PRESIDENCY UNIVERSITY
KOLKATA

04 Years Bachelor Programme under CHOICE BASED CREDIT SYSTEM for B. Sc. Honours with Research in Life Sciences

(Total Credits:194)

(Effective from 2023-24 Academic Session)

Department of Life Sciences

Presidency University

Department of Life Sciences
(Faculty of Natural and Mathematical Sciences)
Presidency University
Hindoo College (1817-1855), Presidency College (1855-2010)
86/1, College Street, Kolkata - 700 073
West Bengal, India

Contents

Credit Allocation and Marks Distribution for 04 Years Bachelor Programme under CHOICE BASED CREDIT SYSTEM for B. Sc. Honours with Research in Life Sciences

Semester	Course	Paper Code	Course Name	Credits			Evaluation Pattern (Marks)			Classes per week	Course Type
				Theory	Practical	Total	End-term	Mid-term	Total		Taught (T)/ Sessional (S)
First	Major Course	LISC101C01	Introduction to Living Systems	4	2	6	70	30	100	8 hr	T
First	Major Course	LISC102C02	Ecology, Evolution and Biodiversity	4	2	6	70	30	100	8 hr	T
First	Ability Enhancement Course	103AECC01	English Communication /MIL	4	0	4	70	30	100	4hr	T
First	Minor Course	LISC104MC01	Macromolecules of Life	4	2	6	70	30	100	8hr	T
First	Multidisciplinary Course	LISC105MDC01	World of Animals	3		3	50		50	3 hr	T
First	**Total Semester Credits and Evaluation Pattern (Marks)**					**25**	**330**	**120**	**450**		
Second	Major Course	LISC151C03	Biochemistry and Biophysics	4	2	6	70	30	100	8 hr	T
Second	Major Course	LISC152C04	Fundamentals of Cell and Molecular Biology	4	2	6	70	30	100	8 hr	T
Second	Minor Course	LISC154MC02	Introduction to plant tissue culture and Genetically Modified Plants	4	2	6	70	30	100	8 hr	T
Second	Multidisciplinary Course	LISC155MDC02	Human Body the works and its care	3		3	35	15	50	3 hr	T
Second	Multidisciplinary Course	LISC156MDC03	Economic Applications of Plant and Microbial Biotechnology	3		3	35	15	50	3 hr	T
Second	Ability Enhancement Course	153AECC02	English Communication /MIL	4	0	4	70	30	100	4 hr	T
Second	**Total Semester Credits and Evaluation Pattern (Marks)**					**28**	**350**	**150**	**500**		
Third	Major Course	LISC201C05	Introduction to Microbiology and Genetics	4	2	6	70	30	100	8 hr	T
Third	Major Course	LISC202C06	Introduction to Immunology and Developmental Biology	4	2	6	70	30	100	8 hr	T
Third	Skill Enhancement Course (Major)	LISC241SEC01	Applied nutrition and dietetics	4	0	4	100	0	100	4 hr	S
Third	Value Added Course	ENVS204VAC01	Environmental Science	3	0	3	35	15	50	3 hr	T
Third	Minor Course	LISC205MC03	Fundamentals of the Animal World	4	2	6	70	30	100	8 hr	T
Third	**Total Semester Credits and Evaluation Pattern (Marks)**					**25**	**345**	**105**	**450**		
Fourth	Major Course	LISC251C07	Biostatistics and Bioinformatics	4	2	6	70	30	100	8 hr	T
Fourth	Major Course	LISC252C08	Ethology and adaptation	4	2	6	70	30	100	8 hr	T
Fourth	Skill Enhancement Course (Major)	LISC291SEC02	Economic Zoology	5	0	5	100	0	100	5hr	S
Fourth	Value Added Course	LISC292VAC02	Advances in Cancer Diagnostics and Therapeutics	3	0	3	50	0	50	3 hr	S
Fourth	Minor Course	LISC255MC04	Modern lifestyle and associated ailments	4	2	6	70	30	100	8 hr	T
Fourth	**Total Semester Credits and Evaluation Pattern (Marks)**					**26**	**360**	**90**	**450**		
Fifth	Major Course Elective	LISC301C09	A/ B /C/D/E	4	2	6	70	30	100	8 hr	T
Fifth	Major Course Elective	LISC302C10	A/ B /C/D/E	4	2	6	70	30	100	8 hr	T

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Semester	Course	Paper Code	Course Name	Credits			Marks			Classes per week	Course Type
				Theory	Practical	Total	End-term	Mid-term	Total		Taught (T) / Sessional (S)
Fifth	Major Course Elective	LISC303C11	A/ B /C/D/E	4	2	6	70	30	100	8 hr	T
Fifth	Summer training	LISC341SI01	Summer Internship	0	4	4	100	0	100	64 hr (total)	S
Fifth	**Total Semester Credits and Evaluation Pattern (Marks)**					**22**	**310**	**90**	**400**		
Sixth	Major Course Elective	LISC351C12	A/ B /C/D/E	4	2	6	70	30	100	8 hr	T
Sixth	Major Course Elective	LISC352C13	A/ B /C/D/E	4	2	6	70	30	100	8 hr	T
Sixth	Major Course Elective	LISC353C14	A/ B /C/D/E	4	2	6	70	30	100	8 hr	T
Sixth	Major Course Elective	LISC354C15	A/ B /C/D/E	4	2	6	70	30	100	8 hr	T
Sixth	**Total Semester Credits and Evaluation Pattern (Marks)**					**24**	**280**	**120**	**400**		
Seventh	Major Course Elective	LISC401C16	A/ B /C/D/E	4	0	4	70	30	100	4hr	T
Seventh	Major Course Elective	LISC402C17	A/ B /C/D/E	4	0	4	70	30	100	4hr	T
Seventh	Major Course Elective	LISC403C18	A/ B /C/D/E	4	0	4	70	30	100	4hr	T
Seventh	Major Course Elective	LISC441C19	DISSERTATION	-	-	4	100	0	100	8hr	S
Seventh	Minor Course	LISC442MC05	Research Methodology	-	-	4	100	0	100	4 hr	S
Seventh	**Total Semester Credits and Evaluation Pattern (Marks)**					**20**	**410**	**90**	**500**		
Eighth	Major Course Elective	LISC451C20	A/ B /C/D/E	4	0	4	70	30	100	4 hr	T
Eighth	Major Course Elective	LISC452C21	A/ B /C/D/E	4	0	4	70	30	100	4 hr	T
Eighth	Major Course Elective	LISC453C22	A/ B /C/D/E	4	0	4	70	30	100	4 hr	T
Eighth	Major Course Elective	LISC491C23	DISSERTATION	-	-	8	100	0	100	16hr	S
Eighth	Minor Course	LISC492MC06	Research and Publication Ethics	-	-	4	100	0	100	4 hr	S
Eighth	**Total Semester Credits and Evaluation Pattern (Marks)**					**24**	**410**	**90**	**500**		
	Total Credit					**194**	**2795**	**855**	**3650**		

04 Years Bachelor Programme under CHOICE BASED CREDIT SYSTEM for B. Sc. Honours with Research in Life Sciences

Introduction:

The Department of Life Sciences in Presidency University has been created by merging together the pre-existing Departments of Botany, Zoology, Physiology, Molecular Biology, Biochemistry and Biotechnology. The result is a dynamic interdisciplinary Department with a holistic approach towards the study of Biology. The mixture of young and experienced faculty in the Department of Life Sciences promises an outstanding academic experience to its students. They will have the opportunity of learning a multitude of inter-disciplinary subjects along with options for some in depth disciple specific study, and will also have research experience by the completion of their studies.

Four years B.Sc Course in Life Sciences is being offered by the Department of Life Sciences, Presidency University Kolkata from the academic year 2023-24. It aims to impart higher quality integrated education in a vibrant academic ambiance with distinguished teachers and infrastructure available at this department of the University. Life Sciences is essentially a subject that unifies multi-disciplinary themes for understanding the basic functions of life process that in turn facilitate the objective of benefiting mankind and has impacts on health and diseases across species, agriculture and environment. The purpose of the course is primarily to prepare the students with in – depth integrated knowledge of various branches of biology together with applications using modern tools and techniques. In addition to theory and laboratory classes the students will have research projects supervised by the faculty which in turn prepares them for teaching and research level careers in bio-industries, Government sectors and academia.

Study of Life Sciences is central to the fundamental understanding of living systems. It relates to other subjects, including Animal and Plant biology, Genetics, Biochemistry, Microbiology, as well as contemporary subjects like Molecular Biology, Biostatistics, Bioinformatics, Immunology, Biotechnology, Cancer Biology and Developmental Biology to foster comprehensive understanding about various aspects of living world. This Program in Life Sciences also includes the industry relevant, advanced life science topics like Genomics, Proteomics, Nanobiology, Systems Biology. It would also include visits to research institute laboratories and fields to get in-depth knowledge of the subject and to explore employment opportunities in the field.

The course allows students the flexibility to combine multi-disciplinary subjects along with vocational courses in Life Sciences. Overall emphasis is on conceptual understanding of Life Sciences with skill enhancement papers on latest advances in the field. This programme provides

students with a flexibility to combine multi-disciplinary subjects along with integration of Value added courses.

Structure of curriculum:

In the curriculum, there will be two semesters in each academic year. All students enrolled in the Bachelor of Science program will study the same course modules in the first four semesters (Semester 1, 2, 3 and 4) and these modules will comprise mostly of the fundamentals of Biological Science, ranging from diversity and evolution to biochemistry and genetics. There will be laboratory based / field study based practical modules related to the theoretical papers. The objective is to generate the knowledge base of the students, upon which they will build up their education. Upon completion of Semester 4, students will have the liberty of choosing theory papers of their personal interest, with the corresponding laboratory modules or they can opt for subject specialization. An advisory committee of Departmental faculty will assist each student at this stage to select their courses for semesters 5, 6, 7 and 8 based on their interests and their future career goals. This curriculum also has an integrated research component (Dissertation project) in the fourth and final year leading to Honours degree with Research upon completion of 194 credits.

Assessment Methods:

The assessment of students' achievement in Life Sciences will be aligned with the course/programme learning outcomes and the academic and professional skills that the programme is designed to develop. A variety of assessment methods that are appropriate will be used including formative and summative assessment modes. Progress towards achievement of learning outcomes will be assessed using the following: time-constrained examinations; closed-book and open-book tests; problem based assignments; practical assignment laboratory reports; individual/ group project reports (survey reports); oral presentations, including seminar presentation; viva voce; peer and self-assessment methods. Any other pedagogic approaches may be adopted as per the context.

All major (C) papers except for C-19 and C-23 , all multidisciplinary (MDC), minor (MC) 1-4 and ENVS-VAC01 courses will be taught papers with an internal assessment component and an end-semester examination.

Major courses (C-19 and C-23), All Skill enhancement (SEC), Value added course (VAC02) and MC 5, 6 will be sessional papers which will be graded via continuous assessments.

COURSE DISTRIBUTION

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SEM	MAJOR COURSE (C)	ABILITY ENHANCEMENT COMPULSORY COURSE (AECC)	SKILL ENHANCEMENT COURSE (SEC-MAJOR)	VALUE ADDED COURSE (VAC)	MINOR COURSE (MC)	MULTI DISCIPLINARY COURSE (MDC)
I	LISC101C01 (6 credits): Introduction to Living Systems LISC102C02 (6 credits): Ecology, Evolution and Biodiversity	103AECC01 (4 credits) English Communication /MIL			LISC104MC01 (6 credits): Macromolecules of Life	LISC105MDC01 (3 credits): World of Animals
II	LISC151C03 (6 credits): Biochemistry and Biophysics LISC152C04 (6 credits): Fundamentals of Cell and Molecular Biology	153AECC02 (4 credits) English Communication/MIL			LISC154MC02 (6 credits) Introduction to plant tissue culture and Genetically Modified Plants	LISC155MDC02 (3 credits): Human Body the works and its care LISC156MDC03 (3 credits): Economic Applications of Plant and Microbial Biotechnology
III	LISC201C05 (6 credits): Introduction to Microbiology and Genetics LISC202C06 (6 credits): Introduction to Immunology and Developmental Biology		LISC241SEC01 (4 credits): Applied nutrition and dietetics	ENVS204VAC01 (3 credit) (Environmental Science)	LISC205MC03 (6 credits) Fundamentals of the Animal World	

IV	LISC251C07 (6 credits): Biostatistics and Bioinformatics LISC252C08 (6 credits): Ethology and adaptation		LISC291SEC02 (5 credits): Economic Zoology	LISC292VAC02 (3 Credits) Advances in Cancer Diagnostics and Therapeutics	LISC255MC04 (6 credits): Modern lifestyle and associated ailments	
V	LISC301C09 (6 credits): Electives as given below LISC302C10 (6 credits) LISC303C11 (6 credits)		LISC341SI01 (Summer Internship: 4 credits)			
VI	LISC351C12 (6 credits) LISC352C13 (6 credits) LISC353C14 (6 credits) LISC354C15 (6 credits)					
VII	LISC401C16 (4 credits) LISC402C17 (4 credits) LISC403C18 (4 credits) LISC441C19 (4 credits) (Dissertation)				LISC442MC05 (4 credits): Research Methodology	
VIII	LISC451C20 (4 credits) LISC452C21 (4 credits) LISC453C22 (4 credit) LISC491C23 (8 credit) (Dissertation)				LISC492MC06 (4 credits): Research and Publication Ethics	

Electives for Semester V-VIII

	(A) Plant Sciences	(B) Animal Sciences	(C) Human Physiology	(D) Biochemistry and Molecular Biology	(E) Microbiology
Semester V					
LISC301C09-6 credits 4 theory, 2 practical	Diversity and evolution of plant groups	Functional morpho-anatomy of non-chordates and chordates	Digestion, nutrition, excretion and thermal homeostasis	Enzymology	Microbial Diversity
LISC302C10-6 credits 4 theory, 2 practical	Plant architecture and systematics	Advanced cell and molecular biology	Blood, body fluids, hematology, cardiovascular system and respiration	Advanced Molecular Biology	Bacteriology & Virology
LISC303C11-6 credits 4 theory, 2 practical	Plant Physiology	Applied ecology and wildlife biology	Intermediary metabolism	Intermediary metabolism	Microbial Nutrition and Metabolism
Semester VI					
LISC351C12-6 credits 4 theory, 2 practical	Plant resources and bioprospecting	Biosystematics and Molecular Phylogenetics	Advanced cell biology	Advanced cell biology	Advanced cell biology
LISC352C13-6 credits 4 theory, 2 practical	Plant tissue culture and plant breeding	Animal Physiology	Endocrinology, neuroendocrinology and human reproduction	Clinical Microbiology	Clinical Microbiology

