transport, semen. Oogenesis- the role of steroid hormones in the development of Graffian follicle, corpus luteum, menarche, mensuration, and menopause. Fertilization, development of the embryo, Evolution of sex mechanism in the animal system, sex determination in embryo, placenta.	27% Weightage, lectures: 12
Unit 2: New reproductive technology Male & Female infertility, causes and management, abortion and law in India. Third party Reproduction, *In-Vitro* fertilization, Artificial insemination, Gamete transfer, Surrogate Mother, Newer technology in the sex determination of the embryo, Laws related to fetal sexing and Laws related to sex determination in India.	27% Weightage, lectures: 11

Unit 3: Population Control Population dynamics: distribution and density, population composition according to age, sex, rural, urban, literacy-all India, Factors affecting the population growth: Fertility, mortality and migration (mobility), Population and quality of Life: Population in relation to socio-economic development, health status, nutrition health services and education, Effect of unchecked growth of population on natural resources and environment.	27% Weightage, lectures: 12
Unit 4: Contraceptives and population policies Consequences of population problems, Development of contraceptive technology- Male and female contraception, working with the community to build awareness, Role of central and state government in population control National population policy, various population-related policies and programs voluntary and international agencies –UNEPA, WHO, UNESCO etc.	27% Weightage, lectures: 10

Content Interaction Plan

Contact Hours	Topic
1-5	Development of reproductive system, Anatomical and hormonal consideration. Spermatogenesis- Sperm transport, semen. Oogenesis- the role of steroid hormones in the development of Graffian follicle, corpus luteum, menarche, mensuration, and menopause.
6-12	Fertilization, development of the embryo, Evolution of sex mechanism in the animal system, sex determination in embryo, placenta.
13-18	Male & Female infertility, causes and management, abortion and law in India. Third party Reproduction, *In-Vitro* fertilization, Artificial insemination, Gamete transfer.
19-24	Surrogate Mother, Newer technology in the sex determination of the embryo, Law and Sex determination in India.
25-30	Population dynamics: distribution and density, population composition according to age, sex, rural, urban, literacy-all India, Factors affecting the population growth: Fertility, mortality and migration(mobility).
30-35	Population and quality of Life: Population in relation to socio-economic development, health status, nutrition health services and education, Effect of unchecked growth of population on natural resources and environment.
36-40	Consequences of population problems, Development of contraceptive technology- Male and female contraception, working with the community to build awareness,
41-45	Role of central and state government in population control National population policy, various population-related policies and programs voluntary and international agencies –UNEPA, WHO, UNESCO etc.

Suggested Readings*:

Lisa A. Urry, Jane Reece, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky. Campbell Biology (11th Revised Edition).
Gilbert, S.F. 2000. Developmental Biology. Sixth edition. INC Publishers, USA.
World Population Policies 2015. United Nations New York, 2018.
National population policy 2000.

**Please refer to latest editions available.*

Elective Basket – III
Mandatory Elective Non-Credit Course equivalent to 2 credits

Course Title: Nutrition and Health			
Course Code	LSC81ME02800 LSC82ME02800 LSC91ME02800	**Credits**	2
L + T + P	2 + 0 + 0	**Course Duration**	One Semester
Semester	I/II/III	**Contact Hours**	30 (L) + 0 (T) + 0 (P) Hour
Course Type	Mandatory Elective Non-Credit Course (MENC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Skill Based / Indian Knowledge System (IKS)/Life Skill		
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 innature but also contributing to the final grades) 70% - End Term External Examination (University Examination)		

Course Objectives:

- To introduce the students to the fundaments of nutrition, food and health
- To familiarize the student with importance of nutrition during various stages of life.
- To impart knowledge regarding etiology and management of nutritional disorders ranging from nutritional deficiencies to life style disorders.
- To emphasize on the importance of food safety, food quality, food laws and regulations, ongoing national programmes and UN Sustainable Development Goals (SDGs).

Course Learning Outcomes: This course aims to develop a holistic understanding of the various topics. Syllabus covers basic aspects of nutrients, food science, and nutrition concerns in various stages of life cycle, food safety, and food security as well as open an understanding of the current spectrum of malnutrition. This course equips the students for academic understanding, community role and appetizer for to develop interest in nutrition as major factor that drive society and its health as per Sustainable Developmental Goals (SDGs) of UN.

Course Content

Unit 1: Human nutrition and a lifespan approach Basic Concepts in Nutrition, Nutrients, Nutrition during Lifecycle: Principles of meal planning, Nutrient requirements, Nutrition for adulthood and old age, Nutrition during pregnancy and lactation, Nutrition during childhood.	Weightage: 50 %
Unit 2: Current concerns in public health nutrition	Weightage: 50 %

Nutritional problems affecting the community, Strategies for improving nutrition and health status of the community, Nutrition Policy and Programmes, Food and Nutrition Security	

Content Interaction Plan:

Contact Hours	Topic
1-16	**Unit 1: Human nutrition and a lifespan approach** Basic Concepts in Nutrition, Nutrients, Nutrition during Lifecycle: Principles of meal planning, Nutrient requirements, Nutrition for adulthood and old age, Nutrition during pregnancy and lactation, Nutrition during childhood.
17 – 30	**Unit 2: Current concerns in public health nutrition** Nutritional problems affecting the community, Strategies for improving nutrition and health status of the community, Nutrition Policy and Programmes, Food and Nutrition Security

Suggested Readings*:

- Wardlaw and Insel MG, Insel PM (2004). Perspectives in Nutrition. Sixth Edition, McGraw Hill.
- Srilakshmi B (2012). Nutrition Science.4th Revised Edition, New Age Interntional Publishers.
- Khanna K, Gupta S, Seth R, Passi SJ, Mahna R, Puri S (2013). Textbook of Nutrition and Dietetics. Phoenix Publishing House Pvt. Ltd.
- ICMR (1989) Nutritive Value of Indian Foods. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad.
- ICMR (2011) Dietary Guidelines for Indians – A Manual. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad.
- Jelliffe DB, Jelliffe ERP, Zerfas A and Neumann CG (1989). Community Nutritional Assessment with special reference to less technically developed countries. Oxford University Press. Oxford.
- World Health Organization (2006). WHO Child Growth Standards: Methods and development: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age (d)
- Bamji MS, Krishnaswamy K and Brahmam GNV (Eds) (2009). Textbook of Human Nutrition, 3rd edition. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Gibney MJ (2005). Public Health Nutrition

** Please refer to latest editions available*

Course Title: Mushroom Farming			
Course Code	LSC81ME02900 LSC82ME02900 LSC91ME02900	**Credits**	2
L + T + P	1+0+1	**Course Duration**	One Semester
Semester	I/II/III	**Contact Hours**	15 (L) + 0 (T) + 30 (P) Hours
Course Type	Mandatory Elective Non-Credit (MENC)		
Nature of the Course	Theory & Hands-on training		
Special Nature/ Category of the Course (*if applicable*)	Skill Based/entrepreneurship/sustainable development		
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)		

Course Objectives:

- The course aims to
  1. Introduce the students to mushrooms and help in understand the economic value of mushroom production.
  2. Gain knowledge on the selection of mushroom varieties as per the local environment.
  3. Know the challenges faced in setting up a mushroom cultivation center and the availability of various govt. funding resources will be discussed.

Course Learning Outcomes:

After completion of the course the students shall have an understanding of:

- The students will be able to understand the basics of mushroom cultivation, the criterion to choose a particular species, and various methods of cultivation.
- They will develop an understanding of setting up a govt. funded or self-funded production center, challenges, and success stories related to same.

Course Contents

Unit 1: Introduction to mushroom farming Overview of mushrooms, classification of mushrooms, mushroom hunting, mushroom statistics, Science and art of mushroom cultivation, Differences in mushroom production and pattern, world mushroom market, Types of mushrooms, economically important and medicinal mushroom, selecting a mushroom species	24% Weightage, lectures: 7
Unit 2: Methods of cultivation for shitake mushroom, oyster mushroom, button mushroom, and milky mushroom. Mushroom growing unit/house, mushroom diseases, post-harvest handling, Waste disposal of various mushrooms, Setting-up of mushroom cultivation center, Government aided financial support for setting-up of mushroom cultivation center, and discussion on success stories of mushroom production and sustainable	24% Weightage, lectures: 8

development.	