LISC353C14-6 credits 4 theory, 2 practical	Stress Biology (plant)	Advanced Immunology	Advanced Immunology	Advanced Immunology	Advanced Immunology
LISC354C15-6 credits 4 theory, 2 practical	Plant biochemistry and cell biology	Animal histology, and histochemistry	Nervous system, physiology of nerve and muscle, sensory physiology	Biophysical methods	Environmental Microbiology
Semester VII					
LISC401C16-4 credits (Theory)	Plant Genetic engineering	Parasitology and Vector biology	Pathophysiology of common human diseases and pharmacological drug design	Molecular Biology of Human diseases and Therapeutic Interventions	Food and Industrial Microbiology
LISC402C17-4 credits (Theory)	Advanced genetics	Advanced genetics	Advanced genetics	Advanced genetics	Advanced genetics
LISC403C18-4 credits (Theory)	Plant Developmental Biology	Animal Developmental Biology	Human Embryology	Animal Developmental Biology	Microbiome and Metagenomics
LISC441C19-4 credits	Dissertation	Dissertation	Dissertation	Dissertation	Dissertation

Semester VIII					
LISC451C20-4 credits (Theory)	Molecular Plant-Microbe Interactions	Evolutionary Biology	Stress Biology	Stress Biology	Host-pathogen interactions
LISC452C21-4 credits (Theory)	Instrumentation in Research	Instrumentation in Research	Instrumentation in Research	Instrumentation in Research	Instrumentation in Research
LISC453C22-4 credits (Theory)	Frontier Areas of Plant Science	Frontiers in animal science research	Social, stress and sports physiology. Ergonomics	Molecular Cloning and Transgenic technology	Molecular Cloning and Transgenic technology
LISC491C23-8 credits	Dissertation	Dissertation	Dissertation	Dissertation	Dissertation

DETAILED SYLLABUS

MAJOR COURSES *(Offered to all DLS Students)*

LISC101C01: Introduction to Living Systems

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Concept of Animal kingdom and Protista
2. Classification of animal phyla: Classification of extant major phyla (upto 'class' in case of invertebrates and upto 'order' in case of vertebrates).
3. Diversity of plant group: Diagnostic features and economic importance of selected algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms. Basic concept on Plant classification.
4. Introduction to the human systems. Concepts of tissues, organs and systems. Regulation and homeostasis between the different systems.
5. Microbial classification and Evolution: Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Endosymbiotic origin of Mitochondria, Chloroplasts, and Hydrogenosomes.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Study of microscopes.
2. Concepts of fixation and staining.
3. Staining of squamous epithelial cells.
4. Identification from permanent slides.
5. Demonstration of slides/ specimens of a few important algae, fungi, bryophytes, pteridophytes, gymnosperms
6. Identification - *Aurelia,* Sea anemone, *Nereis*, *Squilla,* King crab, *Peripatus, Pila, Sepia, Asterias,* Sea-urchin, *Balanoglossus, Ascidia, Petromyzon, Torpedo, Ichthyophis,* Axolotl*, Hyla, Chameleon, Gekko, Naja.*

LISC102C02: Ecology, Evolution and Biodiversity

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Evolution

1. Origin of life: Abiotic origin of life with reference to Miller's experiment, physical and chemical catalysis of formation of macromolecules, Oparin's 'proteinoid droplet' concept and Crick's 'Nucleic acid first' hypothesis.
2. Geological era: Climatic, floral and faunal characteristics of different geological era.
3. Classical theories of evolution: Critical review of Lamarckism, Darwinism and mutation theory of de Vries.

Ecology

1. Ecosystem function: Energy flow in ecosystem, food chain, food web and ecological pyramids; Productivity in terrestrial and aquatic ecosystems.
2. Population Ecology: Characteristics of population, population growth curves, r and k selections, population regulation by density-dependent and density-independent factors, concept of self-regulation of population.
3. Community Ecology: Habitat and niche concept; Keystone species and dominant species; Ecotone and edge effect; Heterospecific associations with reference to competition, protocooperation, commensalism and mutualism.
4. Ecological succession: Causes, types and process, climax concept, theories on ecological succession.

Biodiversity

1. Different levels and values of biodiversity
2. Threats to biodiversity
3. Biodiversity hotspots.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Study of a few endangered species of amphibians, reptiles, birds and mammals of India
2. To study the faunal composition (insects and mites) of soil samples. (Berley's funnel)
3. To study faunal composition of water samples (Lucky drop method)
4. Report on visit to Botanical garden/ Zoological Garden.

SEMESTER II

LISC151C03: Biochemistry and Biophysics

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Biophysical Principles

1. Forces stabilizing atomic and molecular interactions: Formation, properties and biological significance of Van der Waals force, hydrogen bond, ionic bond, covalent bond and hydrophobic interaction.
2. pH and buffer: Derivation of upper and lower limits of pH; Biological significance of pH; Characteristics of buffer; Deduction of Henderson-Hasselbalch equation of pH of buffer; Principal buffers of extracellular and intracellular fluids and their function.
3. Biological membranes and Channel Proteins: Colloidal solution, Micelles, reverse micelles, bilayers, liposomes, phase transitions; active, passive and facilitated transport of solutes and ions, Fick's Laws, Diffusion, Osmosis, Isosmotic and isotonic solutions; Effect of hyper- and hypotonic media on cells; Van't Hoff's laws, Donnan effect, permeability coefficient, membrane potential, molecular mechanism of ion transporters; water potential in context to aquaporins; gating mechanism.
4. Thermodynamics and reaction kinetics: First and second laws of thermodynamics and their biological significance; Important principles and definitions of thermochemistry; Concept of standard state and standard enthalpies, Kirchhoff's Equation, concept of entropy, Gibbs free energy and Helmholtz free energy, Gibbs Helmholtz equation, Maxwell's relations; Activation energy and transition-state theory; Different orders of chemical reactions.

Biochemistry

1. Carbohydrate chemistry: Classification and properties of carbohydrates with emphasis onstereoisomerism, optical isomerism, epimerization, mutarotation and reducing action of sugars.
2. Protein chemistry: structure of protein building block- amino acids, peptide bond formation, classification of proteins; primary, secondary, tertiary and quaternary structure of proteins; Properties of proteins with emphasis on isoelectric pH, salting in and out, biuret test and protein denaturation-renaturation
3. Lipid chemistry: Classification and properties of lipids with emphasis on saponification number, iodine number, acetyl number, Reichert-Meissel number, hydrogenation and rancidity of fats.
4. Nucleic acid chemistry: elementary concept of nucleoside, nucleotide, polynucleotide; elementary concept of RNA, denaturation - renaturation of DNA.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Estimation of the heat of combustion using a bomb calorimeter.
2. Standardization of acid solution using standard solution of sodium carbonate.
3. Standardization of Mohr's salt solution against standard $K_2Cr_2O_7$ solution.
4. Preparation of different buffers.
5. Qualitative estimation of substances of biological importance by biochemical methods.
6. Estimation of glucose/ sucrose/ lactose by Benedict's method.

LISC152C04 : Fundamentals of Cell and Molecular Biology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Cell Biology:

1. History, Cell theory, Overview of Prokaryotic and Eukaryotic Cells, Plant and Animal cells, Phages, Virioids, Mycoplasmas, Viruses, Prions, organization from cells to tissues.
2. Cell structure and organization: Structural uniqueness of prokaryotic, plant and animal cells; structural organization of the plasma membrane, cellular organelles.
3. The cytoplasmic organelles and their functions: Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, Endosome, Ribosome, Nucleus. Transport of molecules across membranes.
4. Brief introduction to cytoskeleton: organization of the Cytoskeleton, microtubules, microfilaments, intermediate filaments.
5. Cell junctions and the extracellular matrix.
6. Cell signaling and communication.
7. Chromosomes, chromatin and nucleosome: Chromosome structure in bacteria and eukaryotes, centromere, telomere, Hetero- and euchromatin, Nucleosome model and radial-loop scaffold model.
8. Overview of Cell cycle: Stages of cell cycle, Mitotic and meiotic cell division; Distinction between mitosis in plant and animal.

Molecular Biology:

1. Birth and development of Molecular Biology; Contribution from Biochemistry, Genetics, Physics, etc.; DNA as genetic material; Landmark discoveries in Molecular Biology; Model organisms in Molecular Biology
2. A, B and Z forms of DNA; RNA types, distinctions between DNA, RNA and Polypeptides
3. The Central Dogma of Molecular Biology: DNA Replication & Repair; Transcription; Reverse Transcription, Translation
4. The Genetic Code: Genetic code and its properties; flow of genetic information from genome to transcriptome to proteome; fidelity of replication, transcription and translation.
5. Regulation of gene expression; levels of gene regulation; examples of positive and negative regulatory mechanisms.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Staining of adipose and areolar tissue

2. Visualization of slides on mitosis and meiosis
3. Study of structure and ultrastructure of cell through electron micrographs and photographs.
4. Preparation of Growth Media, Buffers and pH titration.
5. Colorimetric estimation of DNA/RNA.
6. Demonstration of FACS.

Semester III

LISC201C05: Introduction to Microbiology and Genetics

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Microbiology

1. History of Microbiology: The discovery of microorganisms, Developments in the field of Microbiology with contributions of Robert Hooke, Antonie von Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Paul Ehrlich, Alexander Fleming, Ronald Ross, Stanley B. Prusiner etc.
2. Systems of classification: Binomial nomenclature, different classification systems, Acellular (viruses, viroids and prions) and cellular microorganisms (bacteria, algae, fungi and protozoa).
3. Microscopy and the staining Techniques: Light microscopy, different parts and function of light microscope. Dye and stains, Auxochrome and chromophore. Staining techniques (Simple, Gram, Negative)
4. Microbial cell structure and function: General characteristics and cellular morphology of bacteria, algae, fungi, protozoa, viruses.
5. Microbial nutrition and growth: Nutritional requirements and nutritional categories, different types of cultural media, microbial growth kinetics.
6. Basics of microbial pathogenesis: Host, pathogen, pathogenicity factors, Determinants of Microbial Pathogenicity (Adhesion, invasion, colonization factors), virulence and virulence factors, Enzymes as virulence factors (Coagulase, Hyaluronidase, Collagenase).
7. Impact of microorganisms on society: Brief outline of the role of micro-organisms in human health and medicine, food and dairy industry, agriculture and environment.

Genetics:

1. Model organisms in genetic analysis: Contributions of model organisms like E. coli, yeast, Neurospora, Arabidopsis, Maize, , Drosophila, C. elegans, Zebra fish
2. Mendelian Inheritance: Mendelian Laws and chromosome theory of inheritance, Brief outline regarding extension of Mendelism

3. Allele concept: Dominant, recessive and co-dominant alleles; Multiple allelism with reference ABO blood group; Pseudoallelism with reference to eye colour in Drosophila,
4. Linkage and Gene Mapping: Phases of linkage, linkage group, complete and incomplete linkage, test cross, recombination frequency, gene mapping, determination of map distances based on two and three-point test crosses, coincidence, interference; cytological proof of crossing over,
5. Mutations and mutagenesis: Definition and types of mutations-base substitutions, frameshifts, deletions, insertions, duplications, inversions. Silent, conditional and lethal mutations. Physical and chemical mutagens. Loss and gain of function mutants, Reversion and suppression: true revertants, intra- and inter-genic suppression. Mutator genes. Uses of mutations. Ames Test.

Practical:
Credit : 2
Contact Hours per Week : 4

1. Operation of Light Microscope
2. Gram staining of bacteria
3. Microbial pure culture technique(Pour plate and streaking)
4. Transformation of Bacteria with plasmid
5. Problems on Mendelian Segregations (Monohybrid, Dihybrid & Trihybrid Crosses)
6. Problems on Linkage analysis and mapping of genes (Dry Lab).

LISC202C06: Introduction to Immunology and Developmental Biology
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

Introduction to Immunology

1. History and Overview of immune system
2. Elements of innate and adaptive immunity in plants: Chemical and morphological defense in plants; Basal resistance and biochemical host defenses. Passive and active defenses.
3. Elements of immunity in animals: Innate vs. acquired immunity; Passive vs. active immunity, Humoral immunity and cell mediated immunity
4. Cells and organs of the Immune system. Primary lymphoid organs and secondary lymphoid organs. Hematopoiesis.
5. Concept of Immunogen and antigen; Characteristics and types of antigens; Epitope, B and T cell epitopes, paratope; monoclonal antibody and polyclonal antibody.
6. Immunoglobulins: Molecular structure and classification. Ig superfamily, T cell receptors and B cell receptors and its signaling; Antibody-mediated effector functions

7. Antigen-antibody interaction: Principle and a few basic application of antigen-antibody interaction; Innate immunity – cellular & humoral components of innate immunity; first response to infection and damaged self Antigen recognition by antibodies and T cell receptors.

Introduction to Development Biology

1. Outline knowledge of gametogenesis, ultrastructure of sperm and ovum, egg types,egg membrane
2. Physical & molecular events of fertilization in sea urchin and mammals
3. Cleavage: types, role of yolk in cleavage
4. Embryonic stem cell (in brief), Potency
5. Formation of blastula in frog and chick
6. Fate map, morphogenetic movement & process of gastrulation in frog and chick
7. Principles of collections and cryopreservation of gametes and embryos
8. In vitro fertilization and embryo transfer (in brief).
9. Basic concept on development, differentiation and de-differentiation; totipotency, STEM cells, polarity.
10. Concept of organogenesis and embryogenesis in plants

Practical:

Credit : 2
Contact Hours per Week : 4

1. ABO and Rh blood grouping
2. Microscopic identification of fungal and bacterial plant pathogens.
3. Identification of chick embryos at 24, 48, 72 and 96 hours of incubations
4. Study of fetal development in mammals through charts/models
5. Study slides of gastrulation and organogenesis.
6. Super ovulation, isolation of oocytes and sperm from mice, IVF (demonstration only)

LISC251C07: Biostatistics and Bioinformatics

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Biostatistics:

1. Introduction to Biostatistics: Variables and attributes; Population vs. sample; Criterion vs. predictor; Statistics and Parameters; Parametric vs. Non-parametric statistics; Sample distribution and Probability distribution; Random vs. Biased sampling

2. Graphical and Tabular presentation of data: Line diagram; Bar diagram; Pie chart; Histogram; Scatter plots; Box-whisker plots; Frequency distribution charts; Frequency Polygon & Ogive; Skewness & Kurtosis.
3. Measures of central tendency: Arithmetic Mean; Median; Mode of raw data and grouped data.
4. Measures of dispersion: Variance; Standard deviation; Standard error of mean; Standard score.
5. Testing of Hypothesis: Null hypothesis and alternative hypothesis; levels of significance; critical scores; errors of interference, Z test, Student's t-test.
6. Nonparametric statistics: Chi-square test, G test for goodness of fit.
7. Correlation: Tests for parametric and nonparametric variables.
8. Regression: Linear regression

Bioinformatics:

1. Introduction to Bioinformatics: Scope and applications of bioinformatics, Global bioinformatics scenario, Information from nucleic acid/protein sequences and structures. Introduction to databases: types of databases, information retrieval system (Entrez and SRS) and database collaboration, file formats, sequence, structure and pathway databases of nucleotides and proteins
2. Protein and Nucleic Acid Sequence Data Banks – NBRF-PIR, SWISSPORT, GenBank, EMBL.
3. Structural data bank – PDB, SCOP, CATH, CSD
4. Sequence Analysis – Analysis tools for sequence data banks, Pair–wise alignment – NEEDLEMAN AND WUNSCH ALGORITHM, SMITH WATERMAN. Multiple alignments – CLUSTAL, BLAST, FASTA algorithm to analyze sequence pattern, motifs and profiles.
5. Basics of Systems biology.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Biostatistics: Solving problems based on each test.
2. Pairwise and Multiple Sequence Alignment.
3. Accessing sequence and structure databases and information retrieval
4. Phylogenetic tree Analysis
5. Prediction of protein structure
6. Viewing three dimensional Structures of Macromolecules.
7. Protein- Protein Interactions (STRING)

LISC252C08: Ethology and adaptation

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Concept of innate and learning behavior
2. Eusociality and Elements of social behaviors in animals (selfishness, altruism, kinship and cooperation)
3. Communication – channels of communication, bee dance, role of pheromone in regulating communication.
4. Parental care in fish and amphibia.
5. Foraging behavior of animals with reference to cost and benefit analysis.
6. Aggressive behavior – competition, territoriality and dominance hierarchy; Game theory and evolutionary stable strategy.
7. Adaptations in animals – primary and secondary aquatic adaptation, primary and secondary volant adaptation, cursorial adaptation, arboreal adaptation, fossorial and desert adaptation. Adaptive radiation in vertebrates

Practical:
Credit : 2
Contact Hours per Week : 4

1. Identification of Birds and birds call
2. Pug mark and hoof mark identification (Tiger, leopard Gaur, Chital).
3. T-tube experiment on insect behavior.
4. Adaptive feature of forest animals
5. Identification of common lepidopteran insect (Butterflies)
8. Identification of common Hymenopteran insect

SEMESTER V (MAJOR COURSE ELECTIVES)

LISC301C09 A: Diversities and Evolution of Plant Groups
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Transition of plants from aquatic to land Habit: morphological, anatomical and biochemical adaptations, heterospory and origin of seed habit
2. Special adaptations in angiosperms: Insectivorous plants, parasitic plants, halophytic plants, xerophytic plants,
3. Special adaptations in algae and fungi: origin and evolution of sex in algae, heterocyst; heterotrophy, heterothallism, parasexualism in fungi
4. Molecular and Chemical approaches to plant diversity: Application of DNA markers to study genetic diversity; molecular phylogeny; Chloroplast, nuclear and mitochondrial DNA markers; Role of phytochemicals in plant diversity.

Practical:
Credit : 2
Contact Hours per Week : 4

1. Demonstration of specimens having heterocyst
2. Demonstration of VAM fungi and Mycorrhizal roots
3. Study through specimens/slides of Parasitic angiosperms, Velamen roots
4. Plant genomic DNA Isolation, quantitative and qualitative assessment.

LISC301C09 B: Functional morpho-anatomy of non-chordates and chordates
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Aquiferous system and endoskeleton in Porifera.
2. Coral and coral reef formation
3. Locomotion and excretion in Annelida
4. Respiration and excretion in Arthropoda.
5. Nervous system and respiration in Mollusca.
6. Water vascular system in Echinodermata.
7. Balanoglossus - anatomy, affinities and systematic position
8. Comparative account -Lamprey and Hagfish, Elasmobranchii and Teleostomi, Lacertilia and Ophidia, Ratitae and Carinatae
9. Anatomy and affinities of sphenodon.
10. Exoskeletal structure in amniotes.
11. Comparative anatomy of heart and aortic arch.
12. Comparative anatomy of kidney.
13. Ruminant stomach.

Practical:
Credit : 2
Contact Hours per Week : 4

1. **Major dissections**
   Cockroach : i) Salivary apparatus (with Hypopharynx), ii) Nervous system and iii) Male reproductive system iv) Urinogenital system of *Tilapia* sp.
2. **Minor dissections**
   i. Digestive system of cockroach
   ii. Female reproductive system of cockroach

iii. Mouth parts of cockroach
iv. Brain,
v. Pituitary gland of *Tilapia sp. / Oreochromis sp.* (as available)
vi. Cycloid and Ctenoid scale of fin fish

LISC301C09 C: Digestion, Excretion and Thermal Homeostasis

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Structure, function and regulation of the alimentary system: Alimentary system: Anatomy and histology of the alimentary canal. Digestive glands, Movements of alimentary canal, Composition, functions and regulation of the secretion of salivary, gastric, pancreatic and intestinal juices and bile. Enterohepatic circulation. Digestion and absorption of macro and micronutrients. Common disorders of the GI tract.
2. Renal physiology: Anatomy of kidney; Histology of nephron. Renal circulation – Formation of urine. Countercurrent multiplier and exchanger. Renal regulation of osmolarity. Renal regulation of acid-base balance. Physiology of urinary bladder and micturition. Composition of urine. Abnormal constituents of urine, renal dialysis. Non-excretory functions of kidney. Renal function tests.
3. Skin and body temperature regulation: Structure and functions of skin. Cutaneous circulation. Sweat glands Sweat formation, secretion and its regulation. Insensible perspiration. Regulation of body temperature in homeotherms, pyrexia, hyperthermia and hypothermia. Concept of Q10.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Study of Intestinal movements of rats and the effect of drugs on such movements.
2. Histological study of kidney, bladder, different regions of GI tract and skin.
3. Field study.
4. Diet Survey

LISC301C09 D: Enzymology

Credits - 6: (Theory:- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Basics of enzymology: Definition, examples of holoenzymes, apoenzyme, cofactors: definition, examples of a) metal ions b) coenzymes c) prosthetic group, classification of enzymes: IUPAC nomenclature, Name and examples of each class.
2. Enzyme Kinetics: concept of enzyme catalysis: active site, activation energy and Arrhenius concepts, specificity of enzymes-geometric and stereo specificity with example, lock and key hypothesis, induced fit hypothesis, derivation of Michaelis-Menten equation for uni-substrate reactions. Different plots for the determination of Km and Vmax and their physiological significance. Importance of Kcat/Km. Kinetics of zero and first order reactions. Classification of multi-substrate reactions with examples of each class. Ping Pong, random and ordered Bi-Bi mechanisms.
3. Quantitative assay of enzyme activity: Unit of enzyme activity, specific activity, molecularactivity/turnover number, molar activity, katal.
4. Factors affecting enzyme catalyzed reaction: concentration, temperature, pH, time and cofactors.
5. Inhibition of enzyme catalyzed reaction: reversible and irreversible inhibition, linear-mixed type inhibitions and their kinetics, Suicide inhibitor.
6. Mechanism of Enzyme Action: Enzyme catalysis- acid-base, covalent and metal ion catalysis, proximity-orientation effect, strain and distortion theory; case studies. Experimental approaches to determine the mechanism of enzyme action.
7. Variation from classical types: Isozymes with examples, abzymes, synzymes, non-protein enzymes.
8. Regulation of enzymes: allosterism, sequential and concerted model, feedback inhibition and feedforward stimulation, reversible (glutamine synthase and phosphorylase) and irreversible (proteases) covalent modifications of enzymes, zymogens. Monocyclic and multicyclic cascade systems with specific examples; flip flop mechanism.
9. Methods of enzyme purification and characterization - dialysis, ultra-filtration, ultracentrifugation, molecular exclusion chromatography, isoelectric precipitation, salting in, salting out, solvent fractionation, electrophoresis- paper and SDS-PAGE, ion exchange chromatography, adsorption chromatography, affinity chromatography. Basic concepts of proteomics and enzyme identification.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Preparation of standard curve of p-nitrophenol and determination of molar extinction coefficient.
2. Determination of optimum substrate concentration and enzyme kinetic parameters of alkaline phosphatase using MichaelisMenten hyperbolic curve.
3. Determination of Km and Vmax of alkaline phosphatase using Line weaver Burk plot.
4. Determination of optimum pH of alkaline phosphatase.

LISC301C09 E: Microbial diversity

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Members of the Microbial World

1. Acellular microorganisms:
   Viruses, subviral agents (Viroids and Prions) with emphasis on distribution occurrence, general morphology and infectivity.
2. Cellular microorganisms:
   Archaea: Systematics, and occurrence, diversity, characteristic features, significance and potential applications (eg. biochips, methane generation, ultrafiltation membranes, production of PHB and PHA, desulphurization of coal and crude oil, bioleaching of metals, enzymes, compatible solutes and others) of different groups of archaebacteria (Crenarchaeota, Euarchaeota, Korarchaeota, Nanoarchaeota).
   Bacteria: General discussion on the occurrence, diversity, characteristic features, significance and potential applications of various groups of bacteria according to Bergey's Manual of Systematic Bacteriology.
   Algae: General characteristics of algae, thallus organization, ultra-structure of algae cell, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles. Importance of algae in production of algal pigments, biofuels, hydrogen production, important bioactive molecules, role of algae in sustainable environment.
   Fungi: General characteristics of fungi, fungal cell wall, ultra- structure, thallus organization and aggregation. Asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Economic importance of fungi.
   Protozoa: General characteristics with special reference to *Amoeba, Paramecium, and Leishmania.*

Practical:

Credit : 2
Contact Hours per Week : 4

1. Good laboratory practices and biosafety measures in microbiological laboratory.
2. Application and principles of biological safety cabinets, autoclave and hot air oven.
3. Operation of light microscope.
4. Study of *Penicillium/Aspergillus* using permanent mounts.
5. Study of *Spirogyra/ Volvox/ Amoeba/Paramecium* using permanent mounts.

LISC302C10A: Plant Architecture and Systematics

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Morphology:

1. General concepts of root, stem, and leaf morphology and modifications
2. Flower: Types; Parts Calyx (modification), Corolla (Forms and aestivation), Stamen (adhesion and cohesion, attachment of anther), Carpel (apocarpous and syncarpous), Placentation (types) Ovules (types and structure); Inflorescence: Types with examples
3. Pollination: Types, contrivances; Fruit: Types and examples.

Anatomy:

1. Apical meristem: Organization of shoot apex (Tunica Corpus), root apex (KorperKappe)concept.
2. Stomata: Types (Metchalfe and Chalk), Ontogeny.
3. Stele: Types and Evolution.
4. Secondary growth: Normal (intra and extra stelar), Anomalous (with common examples)
5. Introduction to Plant systematics:
6. Classification: Broad outline of Bentham and Hooker (1862-1883) and Angiosperm Phylogeny Group (APG) Classification.
7. Numerical Taxonomy: Aims and objectives, characters and attributes, Operational Taxonomic Units (OTU), Coding cluster analyses, merits and demerits, cluster analysis, phenograms, cladistics.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Identification of different types of inflorescence available in the study area
2. Anatomical study of secondary anomalous growth and structures of vascular bundles
3. *In silico* study to calculate similarity index and development of phylogenetic tree
4. Field visit to study important Family specific taxonomic characters

LISC302C10B: Advanced cell and molecular biology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Cell Biology

1. Fluid mosaic model; Experimental supports to membrane fluidity; Molecular organisations of voltage gated and ligand-gated ion channels; Glycocalyx and its significance.
2. Physical and chemical signals; second messenger; Enzymatic, G-protein coupled and channel-linked receptor signals; signal transduction by enzymatic receptors with reference to insulin action; signal transduction by GPCR.
3. Phases of cell cycle and its regulations; cadherins and their role in cell-cell adhesion; molecular structure and composition of collagen fibres.
4. Characteristics of cancerous cells; classification of cellular and viral oncogenes; Tumor suppressor genes; Cancer therapy.

Molecular Biology

5. Process of replication in pro- and eukaryotes; Bidirectional replication in eukaryotes; DNA damage and repair pathways; Disease due to failure of DNA repair.
6. Types and structure of RNA; Pro- and eukaryotic RNA polymerases; promoters in pro- and eukaryotes; mechanism of transcription.
7. Genetic code and its properties; Wobble base-pairing; biosynthesis of proteins in pro- and eukaryotes; Operon concept.
8. Restriction endonuclease action; cloning of genomic DNA; cDNA cloning and its advantage; different cloning vectors; polymerase chain reaction and its modification.
9. Southern, Northern and Western blotting; Analysis of RFLP and detection of genetic disease; DNA fingerprinting and paternity testing; RAPD analysis.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Study of different stages of meiosis by grasshopper testis preparation
2. Genomic DNA isolation from animal tissue
3. RNA isolation from bacteria/ yeast/ animal tissue/ plant tissue
4. Polymerase chain reaction.

LISC302C10 C: Blood, body fluids, hematology, cardiovascular system and respiration

Credits - 6: (Theory- 04, Practical:- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Blood and body fluids: Formed elements of blood. Plasma proteins, Haemoglobin: types, abnormalities, biosynthesis and catabolism. Different types of anaemia and their causes. Blood volume; Hemostasis –factors, mechanism, anticoagulants and disorders. Blood groups; Blood transfusion and its hazards. Lymph and tissue fluids; Lymphatic organs.

2. Physiology of Heart: Anatomy of the heart. Properties of cardiac muscle. Cardiac action potential; cardiac impulse. The cardiac cycle - Heart sounds. Cardiac output-Electrocardiography – the normal electrocardiogram, the mean electrical axis of the heart.Principles of Echocardiography. Cardiac Arrhythmias –Myocardial Infarctions.
3. Vascular Physiology: Functional morphology of arteries, arterioles, capillaries, venules and veins, sinusoids. General pattern of circulation; the pulse – Hemodynamics of blood flow; Blood pressure – factors affecting. Cardiac and vasomotor centers, baroreceptors and chemoreceptors, cardiac and vasomotor reflexes. Cardiovascular homeostasis.
4. Regional circulation: Cerebral, Coronary, Hepatic, Splanchnic and skeletal muscle circulation.Pathophysiology of circulation: Haemorrhage, Hypovolemic and hypervolemic shock. RTI and atherosclerosis.
5. Physiology of respiration: Anatomy and histology of the lung and airways. Mechanics of breathing -Lung volumes and capacities. Alveolar surface tension and surfactant, work of breathing. Ventilation- perfusion ratio Dead space and uneven ventilation. Spirometry. Pulmonary circulation. Transport of gases in the body. Partial pressure and composition of normal atmospheric gases in inspired, expired, alveolar airs and blood. Oxygen dissociation curve of haemoglobin and myoglobin – factors affecting. Carbon dioxide dissociation curve. Regulation of respiration -neural and chemical, respiratory centres, chemoreceptors, baroreceptors, pulmonary receptors. Hypoxia –Asphyxia, Voluntary hyperpnoea, Apnoea, Cyanosis, Periodic breathing, Asthma, Emphysema. Lung function tests. Concept of non-respiratory functions of the lung.