Content Interaction Plan

Contact Hours	Topic
1-3	Overview of mushrooms, classification of mushrooms, mushroom hunting, mushroom statistics, Science and art of mushroom cultivation,
4-7	Differences in mushroom production and pattern, world mushroom market, Types of mushrooms, economically important and medicinal mushroom, selecting a mushroom species
8-12	Methods of cultivation for shitake mushroom, oyster mushroom, button mushroom, and milky mushroom. Mushroom growing unit/house, mushroom diseases, post-harvest handling, Waste disposal of various mushrooms
13-15	Setting-up of mushroom cultivation center, Government aided financial support for setting-up of mushroom cultivation center and discussion on success stories of mushroom production and sustainable development.

Suggested Readings*:

B.C. Suman, V.P. Sharma. 2007. Mushroom Cultivation in India

R. Gogoi, Y. Rathaiah, T.R. Borah. 2019. Mushroom Cultivation Technology

Reviews: Arpita Das, Chiao-Ming Chen, Shu-Chi Mu, Shu-Hui Yang , Yu-Ming Ju , Sing-Chung Li. 2022. Medicinal Components in Edible Mushrooms on Diabetes Mellitus Treatment. Pharmaceutics. Feb 17;14(2):436. doi: 10.3390/pharmaceutics14020436.

Patel et al, 2021. Mushroom-Derived Bioactive Molecules as Immunotherapeutic Agents: A Review. Molecules. Mar 4;26(5):1359. doi: 10.3390/molecules26051359.

**Please refer to latest editions available*

Course Title: Post-Harvest Technology for Crop Management			
Course code	LSC81ME03000 LSC82ME03000 LSC91ME03000	**Credit**	2
L+T+P	1+0+1	**Course duration**	One Semester
Semester	I/II/III	**Contact Hours**	15 (L) + 0 (T) + 30 (P) Hour
Course Type	Mandatory Elective Non-Credit Course (MENC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Skill course/Value Added		
Methods of content Interaction	Lecture, Group discussion; self-study, seminar, presentations by students		
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 objective: The course will provide knowledge on how to maintain the quality of horticultural products after harvest, as well as which factors affect quality after harvest and how losses can be reduced using different methods.

Learning outcomes: Upon successful completion of this course, students should be able to:

- Explain the principles of post-harvest technology
- Illustrate the physiological and biochemical changes occurring during various stages of fruit and vegetable development and production
- Indicate the importance and the significance of proper post-harvest handling to maintain the quality of fruits and vegetables
- Learn about different methods of postharvest treatments for preventing crop loss

Course contents

Unit 1: Post-harvest technology and its significance, shelf life of fruits and vegetables after harvesting, physiology of harvested crop Structure of Fruits and Vegetables, cellular components and their function relevant to postharvest management, Biochemical composition of postharvest crops. Biosynthesis of ethylene and its role in ripening, biochemical changes that occur during the ripening. Reasons for postharvest loss of crops and vegetables	Weightage 35%
Unit 2: A wide range of factors affects the quality of horticultural produce, including pre-harvest, harvest, and post-harvest factors.	Weightage

Physiological Maturity, Commercial Maturity, Maturity Indices Determination: Physical Methods, Chemical Methods, Physiological methods and Computational Methods Harvesting: Hand and mechanical harvesting; handling of horticultural produce: handling at the time of harvest, at the field, during transportation, at retail market, at customer end. Post- harvest treatments on horticultural produce: Pre-cooling, Cleaning, washing and trimming, High temperature, chemical treatment Fruit coating-waxing: Types of Waxing, Methods of wax application Ripening regulation: Delay of ripening, enhancing ripening, artificial ripening Methods of sprout suppression: Physical, chemical and ionization methods	65%

Content Interaction Plan

Contact Hours	Topic
1-3	Post-harvest technology and its significance, shelf life of fruits and vegetables after harvesting, physiology of harvested crop, Structure of Fruits and Vegetables, cellular components and their function relevant to postharvest management, Biochemical composition of postharvest crops
4-5	osynthesis of ethylene and its role in ripening, biochemical changes that occur during the ripening, reasons for postharvest loss of crops and vegetables
6-8	Factors affecting the quality of horticultural produce: pre-harvest factors, harvest factors, post-harvest factors, Maturity Indices in Horticultural Produce: Physiological maturity, commercial maturity; determination of maturity indices: physical methods, computational methods
9-10	Maturity Indices in Horticultural Produce: Physiological maturity, commercial maturity; determination of maturity indices: physical methods, computational methods
11-13	Hand and mechanical harvesting; handling of horticultural produce: handling at the time of harvest, at the field, during transportation, at retail market, at customer end, post-harvest treatments on horticultural produce: Pre-cooling, Cleaning, washing and trimming, High temperature, chemical treatment
14-15	Fruit coating-waxing: Types of Waxing, Methods of wax application, Ripening regulation: Delay of ripening, enhancing ripening, artificial ripening, Methods of sprout suppression: Physical, chemical and ionization methods.
15 hours	**Tutorial**