Practical:
Credit : 2
Contact Hours per Week : 4

1. Introduction to Experimental Physiology : Study of the kymographic recording of perfused heart beats of toad, recording respiratory movements using pneumograph
2. Recording of Arterial Blood pressure by Auscultatory method.
3. Estimation of haemoglobin.
4. Preparation and staining of blood film, total and Differential count.

LISC302C10D: Advanced Molecular Biology
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Organization of the genome: Organization of bacterial and viral genome Complexity of eukaryotic genes and chromosomes, Cot Curve analysis, Nucleosome structure and

packaging of DNA into higher order structures, DNA topology and topoisomerases, Mitochondrial and Chloroplast genome organization.

2. DNA Replication, Recombination and Repair: Chemistry of DNA synthesis, Mechanism of DNA Replication in prokaryotes and eukaryotes, Replication errors, DNA damage and repair pathways in bacteria as well as eukaryotes, Homologous recombination, site specific recombination, Non-homologous end joining and Transposition of DNA.
3. Transcription and post-transcriptional processing: Types of RNAs, DNA-dependent RNA polymerase, sigma factor, bacterial promoters, identification of DNA binding sites by DNA footprinting, the three stages of RNA synthesis, initiation, elongation and termination, rho-dependent and rho-independent termination. Transcription in eukaryotes, inhibitors of transcription and applications as antibiotics, Modification of eukaryotic mRNA at the 5' and the 3' end, splicing introns, differential RNA processing, processing of rRNAs and tRNAs, special function RNAs, RNA as enzyme.
4. Translation: Cracking the genetic code, degeneracy, wobble hypothesis, features of the genetic code, translational frameshifting and RNA editing, the ribosome as a supramolecular machine, structure of tRNAs, the five stages of protein biosynthesis, aminoacyl-tRNA synthetases, initiation in prokaryotes and in eukaryotes, elongation, termination, folding and processing, inhibitors of protein synthesis.
5. Regulation of gene expression in Bacteria and Bacteriophages: Operon concept with reference to *lac, trp* and *ara* operons in *E. coli;* Gene Regulation in bacteriophage Lambda, Riboswitches, Post transcriptional and post translational regulation in bacteria
6. Regulation of gene expression in Eukaryotes: Levels of control of gene expression in Eukaryotes, Role of chromatin in regulation of Transcription, gene regulation during development in few model organisms, RNA processing control, mRNA translational control, RNA Interference, Gene silencing, Genomic Imprinting, Post transcriptional and post translational regulation.

Practical:
Credit : 2
Contact Hours per Week : 4

5. Genomic DNA isolation from bacteria/ yeast/ animal tissue/ plant tissue
6. Plasmid DNA isolation from bacteria
7. RNA isolation from bacteria/ yeast/ animal tissue/ plant tissue
8. Polymerase chain reaction.

LISC302C10E: Bacteriology and Virology
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

Bacteriology

1. Bacterial morphology and subcellular structures
   - Bacterial Cell: Size and shape, organization, cytoskeleton
   - Cell membrane and cell wall: Cell membrane, cell wall capsule and other layers. Proteobacterial cell envelope, Mycobacterial cell envelope, Archaeal cell wall.
   - Locomotory system: Flagella and others (structure, composition and function) gliding motility, twitching motility.
   - Subcellular structures: Ribosomes, cytoplasmic inclusions (carboxysomes, magnetosomes, polyphosphate, sulfur, and carbonate minerals), Gas vacuoles.
   - Nuclear and extra-chromosomal materials: Nucleoid and its differences with the eukaryotic chromosome. Plasmids and episomes.
   - Special structures: Endospore (structure, formation and maturation), Exospores and cysts.
   - Cell Polarity and Aging: Bacterial cell differentiation, Polar Aging.
2. Bacterial Transport system: Passive and facilitated diffusion, Primary and secondary Active transport, Group translocation, Iron uptake.
3. Bacterial Reproduction: Asexual & bacterial recombination (Transformation, Transduction, Conjugation).

Virology

1. General characteristics and classification: Baltimore classification, classification of viruses based on capsid symmetry- helical (TMV), icosahedral (polyoma), complex (bacteriophage) viruses with examples.
2. Bacteriophages: Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage.
3. Viral Transmission: Characteristics of viral nucleic acids and replication modes of viral transmission: persistent, non-persistent, vertical and horizontal. Replication strategies of viruses as per Baltimore classification, assembly, maturation and release of virions.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Capsule staining.
2. Endospore staining
3. Isolation of Bacteria from atmosphere.
4. Viral titer determination using plaque assay

LISC303C11A: Plant Physiology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Water and Plant cells: Water balance of plants, Water potential, Xylem components, Solute transport - Long-distance transport of water and dissolved solutes via xylem, The Soil-Plant-Atmosphere continuum
2. Translocation via phloem: Constituents of phloem, concept of source and sink, mechanism of translocation via phloem.
3. Mineral nutrition: Essential nutrients, deficiencies and plant disorders
4. Plant hormones: Auxin, Cytokinin, Gibberellin, Ethylene, Abscisic acid, Strigolactone - Biosynthesis, transport, signaling, and physiological effects
5. Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins
6. Transpiration in plants: Role of stomata and ABA. stomatal movement
7. Seed Dormancy and senescence

Practical:

Credit : 2
Contact Hours per Week : 4

1. Calculation of stomatal index
2. Biochemical estimation of a Plant Growth Regulator
3. Test of pollen viability
4. Evaluation of heavy metal stress (Arsenic and Cadmium) in rice using hydroponics

LISC303C11 B: Applied ecology and wildlife biology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Applied Ecology

1. Species Interaction: Community dynamics, structure and interaction; interactions among ecological processes; diversity and stability.
2. Evolutionary Ecology: Natural selection; Adaptation; Phenotypic Plasticity; Evolutionary significance of Predator-prey interactions, Parasite-host interactions, Plant-herbivore interactions; co evolution.
3. Molecular and Chemical Ecology: Concept of molecular and chemical ecology, molecular marker in ecology; applications of molecular and chemical ecology.

5. Microbial Ecology: Diversity and function; microbes in relation to garbage and sewage management; microbes in biogeochemical cycle.
6. Resource Ecology: Concept, human impact, physiochemical factors and their impacts on aquatic biota, agro-ecosystem, productivity and factors influencing productivity.
7. Field Ecology: Monitoring of site characteristics; Sampling techniques of static and mobile organism (pit fall trap, quadrate sampling, transects, direct observations, indirect methods, capture techniques, marking individuals, pug mark techniques, radio-tracking etc.).

Wildlife Biology

1. Indian Wildlife: Introduction, Distribution of Wildlife in Ecological Subdivision of India, IUCN Categories
2. Protected Area Network: National Parks, Wildlife Sanctuaries, Biosphere Reserves and Zoos in India,
3. Reasons for Wildlife Depletion: Habitat Fragmentation, Habitat Destruction, Commercial Wildlife Exploitation, Overgrazing Etc.,
4. Wildlife Conservation: Special Projects for Endangered Species
5. Introduction to Conservation Biology, Conservation Values and Ethics of Conservation of Natural Resources.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Principle and function of some aquatic and sediment sample collection equipments
2. Estimation of some water quality parameters (e.g. dissolved oxygen, Free CO_2, pH, Ammonia)
3. Study of biotic components of an aquatic body
4. To determine water holding capacity and percolation rate of soil
5. Estimation of calorific value of some economically important aquatic animals
6. Plotting of survivorship curves from hypothetical life table data
7. Study of ecology of animals in their natural habitat (Forest/ aquatic ecosystem) by field excursion tour

LISC303C11C/D: Intermediary Metabolism

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Concept of Metabolism: Principles of bioenergetics-Standard free energy change, metabolic roles of ATP-Phosphoryl group transfer, nucleotidyl group transfer. Experimental approaches to study of metabolism; Primary and secondary metabolism Energetics.

2. Metabolic Pathways
    a. Carbohydrate metabolism - Glycolysis, alcoholic and lactic acid fermentation, Pasteur Effect, gluconeogenesis, Cori cycle, glucose-alanine cycle, futile cycle. TCA cycle, HMP shunt, glycogenolysis& glycogen synthesis. Disorders associated with defects in carbohydrate metabolism- a brief account on fructose intolerance, lactose intolerance, lactic acidosis, disorders related to glycogen metabolism, genetic deficiency of Glucose-6- phosphate dehydrogenase, Galactosemia, Diabetes Mellitus (NIDDM and IDDM).
    b. Lipid metabolism - Mobilization of triglycerides, metabolism of glycerol, β-oxidation of saturated, monounsaturated and poly-unsaturated fatty acids, even and odd chain fatty acids. Ketogenesis and significance, Biosynthesis of saturated and unsaturated fatty acids, synthesis of triglycerides and cholesterol, lipoproteins-synthesis, transport and its disorders.
    c. Protein metabolism - basic reactions: transamination and deamination, decarboxylation, glucogenic and ketogenic amino acids, Urea cycle, biosynthesis and catabolism of amino acids (glycine, phenylalanine, glutamic acid).
    d. Nucleotide metabolism: Biosynthesis and catabolism of purines and pyrimidines (Adenine and cytosine). Porphyrin metabolism: Biosynthesis and degradation of porphyrins, biosynthesis of bile pigments.
3. Nutritional disorders: PEM (Kwashiorkor, and Marasmus), Micronutrient deficiency, Obesity.
4. Metabolic disorder :Diabetes.
5. Inborn errors of metabolism-Protein-PKU, Alkaptonuria and Maple syrup and Gaucher's disease.
6. Metabolic Integration: Metabolic changes during starve-feed cycle, exercise, diabetes and alcohol abuse.
7. Oxidative phosphorylation: Components, properties and function of electron transport system, chemiosmotic hypothesis, inhibitors and uncouplers of the electron transport system, Shuttle systems.
8. Microbes and Metabolism: Role of microbes in metabolic tasks- alternate metabolic cycles. Carbon metabolism of intracellular bacterial pathogens, Nitrogen fixation; environmental cleansing, metabolic handling of xenobiotics and drug resistance, photo and lithotrophic metabolic capabilities.

Practical:
Credit : 2
Contact Hours per Week: 4

1. Estimation of blood glucose – Glucose Oxidase method
2. Estimation of Cholesterol
3. Estimation of SGPT and SGOT
4. Estimation of Bilirubin

5. Estimation of creatinine
6. Estimation of serum protein, serum albumin, serum A: G ratio.

LISC303C11E: Microbial Nutrition and Metabolism:

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4

Contact Hours per Week 4

Microbial Nutrition

1. Cultivation of microbes: Nutritional requirements of microbes; Classification of microbes on the basis of nutrition – Phototrophs, Chemotrophs, Autotrophs and Heterotrophs; Different types of Media; Physical conditions required for microbial growth – temperature, gaseous conditions and pH; Choice of media and conditions of incubation.
2. Reproduction and growth of Microbes: Growth Curve; Transitional periods between growth phases; Synchronous Growth; Continuous Culture. Different techniques for growth measurements; Determination of nitrogen content and dry weight of cells. Mode of nutrition in methylotrophs and methanogens; Utilization of light energy by halobacterium.
3. Pure Cultures and Characteristics of cultures: Natural microbial populations (mixed cultures); Chemical methods of selection; Physical methods of selection; Biological methods of selection; Selection in nature; Methods of isolating pure cultures; Maintenance and preservation of pure cultures - methods of maintenance and preservation.

Microbial Metabolism:

1. Microbial enzymes and energetics: Classification of microorganisms on the basis of energy requirement; Basics of bioenergetics; Free energy formation and calculation of free energy changes; Catalysis and enzymes – their involvement in microbial metabolism; Factors affecting the rate of enzyme mediated reactions; The role of ATP in metabolism.
2. Microbial photosynthesis: Photosynthetic pigments and apparatus in bacteria; Photophosphorylation; C_3 and C_4 pathways; Oxygenic and anoxygenic photosynthesis – their significance and characteristics.
3. Microbial respiration and fermentation: Concept of aerobic respiration, anaerobic respiration and fermentation; Sugar degradation pathways - EMP, ED and Pentose phosphate pathway; TCA cycle and Electron transport chain.

Practical:

Credit : 2

Contact Hours per Week : 4

1. Growth kinetics of Bacteria
2. Effect of temperature and pH on growth of *E.coli*.
3. Demonstration of Microbial cell count.

LISC341SI01 (Summer Internship: 4 credits)

Credit : 4
Contact Hours per Week : 8

Students will do internship under the supervision of Faculty members of DLS during semester break.

SEMESTER VI (MAJOR COURSE ELECTIVES)

LISC351C12A: Plant Resources and Bioprospecting

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Bioprospecting: General introduction to bioprospecting, Current practices in Bioprospecting for conservation of Biodiversity and Genetic resources. India as a Traditional Knowledge and biodiversity hotspot; Bioprospecting Act.
2. Plant Bioprospecting: Cultivation and Marketing of Medicinal Plants/Threatened Medicinal and Aromatic plants. and Conservation; Ethnopharmacology, Drug Discovery and Product Development; Pharmacology of Plant Products, Non-timber forest products (NTFPs): Bamboos, Gums, Dyes, Lichens, Resins
3. Marine Bioprospecting: Sources of marine organisms and their Bioprospecting, Isolation and cultivation of Marine bioresources and their industrial applications; phytoplanktons, seaweeds, and fungi.
4. Microbial Bioprospecting: Isolation of Microbial metabolites and their bio-activity; Endophytic microbial products as Antibiotics; extremophiles as source of bioactive compounds
5. Biopiracy: Threats and effects; Recent cases of Biopiracy: Neem, haldi and basmati patent; Intellectual Property Rights (IPR).

Practical:

Credit : 2
Contact Hours per Week : 4

Practical syllabus

1. Identification of phytoplanktons from aquatic habitat
2. Field visit to study economically important plants/ algae *in situ*
3. Biopiracy in economically important flora from biodiversity hotspot and their *in situ* conservation: a field study
4. Sustainable utilization of medicinal plants and NTFPs from different geographical regions.

LISC351C12 B: Biosystematics and Molecular Phylogenetics

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Concept of systematics and taxonomy, alpha, beta and gamma taxonomy, phenon, taxon, taxonomic category, Linnean hierarchy.
2. Nomenclature of animal and plant taxa and International code of Zoological nomenclature
3. Type concept and its applications
4. Different species concept, their merit and demerits.
5. Characters; OTU, Principles and theories of animal classification (Phenetics and Cladistics concept)
6. Phenogram and Cladogram constructions
7. Concept of cytotaxonomy, Biochemical taxonomy and Molecular Taxonomy
8. Phylogenetic tree reconstruction (cluster analysis).

Practical:

Credit : 2
Contact Hours per Week : 4

1. Study of museum specimen for preparations of taxonomic key (non-chordates and chordates)
2. Analysis of cytotaxonomic and biochemical taxonomic data.
3. Construction of phylogenetic tree by using sequence data

LISC351C12C/D/E: Advanced Cell Biology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Structure and functions of cell membrane, membrane transport: types of membrane transport and transporter proteins, ATP powered pumps and ion channels. Concept of resting membrane potential, Transport system in prokaryotes
2. Structure and functions of Endoplasmic reticulum and Golgi apparatus. Protein import, processing and post translational modifications. Exocytosis and endocytosis.
3. Quality control (unfolded protein response, autophagy, degradative pathways). Cellular responses to stress. The lysosome and its function.
4. The cytoskeleton and its regulation. Microtubules, microfilaments and proteins regulating their function. Molecular motors. Intermediate filaments. Concept of cell adhesion and

the use of cytoskeleton to regulate cell shape, muscle contraction, mitosis, and cell migration.

5. Nuclear envelope, structure of nuclear pore complex, nuclear lamina, transport across nuclear membrane, Nucleolus, rRNA processing.
6. Structural organization, function, biogenesis of mitochondria and chloroplasts, brief account of transport in mitochondria and chloroplasts (Tim/Tom; Tic/Toc) and semiautonomous nature of mitochondria and chloroplast.
7. Signaling molecules and their receptors, functions; intracellular signal transduction pathways (with special reference to some selected pathways); signaling networks and cross talk;
8. Cell cycle and its regulation. Cell cycle analysis by flow cytometry.
9. Different types of cell death: apoptosis, necrosis. Apoptotic pathways and their regulations. Methods to study cell death.
10. Cancer, dysregulation of cell cycle. Biology and elementary knowledge of development and causes of cancer; Types and stages of cancer, concept of Oncogenes and suppressor genes, cellular and viral oncogene, Tumor heterogeneity and tumor microenvironment. Invasion and metastasis. Cancer treatment-Molecular approach, Stem cell therapy and immunotherapy
11. Experimental approaches to study cellular organization and processes: Use of pulse-chase experiments, mutants- temperature-sensitive mutants, yeast genetic mutants, dominant-negative mutants, immunoprecipitation and protein-protein interaction studies, use of drugs/ toxins/inhibitors, siRNA mediated knockdown of key proteins, post-translational modifications and how to test for them, marker enzymes of organelles,

Practical:

Credit : 2
Contact Hours per Week : 4

1. Study of different stages of meiosis by temporary preparation/ permanent slides of onion flower buds.
2. Study of different stages of mitosis by temporary preparation/ permanent slides of onion root tips.
3. Staining of fixed tissue sections by hematoxylin - eosin method.
4. Identification and study of types of cancer, cancer cells by permanent slides/ photographs.
5. Study of the following microscopic techniques by photographs: Fluorescence microscopy, autoradiography, positive staining, negative staining, freeze fracture, freeze etching, shadow casting
6. Cell fractionation using differential centrifugation.

LISC352C13-A: Plant Tissue Culture and Plant Breeding

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

Plant Tissue culture:

1. General Concepts: Totipotency: definition and importance, Callus culture, Somaclonal variation and assessment of clonal fidelity; Culture media: composition, preparation and sterilization
2. Suspension Culture: Culture systems, Isolation of single and aggregate of cells and regeneration of plants; Immobilization of cells and use of bioreactors and hairy root culture
3. Protoplast Culture: Isolation of protoplast, culture of protoplast; Protoplast fusion: Electrofusion and Chemical fusion; Somatic cell hybridization- cybrids
4. Commercial Applications: Somatic embryogenesis and Organogenesis, Synthetic seeds, Micropropagation and its application, Anther culture and production of haploids
5. Conventional Breeding Concepts: Maintenance and conservation of germplasm, Cryopreservation, Mass selection and Pure line selection, Heterosis and hybrid seed production, Male sterility, types and its use in plant breeding. Basic concepts on polyploidy and mutation breeding
6. Molecular Plant Breeding: Techniques: RFLP, RAPD, SCAR, SSR, AFLP, ITS, cDNA-AFLP, Utility of marker assisted selection (MAS) in crop improvement.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Different sterilization and explant preparation techniques
2. Preparation of tissue culture media
3. Seed embryo rescue and synthetic seed preparation
4. Establishment of callus culture
5. Visiting a commercial Tissue Culture Facility

LISC352C13 B:Animal Physiology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Physiology of circulation
2. Physiology of osmoregulation
3. Animal endocrinology

3. Physiology of excretion
4. Nervous system and Sensory physiology
5. Temperature regulation

Practical:
Credit : 2
Contact Hours per Week : 4

1. Staining and identification of various stages of estrous cycle of rat
2. Estimation of blood haemoglobin
3. Estimation of salivary amylase activity in animal model

LISC352C13C: Endocrinology, Neuroendocrinology and Human Reproduction
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Biology of Informational Molecules.
2. Classification of endocrine glands and hormones. Patterns of hormone biosynthesis.
3. Regulation of secretion of the hormones.
4. Receptors and Bio signalling: Mechanism of hormone action and genetic control of endocrine function. Cell surface and intracellular receptor proteins. Intracellular messengers. Signal transduction pathways.
5. Neuroendocrinology: Hypothalamus as a neuroendocrine organ. Pineal gland – structure and function.
6. Role of Hormones in Metabolism: Structure and function of anterior and posterior pituitary, thyroid and parathyroid glands, Thymus , adrenal, Pancreas and regulation of blood sugar, Hormonal regulation of calcium metabolism. Heart as an endocrine organ. Prostaglandins and Kinins; Gastro-intestinal hormones, Endocrine disorders. Endocrine responsive cancers in humans, Autoimmunity and endocrine disease.
7. Biology of Human Reproduction: Physiology of puberty. Histology and endocrine functions of testis. Spermatogenesis. Regulation of testicular functions, sexual differentiation. Histology of ovary. Ovarian hormones and their functions and control. Oogenesis, folliculogenesis and ovulation. Corpus luteum and leuteolysis. Estrous cycle. Menstrual cycle, regulation of reproductive cycle, Menopause; Fertilization, gamete transport, Implantation. Structure and functions of placenta. Maintenance of pregnancy and the bodily changes during pregnancy. Pregnancy tests. Parturition. Lactation - Growth and development of mammary gland, milk production and ejection, mechanism of prolactin action, Galactopoiesis.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Study of Rat estrous cycle
2. Staining and identification of permanent sections of endocrine glands
3. Preparation of rat sperm suspension and sperm count (Macklers chamber/ Neuber's chamber)
4. Ectomy of rat testis, ovary and adrenal gland.

LISC352C13D/E: Clinical Microbiology

Credits - 6: (Theory- 04, Practical- 02)

Theory : 4
Credit : 4
Contact Hours per Week : 4

1. Distribution, Emergence, and Re-emergence of pathogenic disease(s) in India.
   Introduction to Major Pathogenic Diseases and Diagnosis: Respiratory Infections, Tuberculosis [The Mantoux tuberculin skin test (TST) or the TB blood test]. Introduction to Urinary Tract Infection, and Enteric Diseases. Concepts of drug resistance and drug repurposing.
2. Viruses as a causative agent for Cancer:Human papillomavirus (HPV): Cervical Cancer, PAP Smear, Epstein-Barr virus (EBV), Human immunodeficiency virus (HIV), and Hepatitis C virus (HCV).
3. Wound Microbiology: *Staphylococcus aureus*, *Clostridium tetani*, Gangrene and causative bacteria *Clostridium perfringens*. Post-surgery infection, MRSA.
4. Mycosis (Fungal infection) management: Candidiasis, Ringworm (dermatophytosis) Onychomycosis.
5. Protozoan diseases: Malaria, Giardiasis and Trichomoniasis
6. Diagnostic methods and handling sample pre and post examination : CD4 enumeration by FACS for HIV diagnosis : ELISA for Hepatitis and RT-PCR for COVID-19.
7. Working principles and the emergence of Rapid diagnostic tests: Rapid antibody tests; Rapid HIV test, Rapid plasma regain: Rapid antigen tests, Rapid COVID-19 test, Rapid influenza diagnostic test, Malaria antigen detection tests, Rapid strep test, Rapid urease test (detection of *H. pylori*)

Practical:
Credit : 2
Contact Hours per Week : 4

1. Study of Bacterial flora of skin by swab method
2. Determination of minimal inhibitory concentration (MIC) of antibiotic(s)
3. Microscopic visualization and organelle identification in protozoan parasite
4. Identify bacteria on the basis of biochemical characteristic- IMViC

LISC353C14A: Stress Biology (Plants)

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Crop stress and productivity: General introduction to Biotic and Abiotic stresses, Concept of stress tolerant / susceptible germplasms, Plant physiological and biochemical changes under stress, The oxidative stress paradigm, ROS and redox signaling in response of plants to stresses, Perception and transduction of stress signaling, Stress responsive genes, Cross-tolerance to biotic and abiotic stresses in plants.
2. Genetic engineering for stress tolerance : Important biotic and abiotic stress genes and their utility in crop improvement: Bacterial resistance, Viral resistance (coat protein mediated, nucleocapsid gene), Fungal resistance (chitinase, 1-3 beta glucanase, RIP, PR proteins), Insect pests resistance (Bt toxins, lectins, protease inhibitors, alpha amylase inhibitor), herbicide resistance, Salinity (SOS, NHX, HKT1), Drought (DREB, ABI), thermal stress (COR, ABI), flooding (ANPs) and submergence tolerance (Sub1A), nutrient stress and nutrient use efficiency improvement, Root and root nodule engineering.
3. Pollution and Phytoremediation: Basic concepts of Air, water, and soil pollution. Phytoremediation - introduction, types of phytoremediation, bioremediation, genes regulating different phytoremediation properties and their impact in crop improvement.

Practical:

Credit : 2
Contact Hours per Week : 4

1. General laboratory practices in plant-pathology
2. Field survey of agricultural lands to diagnose field crop diseases and plant disease specimen collection
3. Staining bacterial/ fungal pathogen samples and microscopic observations
4. Demonstration of infection structures in plant pathogen samples by microscopy

LISC353C14B/C/D/E: Advanced Immunology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4

Contact Hours per Week : 4

1. Introduction to immunology, PAMP, DAMP, Pattern Recognition Receptor (PRR) and its functions; Antigen presentation, APC, Types of APC, MHC, MHC genes, concept of MHC Haplotype, Inheritance of MHC, Endogenous and exogenous antigen presentation, cross presentation.
2. Organization and expression of immunoglobulin genes, B cell receptor expression, T cell receptor expression
3. Cytokines and chemokines, Complement system- major pathways of activation, functions and regulations of complement activity, complement deficiency; Inflammations
4. T cell development and activation, positive selection, negative selection, self-tolerance, T cell differentiation and memory
5. B cell development and activation, germinal center, class switching, somatic hypermutation, affinity maturation, T cell independent B cell response, negative regulations of B cell
6. Cell and antibody mediated immune response in space and time, specialized immunity at epithelial barriers.
7. Allergy, Hypersensitivity, Autoimmunity and transplantation immunity.
8. Infectious disease and vaccines, Immunity against microbes, cancer and immune systems.
9. Immunological techniques: RIA, ELISA, Western blotting, Flowcytometry, Cytokine bead array, Experimental animal models.
10. Experimental approaches towards immunology

Practical:
Credit : 2
Contact Hours per Week : 4

1. Demonstration of isolation of spleen and lymph nodes.
2. Radial Immunodiffusion
3. ELISA
4. Demonstration of heterogeneous WBCs population using flowcytometer

LISC354C15A: Plant Biochemistry and Cell Biology
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

Plant Biochemistry

1. Photosynthesis Light harvesting complexes; mechanisms of electron transport, Photoprotective mechanisms (Xanthophyll cycle)
2. CO2 fixation; C3, Photorespiration, C4, and CAM pathways

3. Nitrogen metabolism Nitrate and ammonium assimilation
4. Secondary metabolites Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles

Plant Cell Biology

1. Introduction to plant cell
2. Biology of plant cell wall and membranes
3. Ultrastructures of important plant organelles: cytoskeletal elements, mitochondria and chloroplast; chloroplast-mitochondrial interaction, plant endomembrane system, plant vacuoles
4. Plant cell division: mitosis and meiosis

Practical:

Credit : 2
Contact Hours per Week : 4

1. Separation of plant organelles by differential centrifugation
2. Isolation of protein from plant samples and electrophoresis by SDS-PAGE
3. Study of different stages of mitosis and meiosis in plants
4. Transient expression studies in onion / tobacco using gene bombardment system

LISC354C15 B: Animal Histology, and Histochemistry

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Histology of mammalian stomach, liver, kidney, thyroid, pancreas and gonads
2. Ultrastructure of sarcomere and neuron
3. Fixation - Non-additive and additive fixatives and their mode of actions
4. Histological dyes – physical and chemical classification of dyes, mordanting, metachromasia
5. Animal histochemistry – Gomori‘s reaction, Saccaguchi‘s reaction, PAS reaction and Feulgen

Practical:

Credit : 2
Contact Hours per Week : 4

1. Identification of mammalian tissue (Stomach, liver, kidney, Pancreas, kidney, testis, placenta)
2. Staining of squamous epithelial cells
3. Tissue fixation and paraffin block preparation.
4. Section cutting and handling of microtomes
6. Staining of tissue sections with hematoxylin and eosin.