Suggested Readings*:

Post-Harvest Technology of Fruits and Vegetables. Vol. I & II Plant Pathology, 2000, Indus Publishing Co. New Delhi

Postharvest: an introduction to the physiology and handling of fruit, vegetables and ornamentals. Wills, R.B.H., McGlasson, W.B., Graham, D. and Joyce, D.C., 2007, CABI.

Small-scale postharvest handling practices: a manual for horticultural crops. Carlifonia: Kitinoja, L. and Kader, A.A., 2002, University of California, Davis, Postharvest Technology Research and Information Center.

Post-harvest technologies of fruits & vegetables. Ramaswamy, H.S., 2014. DEStech Publications, Inc.

Please refer to latest editions available

Course Title: Philosophy of Science and Scientific Ethics			
Course code	LSC81ME03100 LSC82ME03100 LSC91ME03100	**Credit**	2
L+T+P	1+1+0	**Course duration**	One Semester
Semester	I/II/III	**Contact Hours**	24 (L) + 6 (T) + 0 (P) Hour
Course Type	Mandatory Elective Non-Credit Course (MENC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Philosophy based course/IKS		
Methods of content Interaction	Lecture, Group discussion; self-study, seminar, presentations by students		
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 objective: The course will provide knowledge about the philosophy of science, and scientific ethics. Science today is an enterprise. It is an organized activity conducted in Institutions and by teams. When linked to rewards and recognitions, the competitive nature induces in some unethical behavior for possible short term gains. Such aberrant behavioral patterns are subject of this course.

Learning outcomes: Upon successful completion of this course, students should be able to:

- Understand the philosophy of Science and Scientific Ethics must require to conduct good science.

Course contents

Unit 1: What is science? Scientific inference, Explanation in science, Progress through corroboration (Popper), Paradigms (Kuhn), Realism and anti-realism, scientific change and scientific revolutions, Philosophical problems in physics, biology, and psychology, Science and its critics Indian Philosophy and Philosophy of Science	Weightage 50%
Unit 2: Origin of Modern Experimental Science, Science as a Culture and Philosophy, Moral, Ethics and Laws, Evolution of Social Ethics, Ethical Issues in Indian Science, Ethics in Higher Education, Ethics of Research, Ethics in the Use of Animals, Ethics in the Use of Human Subjects, Ethics in measurement practices, Ethics of Publication, Ethics of Outreach	Weightage 50%

Content Interaction Plan

Contact Hours	Topic

1-9	What is science? Scientific inference, Explanation in science, Progress through corroboration (Popper), Paradigms (Kuhn), Realism and anti-realism, scientific change and scientific revolutions, Philosophical problems in physics, biology, and psychology, Science and its critics
10-12	Indian Philosophy and Philosophy of Science
13-24	Origin of Modern Experimental Science, Science as a Culture and Philosophy, Moral, Ethics and Laws, Evolution of Social Ethics, Ethical Issues in Indian Science, Ethics in Higher Education, Ethics of Research, Ethics in the Use of Animals, Ethics in the Use of Human Subjects, Ethics in measurement practices, Ethics of Publication, Ethics of Outreach
6 hours	Tutorial

Suggested Readings*:

Philosophy of Science: Very Short Introduction (2 ed.) by Samir Okasha. 2016. Oxford University Press.

Ethics in Science Education, Research and Governance. 2019. Edited by Muralidhar K, Ghosh A, and Singhvi AK, INSA New Delhi.

Indian Philosophy and Philosophy of Science. by Sundar Sarukkai; PHISPC, Centre for Studies in Civilisations, New Delhi, 2005; pp 273.

Philosophy of Science: Rationality without Foundations. Karl Popper. Routledge; 1st edition (4 November 2010).

Kuhn, Thomas S., author. The Structure of Scientific Revolutions. Chicago :University of Chicago Press, 1970.

Please refer to latest editions available