LISC354C15 C: Nervous system, physiology of nerve and muscle, sensory physiology
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Physiology of skeletal, smooth and cardiac muscle: Structure, mechanism and regulation of muscle contraction . Red and white striated muscle fibres. Single-unit and multi-unit smooth muscle. Muscle groups: antagonists and agonists. Properties of skeletal muscle: excitability, contractility, all or none law, summation, tetanus, onset of fatigue, refractory period, tonicity, conductivity, extensibility and elasticity. Optimal load, optimal length of fibres. Excitation- contraction coupling. Isometric and isotonic contractions. Electromyography.
2. Physiology of nerve: Structure, classification and functions of neurons and neuroglia. Cytoskeletal elements and axoplasmic flow. Myelinogenesis. The resting membrane potential, action potential, electrotonic potentials, current of injury. Propagation of nerve impulse in different types of nerve fibres.
3. Properties of nerve fibres, Synapses, Neurotransmitters, cotransmitters, and neuromodulators. The neuromuscular junction. Injury to peripheral nerves – degeneration and regeneration in nerve fibre, changes in the nerve cell body, Nerve growth factors.
4. Organization of nervous system: A brief outline of organization and basic functions (sensory, motor and association) of the nervous system (central and peripheral). Structural organization of different parts of the brain and spinal cord.
5. Reflex action: definition, reflex arc, classification and properties. Autonomic nervous system: organization, ganglia, functions, Chemical transmission and central control of autonomic nervous system. CSF: formation, circulation and functions. Blood-Brain barrier.
6. Sensory receptors and functional properties: Classification of general and special senses. Receptors as biological transducers. Muller's law of specific nerve energies. Weber-Fechner law, Steven's power law. Sensory transduction in the Pacinian corpuscle. Adaptation of receptors.
7. Physiology of Olfaction and Gustation: Structure and functions of the receptor organs, nerve pathways, centres. Properties of olfactory and gustatory sensation and their transduction and coding. Electro-olfactogram (EOG). Abnormalities of olfactory and taste sensation.
8. Acoustic physiology: Sound waves, decibel. Structure and function of auditory apparatus Organ of Corti. Auditory transduction. Auditory pathways and centres. Mechanism of hearing; Audiometry, Deafness.
9. Physiology of vision: Structure of the eyeball. Structure of lens. Formation of cataract and glaucoma. Mechanism of accommodation. Pupillary reflexes, light reflex, near response. Histology of retina,fovea and blind spot. Visual pathway and centers. Photopic and

scotopic vision. Chemical and electrical changes in retina on exposure to light. Electroretinogram. Light and dark adaptation. Color vision; Color blindness. Visual field-perimetry. Visual acuity, Critical fusion frequency (CFF).

Practical:
Credit : 2
Contact Hours per Week : 4

1. Demonstration: Gastrocnemius muscle-sciatic nerve preparation, recording of muscle response to a single stimulus applied to nerve, effect of changing strength of stimulus, calculation of conduction velocity of nerve impulse.
2. Study of hand grip using dynamometer.
3. Fresh tissue staining-Staining of nodes of Ranvier, skeletal muscle, staining and identification of permanent sections of spinal cord, cerebellum and cerebral cortex.
4. Study of colour blindness by Ishihara's chart, study of visual acuity, Audiometry, Determination of fatigue by CFF

LISC354C15 D: Biophysical Methods
Credits - 6: (Theory- 04, Practical- 02)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Probing biological reactions and interactions using biophysical tools: protein-protein/DNA/small molecules
2. Basics of chromatography, electrophoresis, sedimentation, light scattering.
3. Basic principles of electromagnetic radiation, energy, wavelength, wave numbers and frequency. Review of electronic structure of molecules (Molecular Orbital theory), Principles and applications of spectroscopy: Absorption Spectroscopy, Fluorescence spectroscopy, LASER, ORD and Circular Dichroism Spectroscopy. Infra-red spectroscopy, Isothermal calorimetry (ITC).
4. Techniques for protein structure determination: X-ray crystallography, Nuclear Magnetic Resonance (NMR), Mass spectrometry, cryo electron microscopy.

Practical:
Credit : 2
Contact Hours per Week : 4

1. Estimation of DNA, RNA and protein concentration using Absorption spectroscopy.
2. Determination of protein concentration using Bradford reagent.
3. Structural and functional studies of protein using Fluorescence spectroscopy.

4. Setting up of crystallization trials of lysozyme for X-ray diffraction.
5. Determination of protein molecular weight using size exclusion Chromatography.

LISC354C15E : Environmental Microbiology

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Microorganisms and their Habitats: Structure and function of ecosystems, Terrestrial Environment: Soil profile and soil microflora; Microflora of fresh water and marine habitats; Aeromicroflora and dispersal of microbes.
2. Microorganisms in extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels. Microbial succession in the decomposition of plant organic matter.
3. Microbial Interactions and Nitrogen fixation: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation. Symbiotic and non-symbiotic nitrogen fixation. Nitrogenase enzyme system.
4. Water Potability: Treatment and safety of drinking (potable) water, methods to detect potability of water samples: standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms.
5. Lignin degradation: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in bio-pulping, bio-bleaching, textiles, biofuels.
6. Waste management: Treatment of liquid waste (Primary, Secondary and Tertiary); treatment of industrial effluents, bioremediation of environmental pollutants, solid waste types & their possible usages, landfill development and composting.

Practical:

Credit : 2
Contact Hours per Week : 4

1. MPN method to check the potability of water
2. Isolation microorganisms from air by agar exposure technique
3. Field visit to study microorganisms and their different habitats.
   Collection of samples from the field visit and isolation of microorganism.

SEMESTER VII (MAJOR COURSE ELECTIVES)

LISC401C16A: Plant Genetic Engineering

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Important enzymes for gene cloning: Nucleases- Restriction Enzymes, Methylases, Polymerases, Ligases, Topoisomerases, End Modifying Enzymes
2. Vectors and cloning strategies: Desirable properties of vectors, Prokaryotic and Eukaryotic Expression Systems, Plasmid Vectors, Phage Vectors, Cosmids, BACs, YACs; promoter technology, Gateway cloning, Construction of Genomic & cDNA Libraries
3. Gene transfer methods in plants: Methods of gene transfer in Plants: Gene gun/ biolistics, Ti plasmids and Agrobacterium-mediated transformation
4. Screening of transformants: Plant selectable markers, reporter genes- GFP, luciferase, GUS, analysis of transgenics using Southern, Northern, Western blots, functional validation.
5. Strategies for gene knock-out and knock-down: gene silencing, antisense strategies, ribozymes and siRNAs, RNA interference, Insertional mutagenesis, Transposon genetic elements and gene tagging, Conditional Knockdown systems
6. Applications of recombinant DNA technology: Expression of recombinant proteins, Agriculture related applications, Medicine related applications and Molecular Pharming, environment-related applications, Livestock improvement, biofuel production.

LISC401C16B: Parasitology and Vector Biology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Interspecific interaction – symbiosis, mutualism, commensalism and parasitism.
2. Parasitic adaptations.
3. Protozoan and helminth parasites – life cycle, pathogenicity and control.
4. Characteristic feature of vector organism.
8. Mosquito, sand fly, tick and mite as a vector.

LISC401C16 C: Pathophysiology of common human diseases and pharmacological drug design

Credits - 4: (Theory- 04)

Theory:

Credit : 4

Contact Hours per Week : 4

1. Basic concepts of pathology and development of disease
2. Pathophysiology of common Human Diseases: Discussion of common communicable and non-communicable diseases.
3. Xenobiotics and antioxidants: Definition and classification of Xenobiotics.Brief outline of xenobiotic metabolism.
4. Pharmacology: Basic concept of pharmacology. Pharmacokinetics, Pharmacodynamics, Drug biotransformation.
5. Mechanism of action of common drugs.
6. Basic concept of forensic toxicology.

LISC401C16 D: Molecular Biology of Human diseases and Therapeutic Interventions

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Cancer Biology: oncogenes, tumor suppressor genes, microRNAs in cancer, Chromosomal rearrangements and cancer, Viruses and cancer, Chemical carcinogenesis, Cell Cycle Control, Growth factors and Cancer Signaling, Metastasis, Angiogenesis, Tumor microenvironments and Stroma, Inflammation and Cancer, Therapeutic strategies.
2. Infectious diseases: Molecular mechanisms for Host-pathogen interaction, Disease models of common diseases: Cholera, Tuberculosis, Malaria, Influenza, HIV and AIDS, Prion protein diseases.
3. Human genetic diseases: Loss of function mutations, Gain of function mutations, Molecular pathology: from gene to disease, from disease to gene, chromosomal disorders, molecular basis for Hemophilia, Colour blindness, Sickle cell anemia, Thalassemia, Xeroderma pigmentosum, Cystic fibrosis, Duchenne muscular dystrophy, SLE, Myasthenia gravis.
4. Neuropathological disorders: Molecular pathways to neurodegeneration: β-amyloid, Tau, α-Synuclein, misfolding and aggregation of disease proteins, mitochondrial dysfunction, gene-environment interactions in neurodegenerative disease, Parkinson, Alzheimer, Huntington's disease, Trinucleotide repeat expansion diseases.
5. Molecular mechanisms of metabolic and nutritional diseases: inborn errors of metabolism, diseases related to vitamins and minerals, obesity.
6. Methods and Applications of Gene Therapy: In-vivo gene therapy, Ex-vivo gene therapy, Immunotherapy, CAR-T cell therapy, targeted molecular therapy, stem cells and translational therapy

LISC401C16E: Food and Industrial Microbiology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

Food Microbiology

1. Food safety, preservation and spoilage: Food safety, HACCP, Microbiological Quality Assurance. Factors affecting the survival of microorganisms in food (intrinsic and extrinsic). Food preservation- Pasteurization and Appertization, D and z Values, Irradiation, Pascalization, Chilling and Freezing, chemical preservatives. Food spoilage (milk, meat, fish, vegetables).
2. Food Microbiology and Public Health:
    a. Bacterial Agents of Foodborne Illness: *Brucella, Campylobacter, Escherichia coli, Listeria monocytogenes, Salmonells, Shigella, Vibrio Cholerae.*
    b. Viruses associated Foodborne Illness: Polio, Hepatitis A and E, Gastroenteritis Viruses.

Industrial Microbiology

1. Introduction: History and scope of fermented foods; definition and importance of fermented foods; organisms used for production of fermented food products; environmental parameters for fermentation process; classification of fermentation processes for fermented foods; isolation of industrially important microbial strains and fermentation media; strain improvement.
2. Fermentation: Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch and continuous fermentations. components of a typical bio-reactor; types of bioreactors; microorganisms involved in fermentation, fermentation media and conditions, downstream processing and uses (citric acid, ethanol, wine, antibiotics, vitamins, enzymes, cheeses); Properties and beneficial effects of probiotic and prebiotic; enzyme immobilization - methods and applications; health aspects of fermented foods.
3. Industrial visit and Submission of report

LISC402C17 A/B/C/D/E: Advanced Genetics

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Pattern of Inheritance: Mendelian concept of alleles, types of dominance, Essential genes and lethal alleles, Gene expression and environment: penetrance and expressivity, effects

of environment, Maternal effect genes, Gene interactions and modified Mendelian ratios, Epistasis, polygenic inheritance,Pleiotropy, Phenocopy, Extranuclear inheritance.

2. Genetic analysis and mapping in model systems: Recombination-based mapping in E. coli, transduction-based gene mapping in bacteriophage; Gene mapping in Neurospora and Saccharomyces cerevisiae: tetrad analysis ; Drosophila – gene mapping by recombination, Physical versus genetic maps, Fine genetic mapping using extended pedigrees and ancestral haplotypes, Linkage analysis of complex characters, Association studies and linkage disequilibrium, Identifying the susceptibility alleles.
3. Cytogenetics: Chromosome morphology, chromosome banding, specialized chromosomes: Lampbrush chromosomes, Polytene Chromosomes, Super-numerary chromosomes Chromosome Variation – Structural aberrations: duplications, deletions, inversions & translocations with examples and genetic consequences, Numerical aberrations: aneuploidy, euploidy auto-polyploidy and allopolyploidy, Genetic consequences
4. Sex determination and Dosage Compensation: Sex determination patterns in animals and flowering plants; Dosage Compensation;
5. Human Genetics: Principles and strategies in identifying disease genes, Positional cloning, Use of chromosomal abnormalities, Pedigree analysis: Symbols used; Pedigrees of sex-linked and autosomal traits and patterns of inheritance.
6. Population Genetics: Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, migration,small population size, Genetic drift. Speciation.
7. Quantitative Genetics: Nature and inheritance of continuous traits, Quantitative Genetic Analysis, Heritability, Response to Selection, Genetic Correlations, Quantitative Trait Loci, QTL analysis.

LISC403C18A:Plant Developmental Biology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Basic concept of development: Microsporogenesis, Megasporogenesis, differentiation and de-differentiation; concept of morphogen; role of reference organisms in developmental processes
2. Stem cell types, Meristems- structure of shoot and root apical meristems, Regulation of development pathways- role of transcription factors and receptor kinase-mediated signaling in plant development
3. Embryogenesis, Axial and radial patterning, Specific gene expression related to embryogenesis

4. Morphogenesis and organogenesis- Leaf Development: Abaxial and adaxial identity, Development of roots
5. Flower development, floral and inflorescence meristems, different physical and physiological factors including flower induction, photoperiodic, vernalization, autonomous and physiological age pathways, circadian clock, ABC model and beyond. Genetics of flower development in monocotyledonous flowers, floral asymmetry
6. Gametogenesis and fertilization, seed development

LISC403C18 B/D: Animal Developmental Biology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Stem cells and differentiation: Overview of Stem Cell Biology. Embryonic stem cells: maintenance of pluripotency and early lineage specification in mouse and human ESCs. Adult stem cells: Types of adult stem cells, Stem cell niche and its role in stem cell maintenance, Cellular plasticity Induced pluripotent stem cells: Epigenetics and reprogramming in stem cell biology Metabolic regulation of pluripotency and early lineage.
2. Role of organizers in development
3. Morphogenesis and organogenesis in animals: Cell aggregation and differentiation, patterning and shaping of the early embryo, Gastrulation and morphogenetic movements, axes and pattern formation in Drosophila, amphibia and chick
4. Organogenesis - vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates, neurogenesis.
5. Post embryonic development, environmental regulation of normal development, sex determination.
6. Formation and function of extra embryonic membranes and Placenta a) types with examples b) structure and function of placenta in human

LISC403C18 C: Human Embryology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Gametogenesis- Primordial germ cells, the genetics of germ cells, conversion of germ cells to male and female gametes.
2. Development of the early embryo- Fertilization, implantation and formation of the early fetus, formation of bi-laminar and tri-laminar disc, structural peculiarities of the uterus during early pregnancy, mid pregnancy and at term

3. Formation of the Gut tube and body cavities
4. Time scale developmental changes of the foetus
5. System based embryology (Organogenesis): Development of the skeletal system, muscular system, cardiovascular system, respiratory system, neural system, limbs, urogenital system
6. Clinical applications of embryology

LISC403C18E: Microbiome and Metagenomics

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Introduction to Microbiome: Microbiome – definition and types of microbiomes; Features of sequenced microbial genomes, core genome pool, flexible genome pool and pangenome, Horizontal gene transfer (HGT), Microbiome ecology and evolution; Evolution of bacterial virulence – Genomic islands, Pathogenicity islands (PAI) and their characteristics. Fungal and Viral microbiomes; The Earth Microbiome Project.
2. Human Microbiome Concepts: Genera of human-microbiome; (gut and oral) Alterations in the microbiome during the life cycle of humans. Infectious diseases, host microbiome, and immune system, Microbiome's role in diseases such as Inflammatory bowel disease (IBD), colitis, obesity, diabetes. Phylogeography of epidemics; Microbes as cancer therapeutics; Impacts of antibiotics on the development of resistomes. Viromes and human health
3. Biofilm biology**:** Biofilms: types, molecular aspects and significance in environment, health care, virulence, and antimicrobial resistance ; Extracellular polymeric substances (EPS); Formation of Biofilms – Development and dispersal; Biofilm in infectious diseases – (Bacterial and Fungal); Uses in medicine , food , aquaculture; Eukaryotic biofilms, biofilm as model of microbiome.
4. Metagenomics**:** Brief history and development of metagenomics, Understanding bacterial diversity using metagenomics approach, Prospecting genes of biotechnological importance using metagenomics, Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics and metabolomics. Environmental Metagenomics – Introduction; Metagenome sequencing; Next-generation sequencing approaches to metagenomics.

LISC441C19A/B/C/D/E: Dissertation

Credit : 4
Contact Hours per Week : 8

Students will do original research work as part of their dissertation under the supervision of Faculty members of DLS.

SEMESTER VIII (MAJOR COURSE ELECTIVES)

LISC451C20A: Molecular Plant-Microbe Interactions

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Introduction: Concept of diseases in plants and definitions, Disease development and underlying environmental factors, Disease triangle, Disease Cycle, Recognition between Host and Pathogen, Compatible and incompatible interactions.
2. Genetics of plant disease: General mechanisms of variability, Types of plant resistance to pathogens, The Gene-for-Gene Concept, Types and roles of Effectors; Models to Explain Recognition of Effectors by R-gene Products - The Receptor-Ligand Model, Guard Hypothesis, Decoy Model; Effector Loss, Evolution of effector repertoire; R-genes and their roles in conferring resistance.
3. Plant-microbe interactions: Basic events in an incompatible host–pathogen interaction; Genes involved in pathogenesis and virulence by pathogens, Signal Transduction between Pathogenicity Genes (Avr) and Resistance (R) Genes; Beneficial plant-microbe associations - rhizobia, mycorrhizae.
4. Defense responses in plants: Pattern-triggered immunity (PTI) and Effector-triggered immunity (ETI), Plant Disease Resistance-Related Signaling Pathways: Programmed cell death, Hypersensitive (HR) responses, Pathogenesis–related (PR) proteins, Salicylic acid (SA) mediated signalling response, Genes and Signaling in Systemic Acquired Resistance (SAR), Role of jasmonates (JA) and ethylene in defencesignalling, Phytoalexins.
5. Plant Protection and disease management strategies: Immunization of plants against pathogens; Defense through Plantibodies, Quarantines and Inspections, Host Cultural Methods for pathogen controls - Eradication, Crop Rotation, Polyethylene Traps and Mulches; Biological, physical, and chemical control measures.

LISC451C20 B: Evolutionary Biology

Theory
Credit : 4
Contact Hours per Week : 4

1. Post-Darwinian era – Modern synthetic theory; biomathematics and the theory of population genetics leading to Neo-Darwinism
2. Life's Beginnings Chemogeny – An overview of pre-biotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. Current concept of chemogeny – RNA first hypothesis.
3. Evidences of Evolution - Paleobiological – Concept of Stratigraphy and geological timescale; fossil study (types, formation and dating methods). Anatomical – Vestigial organs; Homologous and Analogous organs (concept of parallelism and convergence in

evolution). Molecule based – Protein model (Cytochrome C); gene model (Globin gene family)

4. Sources of Evolution – Causes, classification and contribution to evolution – Gene mutation; chromosomal aberrations; recombination and random assortment (basis of sexual reproduction); gene regulation. Concept of micro- and macro-evolution – A brief comparison.
5. Forces of Evolution – Natural selection as a guiding force – Its attributes and action Basic characteristics of natural selection. Colouration, camouflage and mimicry, Co-adaptation and co-evolution, Man-made causes of change – Industrial melanism; brief mention of drug, pesticide, antibiotic and herbicide resistance in various organisms. Modes of selection, Genetic Drift (Sewall Wright effect) as a stochastic/random force – Its attributes and action. Basic characteristics of drift; selection vs. drift, Bottleneck effect, Founder principle.
6. Forces of Evolution – Population genetics – Gene pool; gene/allele frequency; genotypic frequency; phenotypic frequency (simple problems for calculation). Conservation of gene frequencies (when selection does not operate) – Hardy-Weinberg's Law of Genetic Equilibrium. Alterations in gene frequency (when selection operates) – Calculation based on Selection Coefficient and Fitness). Fluctuations in gene frequency (when drift operates) – Calculation based on standard deviation.
7. Product of Evolution – Speciation Concept of species as a real entity, Mechanisms of speciation – Allopatric; sympatric; peripatric, Patterns of speciation – Anagenesis and Cladogenesis; Phyletic Gradualism and Punctuated Equilibrium (Quantum Evolution), Basis of speciation – Isolating mechanisms.
8. Extinction- Periodic extinctions, Mass-scale extinctions – Causes and events
9. Human Ancestry and Phylogeny Primate characteristics and unique Hominin characteristics. Primate phylogeny leading to Hominin line.Human migration – Theories. Brief reference to molecular analysis of human origin – Mitochondrial DNA and Y-chromosome studies

LISC451C20 C/D: Stress Biology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Defining stress: Acclimation and adaptation. Brief introduction to diverse stressors in plant, animals and human
2. Environmental factors: Abiotic stress (Water; Salinity, High light, Temperature); Biotics stress (Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates) in plants and animals. Lifestyle and environment induced functional (hormonal, cardiovascular and hepato-renal) changes. Posture- related stress- system design, system optimisation.

3. Stress sensing mechanisms: Role of nitric oxide. Phospholipid signaling, growth factors and arachidonate signaling.
4. Developmental and physiological mechanisms that protect plants, animals and human against environmental stress
5. Morphological, biochemical and genetic adaptation in plants in osmotic stress; Xenobiotics and biotransformation.
6. Redox imbalance, Reactive oxygen species, Production and scavenging mechanisms Sources of ROS, quenching mechanisms in the cell, antioxidants.

LISC451C20E-Host –Pathogen Interactions
Credits - 4: (Theory- 04)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Physiological Adaptations and Communication: Introduction to two component system, regulatory systems during aerobic- anaerobic shifts. Quorum sensing, AHL and diversity of it, interdomain communication. A and C signaling system.
2. Mechanism of Toxigenicy**:** Classification of Toxins (Endotoxins, AB-Type Exotoxins, Cytolytic and Superantigen Exotoxins). Mechanism of different toxins (Diphtheria, cholera, Botulinum, staphylococus superantigen).
3. Antimicrobial Agents: General characteristics and mode of action Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism; Antifungal agents: Antibiotic resistance, MDR, XDR, MRSA, NDM-1
4. Plant-Microbe-Interactions: Events in plant–microbe interaction; susceptibility, Genes involved in pathogenesis and virulence by pathogens, phytoalexins, signal transduction between pathogenicity genes (Avr) and resistance (R) Genes; signaling and regulation of programmed cell death; beneficial plant-microbe associations - *Rhizobium*, ArbuscularMycorrhiza (AM), Pattern-triggered immunity (PTI) and Effector-triggered immunity (ETI).

LISC452C21A/B/C/D/E: Instrumentation in Research
Credits - 4: (Theory- 04)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Microscopy: Light microscopy, Phase contrast microscopy, Confocal microscopy, Electron microscopy (SEM, TEM, STEM), fluorescence microscopy, principles and applications. Basics and uses of flow cytometry, fluorescent probes, Centrifugation, Transmission and Scanning electron microscopy, sample preparation for light and electron microscopy, fixatives, stains, cryofixation,

negative staining, shadow casting, freeze fracture, freeze etching.Chromosome banding, FISH, chromosome painting.

2. Radioisotopes: Use in biological research, auto-radiography, pulse chase experiment.
3. Spectrophotometry: Principle and its application in biological research.
4. Chromatography: Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion exchange chromatography; Molecular sieve chromatography; Affinity chromatography, gel-filtration.
5. Characterization of proteins and nucleic acids: Mass spectrometry; X-ray crystallography, NMR; Characterization of proteins and nucleic acids; Electrophoresis: PAGE, SDS-PAGE

LISC453C22A: Frontiers Areas of Plant Science

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Nanotechnology: Concept of nanotechnology and its applications in Plant Science; nanomaterials for a new generation of medicine; nanoparticles in medical detection and diagnostics; synthesis of nanoparticles, characterization, and applications.
2. Synthetic Biology: Basic concepts of synthetic biology; concepts of synthetic genome, organelles, and minimal cell; metabolic engineering; drug factories, biosensors.
3. Systems Biology: Genomics, transcriptomics, proteomics, metabolomics, lipidomics, ionomics, metagenomics, High throughput screening and Next generation sequencing,
4. Techniques related to gene expression studies: Real Time-PCR, EST, Microarrays, SAGE,
5. Genome editing: Site-directed mutagenesis- CRISPR/Cas9 based genome editing
6. Bioinformatics resources: Characterization of plant genome, proteome, and protein-protein / DNA / RNA / small molecules interactions
7. Biosafety regulations related to genetic engineering: Food safety- allergenicity assessment, Environmental safety- elimination of marker gene
8. Role of artificial intelligence (AI) and phenomics: Crop characterization and improvement, RSM and ANN in product optimization

LISC453C22 B: Frontiers in Animal Science Research

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Gene Transfer Technology in Animals: Viral and Non-Viral Methods, Transfection of Animal Cell Lines, Gene Knock Out
2. Animal Models, Current Status of Production of Transgenic Animals.

3. Animal Cloning: Techniques, Relevance, Case Studies and Ethical Issues.
4. Public Concerns on Human Genome Research and Transgenics
5. Advance studies in Ecological Sciences

LISC453C22 C: Social, Stress physiology, Ergonomics and sports physiology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Social physiology: Population problem – principles of family planning. Infertility, IVF. Malnutrition, and their social implications. Implications of Diabetes, CHD. Principles and social importance of immunization against diseases. Epidemiology and prevention of common diseases.
2. Work, Exercise and Sports Physiology: Concept of work. Physical work—its definition and nature. Power and capacity relation, Classification of workload. Exercise inducing equipment –Aerobic and anaerobic power—concept, factors affecting, methods of measurement and significance of maximal oxygen consumption and excess post exercise oxygen consumption. Energetics of exercise – Short-term and long term, Mechanism of Fatigue and recovery. Concept of endurance, strength and speed in sports activities. Principles of training and detraining. Brief general idea about nutritional aspects of sports, Idea on doping. Lactate threshold, lactate tolerance and their usefulness. Concept of physical fitness and its assessment by Harvard and modified Harvard Step Tests.
3. Stress Biology: Concept of Stress, Stressors and Stress response. Idea of Internal and external stressors. Principles of acclimatization and adaptation. Effects of exposure to hot and cold environments. Acclimatization to hot and cold environments. Heat disorders and its preventive measures. Effects of hypobaric and hyperbaric environments. Caisson's disease. Preventive measure for hypobaric and hyperbaric effects. Acclimatization to high altitudes. G forces. Stress and Aging.

LISC453C22D/E: Molecular Cloning and Transgenic Technology

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Introduction to recombinant DNA technology: Overview of recombinant DNA technology. Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules, separation of DNA by gel electrophoresis. Extraction and purification of plasmid DNA; Introduction to DNA sequencing; Polymerase Chain Reaction.

2. Cloning vectors for prokaryotes and eukaryotes: Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on E. coli plasmids, pBR322, pUC8, pGEM3Z. Joining of DNA fragments: ligation of DNA molecules. DNA ligases, sticky ends, blunt ends, linkers and adapters, expression vectors.
3. Introduction of DNA into cells: Uptake of DNA by cells, preparation of competent cells. Selection for transformed cells. Identification for recombinants - insertional inactivation, blue-white selection. Introduction of phage DNA into bacterial cells. Identification of recombinant phages. Methods for clone identification: The problem of selection, direct selection, marker rescue. Gene libraries, identification of a clone from gene library, colony and plaque hybridization probing, methods based on detection of the translation product of the cloned gene.
4. Methods & Applications of Transgenesis in Plants & Animals: Transgene, Selectable marker and Reporter genes; Retroviral-vector mediated transgenesis; DNA microinjection; Embryonic Stem Cell mediated Methods; Somatic Cell Nuclear Transfer; Molecular Pharming; Electroporation, Lipofection, Protoplast fusion and other physico-chemical methods of transgene delivery; Spatio-temporal regulation of transgene expression by Cre-LoxP, Tet-ON, Tet-OFF systems, Agrobacterium mediated Plant Transgenesis; Transplastomic technology
5. Applications of Molecular Cloning &Transgenesis: Applications in medicine, production of recombinant pharmaceuticals such as insulin, human growth hormone, factor VIII. Recombinant vaccines. Gene therapy. Applications in agriculture - plant genetic engineering, herbicide resistant crops, controversies with genetically modified plants, safety concerns.

LISC491C23A/B/C/D/E: Dissertation

Credit : 8
Contact Hours per Week : 16

Students will do original research work as part of their dissertation under the supervision of Faculty members of DLS.

SKILL ENHANCEMENT COURSES (SEC-MAJOR)

(Common Course offered to all students of DLS)

LISC241SEC01: Applied nutrition and Dietetics

Credits - 4: (Theory- 04)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Nutrition, malnutrition and health: concept, definition and scope.
2. Constituents of food and their significance. Minimum energy requirement and RDA. Energy requirement in humans, basal metabolic rate -factors, determination by Benedict Roth apparatus. Respiratory quotient. Specific dynamic action. Calorific value of foods. Body calorie requirements – adult consumption unit; Dietary requirements of carbohydrates, proteins, lipids and other nutrients. Growth and development from infancy to childhood.
3. Balanced diet and principles of formulation of balanced diets for growing child, adult man and woman, pregnant woman and lactating woman. Nitrogen balance. Essential fatty acids, PUFA, MUFA; Essential amino acids. Proteins sparers. SDA of protein. Protein efficiency ratio, net protein utilisation of dietary proteins, Biological value of proteins. Dietary fibres.
4. Principles of diet survey. Composition and nutritional value of common foodstuffs. Physiology of starvation and obesity. Elementary idea of functional foods,
5. Nutraceuticals, GM foods , Probiotics, food supplements, glycaemic index.
6. Malnutrition – PCM, marasmus, kwashiorkor, marasmic kwashiorkor. Hidden hunger, Endemic goitre, nutritional anemias, rickets, osteomalacia, xerophthalmia, beriberi, anaemia, rickets; Implications of diabetes, CHD.
7. Concept of community nutrition, nutritional assessment and surveillance; nutritional assessment by nutritional anthropometry and diet survey; Nutritional intervention programs; food and water borne diseases; food allergy and food poisoning; Basic concept of diet therapy.

LISC291SEC02: Economic Zoology

Credits - 5: (Theory- 05)

Theory:

Credit : 5
Contact Hours per Week : 5

1. Prawn, Pearl culture.
2. Induced breeding and hybridization techniques in Fish, Composite fish culture.
3. Industrial Entomology – sericulture, apiculture and lac culture

4. Pest biology – bionomics and control of jute, brinjal and sugarcane pests
5. Strategies of Integrated pest management
6. Poultry farming and management
7. Concept of dairy technology with reference to cryopreservation and in vitro fertilization technique.

VALUE ADDED COURSES (VAC)

(Common Course offered to all students of PU)

ENVS204VAC01: Environmental Science

Credits - 3: (Theory- 03)

Theory:

Credit : 3
Contact Hours per Week : 3

Introduction to environmental studies

1. Multidisciplinary nature of environmental studies;
2. Scope and Importance; Concept of sustainability and sustainable development.

Ecosystems

3. What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystem, :
4. Forest ecosystem
5. Grassland ecosystem
6. Desert ecosystem
7. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and Conservation

8. Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots
9. India as a mega biodiversity nation; Endangered and endemic species of India
10. Threats to biodiversity : Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity : in-situ and Ex-situ conservation of biodiversity.
11. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Environmental Pollution

12. Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution
13. Nuclear hazards and human health risks
14. Solid waste management : Control measures of urban and industrial waste.
15. Pollution case studies.

Environmental Policies & Practices

16. Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture
17. Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).

Human Communities and the Environment

18. Human population growth: Impacts on environment, human health and welfare.
19. Environmental movements :Chipko, Silent valley, Bishnois of Rajasthan.

LISC292VAC02: Advances in Cancer Diagnostics and Therapeutics

Credits - 3: (Theory- 03)

Theory:

Credit : 3
Contact Hours per Week : 3

1. Elementary understanding of molecular biology and pathophysiology of cancer
2. Hallmarks of cancer
3. Stages in Cancer pathobiology
4. Cancer Biomarkers
5. Proteo-genomic techniques implicated in cancer diagnostics and therapy;
6. technical know-how of cancer diagnostics and prognostics;
7. immunohistochemistry and immunophenotyping in cancer diagnosis and prognosis
8. Chemotherapy, Radiotherapy, Molecular Therapy & Cancer Immunotherapy.

MINOR COURSES (MC)

(MC 1-4 offered to PU students of Allied Science subjects)
(MC 5-6 offered to DLS students)

LISC104MC01: Macromolecules of Life

Credits - 6: (Theory- 04, Practical- 02)

Theory:

Credit : 4
Contact Hours per Week : 4

1. Proteins: building blocks of life. Basic idea about proteins; amino acids, primary, secondary, tertiary and quaternary structure, enzymes and their functions. Part of the food, daily household, medical and industrial usage. Brief overview of protein synthesis, Concept of codon & anticodon in respect to translation.
2. Carbohydrates: the fuel of life. Classification of carbohydrates, structures, functions, part of the food, daily household and industrial usage, etc.

3. Lipids: the storage. Structure, classification, functions, part of the food, household and industrial usage.
4. Nucleic acids: the coders. Structure, classification, functions of both DNA and RNA. Common techniques used for Nucleic acid Analysis. A basic idea on the effect of nucleic acid dysfunction, Ribozymes.

Practical:
Credit : 2
Contact Hours per Week : 4

1. Identification of substances of biological importance by biochemical tests.
2. Estimation of proteins by Biuret method/ Lowry's method / UV absorption spectroscopy
3. Estimation of glucose / sucrose / lactose in milk by Benedict's method
5. Estimation of DNA / RNA by UV absorption spectroscopy

LISC154MC02: Introduction to Plant tissue culture and Genetically Modified Plants
Credits - 6: (Theory- 04, Practical-02)
Theory:
Credit : 4
Contact Hours per Week : 4

1. Introduction to Plant Biotechnology and its importance - Brief introduction to plant cell structure and functions of organelles.
2. Introduction to plant tissue culture, Lab equipment and their working principles – Various sterilization and media and PGR preparation techniques, used in plant tissue culture.
3. Different types of cultures and methods for micropropagation, organogenesis, somatic embryogenesis and somaclonal variation induction.
4. Introduction to genetically modified plants – Need for genetically modified plants – methods – Controversies - Present status of GMPs with special emphasis on India.
5. Introduction to secondary metabolites and industrial products.

Practical:
Credit : 2
Contact Hours per Week : 4

1. Working principles of common laboratory instruments used in Plant Tissue Culture.
2. Basic techniques related to the sterilization of plant samples
3. Media preparation for plant cell culture.

LISC205MC03: Fundamentals of the Animal World

Credits - 6: (Theory- 04, Practical-02)

Theory:

Credit : 4

Contact Hours per Week : 4

1. Animal associations: symbiosis, mutualism, commensalism, parasitism
2. Basic concepts of Biodiversity and wildlife conservations
3. Life cycle and pathogenicity of common zoonotic diseases
4. Animals as vectors and carriers of diseases
5. Concept of evolution and adaptations

Practical:

Credit : 2

Contact Hours per Week : 4

1. Pictorial classification of insects and mammals (up to order).
2. Identification and adaptive features of insects, birds and mammals.
3. Identification of economically important pests, vectors and pollinators.

LISC255MC04: Modern Lifestyle and Associated Ailments

Credits - 6: (Theory- 04, Practical-02)

Theory:

Credit : 4

Contact Hours per Week : 4

1. Necessities and requirements in our current lifestyle with special emphasis on stresses, availability of fast food, micro family concept and dual income families. Awareness and necessary lifestyle changes: different components of lifestyle such as food style, work pattern, environmental conditions, and their possible modifications.
2. Basic concept of aggression and its management in various settings- in school: effect of punishments, aggression/ violence by children; effect of social media; road traffic violence; child abuse. Unsocial behaviours- too much texting, video game playing; Effect of isolation,
3. Physiological stress from lifestyle patterns, mechanism of developing ailments, food habits and effect of junk food. Good nutrition and a balanced diet. The risk factors in relation to some common diseases: diabetes, obesity, stress syndrome, ischemic heart disease, cancer, asthma. Addiction- alcoholism, narcotics.
4. Common endocrinological disorders of thyroid and pancreas and its management by dietary intervention.

5. Work and its related issues: Posture related problems- low back pain, carpal tunnel syndrome.
6. Social behaviours and communicable diseases: Spread of viral diseases in the modern day society: food and waterborne diseases, bioterrorism, antibiotic resistance, multidrug resistant strains, nosocomial infections. A brief overview and changes in different physiological parameters in relation to them. Vaccine and public health.
7. Autism, awareness and social response towards mental retardation/ physical impairment.
8. Effects of delayed marriage- delayed childbirth and associated genetic problems. Family adjustments to normal physiological alterations during adolescence and menopause.
9. Effects of air, water and noise pollution on social life.
10. Management of stress and social issues related to modern lifestyle ailments: discussion on dietary changes, dealing with stress and psychological alleviation.

Practical:

Credit : 2
Contact Hours per Week : 4

1. Survey of family members/ neighbors on modern lifestyle and public health issues discussed during the course. Analysis of data and its interpretation.
2. Biochemistry: estimation of cholesterol (different components), protein and blood sugar by kit method.
3. Estimation of common adulterants in food.
4. Histology: comparative study of the features of normal and diseased state: slides of polycystic ovary and cirrhotic liver.
5. Experimental: demonstration of the effect of nicotine on the cardiac (amphibian) function or intestinal (mammalian) movement.

LISC442MC05: Research Methodology

Credit : 4
Contact Hours per Week : 4

Hypothesis Development and formulating a research question:

1. Paradigms in science in general and in life sciences. Definition of Paradigm, Definition of normal science VS Paradigms. View of some of the philosophers of Science.
2. Defining a problem, survey of available literature, formulating a hypothesis. Developing objectives to test the hypothesis, study design, importance of controls, data collection, developing a timeline of study.
3. Concepts of intellectual property. (iv) Developing entrepreneurship.

Statistical Methods:

1. Nonparametric statistics: Chi-square test, G test for goodness of fit, Mann-Whitney U – test, Wilcoxon test, Log rank test, Fisher's exact test.

2. Correlation: Tests for parametric and nonparametric variables.. First order partial correlation. Multiple linear correlations with three variables.
3. Regression: Linear regression Models & assumptions. Properties and computation of simple linear regression, multiple linear regression.
4. Analysis of Variance: One way & two way ANOVA; variance ratio, multiple comparison tests, Two way ANOVA without replication.
5. Introduction to multi-parametric statistics: Cluster diagrams, PCA.

Data analysis:

1. Data presentation and handling in Excel; Statistical analysis using SPSS/ statistical software
2. Image processing and calculations using Image J.
3. Use of various analytical techniques such as microarray and real-time PCR data analysis,
4. Use of R software, analysis of data from GEO datasets.
5. Next gen sequencing data analysis,
6. Concept of data normalization and transformation

Applications of Bioinformatics:

1. Introduction to Bioinformatics;
2. Bioinformatics data types;
3. Sequence formats (e.g. raw text, FASTA, Stockholm);
4. Sequence and structure databases (e.g. Genbank, PDB etc.); Important genome databases,
5. Sequence alignments - pairwise and multiple;
6. Basic Bioinformatics tools (BLAST, CLUSTALW etc.);
7. Molecular visualization using Rasmol,
8. Phylogenetic tree generation and analysis
9. Basics of in silico docking analysis and simulation studies.

LISC492MC06: Research and Publication Ethics

Credit : 4
Contact Hours per Week : 4

1. Introduction, Overview, and Research Misconduct, rules and regulations in India.
2. Data Management
3. Mentoring, mentor-mentee responsibilities
4. Authorship Guidelines, Publication and Peer Review
5. Intellectual property, plagiarism, patents
6. Collaboration
7. Reporting and representing research, representing images.
8. Bias, Conflicts of Interest
9. Ethical use of animal subjects
10. Protection of Human subjects and stem Cell Ethics
11. The ethics of transgenic crops
12. Agricultural Ethics

13. Ecosourcing-code of practice
14. Radioactive, chemical and biohazard safety, waste management and disposal

MULTIDISCIPLINARY COURSES (MDC)

(Courses offered to PU students of Humanities and Social Sciences)

LISC105MDC01: World of Animals

Credits - 3: (Theory- 03)

Theory:

Credit : 3
Contact Hours per Week : 3

1. General organization and diversity of animals.
2. Animals of economic importance.
3. Animals as pests - Bionomics and control.
4. Animals as vectors - Bionomics and medical importance.
5. India as a Megadiverse country.
6. Threats to biodiversity.
7. Animal conservation– aims, in-situ and ex-situ strategies of conservation, threatened and endangered animals of India.

LISC155MDC02: The Human Body- the works and its care

Credits - 3: (Theory- 03)

Theory:

Credit : 3
Contact Hours per Week : 3

1. Regulation in the human body: The different systems, concepts of homeostasis.
2. Common regulatory mechanisms: temperature regulation, maintenance of blood pressure.
3. Common ailments : Communicable and non communicable diseases
4. Lifestyle disorders: Aggression, postural problems, environmental adaptation and ailments
5. Good nutrition and balanced diet
6. Fighting infections.

LISC156MDC03: Economic Applications of Plant and Microbial Biotechnology

Credits - 3: (Theory- 03)

Theory:

Credit : 3

Contact Hours per Week : 3

1. Economic importance of lower plant groups: algae, bryophytes, pteridophytes and gymnosperms: pharmacological and medical uses
2. Economic importance of fungi and mushrooms: antibiotics, medicine and food.
3. Medicinally important angiosperms: active constituents and clinical importance.
4. Applied Microbiology: wine and cheese production, bio fertilizers, SCP, biofuel.
5. Introduction to Plant Biotechnology and its importance - Brief introduction to plant cell structure and functions of organelles.
6. Introduction to plant tissue culture, Lab equipment and their working principles -Various sterilization and preparation techniques, used in plant tissue culture.
7. Introduction to secondary metabolites and industrial products

SUGGESTED READING

1. Aber, J.D. and Melillo J.M., Terrestrial Ecosystems: 1991, W.B.Saunders
2. An Introduction to Genetic Analysis (2010), 10th ed., Griffiths, A.J.F, Wessler, S. R,Carroll, S. B. and Doebley, J., W.H. Freeman & Company (New York), ISBN:10: 1-4292-2943-8.
3. An Introduction to Practical Biochemistry (1996) 3rd ed., Plummer, D.T. TataMcGraw-Hill Publishing Co. Ltd. (New Delhi).
4. Buchanan B, Gruissem G & Jones R - 2000 - Biochemistry and Molecular Biology ofPlants.
5. Bjorn, Lars Olof (Editors) , Photobiology: The science of light and life, Springer
6. Becker W. M., Kleinsmith L.J. and Bertni G. P. 2009. The World of the Cell. 7th
2. Barton, Briggs, Eisen, Goldstein and Patel. (2007) Evolution. Cold Spring HarborLaboratory Press Edition. Pearson Benjamin Cummings Publishing, San Francisco.
3. Berne and Levy Physiology
4. Brooker, R. J. (2014). Genetics: Analysis & principles.
5. Cooper G. M. Hausman R. E. 2009. The Cell: A Molecular Approach. 5th edition.ASM Press and Sunderland, Washington D. C.; Sinnauer Academic Press.
6. Carlson B.M. Patterns; Foundations of Embryology.
7. Cutter, S.L. (1999).Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi.
8. De Robertis, E. D. P. and De Robertis R. E. 2009. Cell and Molecular Biology, 8thedition. Lippincott Williams and Wilkins, Philadelphia.
9. David Randall, Eckert's Animal Physiology, W.H.Freeman and Co.
10. Deverall, Brain J. 1977. Defence mechanisms of plants, Cambridge University Press.
11. Elli Kohen, Rene Santus, Joseph G. Hirschberg: Photobiology Academic press.
12. Peter A. Ensminger: Life under the sun , Yale University Press
13. Futuyma, D. (1998) Evolutionary Biology. III Edn.Sinauer Assoc. Inc.
14. Guyton and Hall Text Book of Medical Physiology
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