Structure and Detailed Syllabus

of the Undergraduate Course (B.Sc.) in Biological Science (Hons.) under CBCS

Department of Life Sciences

Presidency University

(Effective from Academic Year 2021-22)

PRESIDENCY UNIVERSITY
KOLKATA

Department of Life Sciences
(Faculty of Natural and Mathematical Sciences)
Presidency University
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B.Sc. (Hons.) Biological Science

Introduction

The Biological Science programme at the undergraduate level has been designed to emphasize the importance of interdisciplinary nature underlying the study of all the aspects of structure and function of living organisms, their different constituent biomolecules and their complex inter relationships. Choice-based Credit System (CBCS) offers sound foundations in the form of Core Courses at the same time allowing freedom to students to select elective courses that augment the understanding of the subject at various levels. The elective courses include Discipline Specific Electives (DSE), Skill Enhancement Courses (SEC) and Generic Elective (GE) courses that broaden their learning horizons and widen the scope for higher education and employment avenues. The revised Choice-Based Credit System (CBCS) curriculum to be implemented from the academic session 2021-2022 conforms to Learning Outcome Based Curriculum Framework (LOCF) and aims at imparting concept based learning with emphasis on skill development and research. The overall objective of this programme is to enable students to learn and integrate knowledge in Biophysics, Chemistry and Biology that is relevant to study and understand the complex biological processes and thus prepare them for post-graduate education and careers in academia, research, medicine and industry.

Aims and Objectives

The program aims to:

- Provide students comprehensive knowledge and understanding of major concepts, principles and experimental findings in Biological Science and related interdisciplinary areas.
- Encourage students to employ critical thinking and efficient problem solving skills in different areas related to Biological Science.
- Train students to work effectively in diverse teams in both classroom, laboratory as well as in field-based situations.
- Provide students with the knowledge and skill base that would enable them to undertake further studies in Biological Science and help develop a range of generic skills that are relevant to pursue teaching, research and entrepreneurship.

Program Design and Structure:

The B.Sc. Honours in Biological Science is a three-year degree programme divided into six semesters. Each academic year (July - June) consists of two semesters (ODD and EVEN). The program has been designed to offer a variety of discipline specific and interdisciplinary courses disseminated through class-room, laboratory and out-of-classroom modes of teaching, monitored through a repertoire of assessment methods. The teaching learning process includes theory classes of one hour duration and practical classes of two hour duration for every credit offered. The curriculum is delivered through various methods including classical chalk and talk, power-point presentations, quiz contests, audio and video tools, e-learning and e-content, virtual labs, field trips, seminars by

external experts, symposiums and class discussions. The learning outcome is assessed by direct and indirect methods comprising broadly of Internal Assessment or Continuous Evaluation and End-Semester Examination. The internal assessment includes multiple choice questions, home and class assignments, oral presentations (seminars), group tasks, class discussions and report writing. End-semester assessments include written tests and practical viva examinations. Each course carries 100 marks. For 6-credit Core courses, General Elective courses and Discipline Specific Elective courses, 30 marks is allotted for each practical component and 70 marks is allotted for the theory component. Each practical component includes end semester viva based examination as well as continuous evaluation reflecting the performance of the student throughout the semester. For 4-credit Skill Enhancement Courses carrying 100 marks, the learning outcome is assessed by means of continuous evaluation involving multiple choice questions, home and class assignments, oral presentations (seminars), group tasks, class discussions and survey report submission.

The programme is structured into a variety of courses with different credits, some mandatory while others elective. Broadly, the programme comprises of Core Courses (CC) and elective courses. The core courses are all compulsory courses. The elective courses are of three kinds: Discipline-Specific Elective (DSE), Skill Enhancement Course (SEC) and Generic Elective (GE). The GE courses offered by the Department of Life Sciences are offered to students of other departments. A DLS student will have the option to choose from a range of GE courses offered by other Departments of Presidency University. Courses from Languages, Humanities and Sciences are all available to choose from. The programme also includes two compulsory Ability Enhancement Courses (AECC). The AECC courses are inter-departmental courses and follow a central syllabus.

To successfully complete the program, a student must study fourteen Core Courses, four Discipline-Specific Electives, two Skill Enhancement Courses and two compulsory Ability Enhancement Courses. The Core Courses, Discipline-Specific Electives and Generic Electives are six-credit courses. The Skill Enhancement Courses and Ability Enhancement Courses are four-credit courses. A student has to earn a minimum of 148 credits to get a degree in B.Sc. (Hons.) Biological Science.

Graduate Attributes in B.Sc. (Hons.) Biological Science

A graduate in the Biological Science programme is expected to demonstrate the following attributes:

Disciplinary knowledge and skills: Capable of demonstrating (i) comprehensive knowledge and understanding of fundamental concepts in Zoology, Physiology, Botany and interdisciplinary topics like Biotechnology, Molecular Biology, Biochemistry, Cell Biology, Immunology, Microbiology, Evolutionary Biology, Environmental Science, Biostatistics, Bioinformatics and Biophysics (ii) ability to use modern instrumentation/techniques for research spanning from molecules to systems.

Skilled communicator: Ability to convey complex information relating to Biological Science in a clear and concise manner both in writing as well as orally, demonstrate the ability to listen carefully, read and write analytically.

Critical thinker and problem solver: Ability to employ critical thinking and efficient problem solving skills in different areas related to Biological Science.

Sense of inquiry: Capability for raising relevant questions relating to basic understanding and applications in the field of Biological Science.

Team player/worker: Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations.

Digitally literate: Capable of using computers for bioinformatic work and appropriate biostatistics software for analysis of data, and employing modern library search tools to locate, retrieve, and evaluate biology-related information.

Ethical awareness/reasoning: Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitivity towards environmental and sustainability issues.

Lifelong learners: Capable of making conscious efforts to achieve self-paced and self directed learning aimed at personal development and for improving knowledge and developing skill.

Qualification descriptors for B.Sc. (Hons.) programme in Biological Science:

- A student should demonstrate (i) systematic and coherent understanding of the field of Biological Science, its applications and links to related disciplinary areas of study; (ii) practical knowledge that enables different types of professions related to Biological Science, including research and development, teaching, entrepreneurship as well as industrial research abilities; (iii) skills in areas pertaining to current developments in the academic field of study, including a critical understanding of the latest developments in the field of Biological Science and an ability to use established techniques of analysis.
- Demonstrate comprehensive knowledge about materials, including current research, scholarly literature, relating to essential and advanced learning areas pertaining to Biological Science, and techniques and skills required for identifying Biological Science-related problems and issues.
- Demonstration of skills in collection of relevant data gathered by reading or experimentation and analysis and interpretation of the data using appropriate methodologies.
- Ability to communicate the results of studies undertaken in an academic field accurately in the form of a paper, oral presentation or report.
- Apply knowledge and skills gained, to new and unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.
- Demonstration of the ability to function in an effective manner both independently as well as a member of a team.

Programme Outcomes (PO)

The programme is designed to achieve the following outcomes:

PO-1: To develop an in-depth knowledge and understanding of the discipline.

PO-2: To encourage students to effectively communicate scientific reasoning and data analysis in both written and oral forms.

PO-3: Create an awareness of the impact of biology on the environment, society, and development outside the scientific community.

PO-4: Inculcate the scientific temperament in the students for careers within and outside the scientific community.

Programme Specific Outcomes (PSO)

At the end of the course, the students will be able to

PSO1: Develop an in-depth knowledge and understanding of the fundamental concepts and principles underlying Biological processes.

PSO2: Develop practical knowledge and skills that are required for pursuing a career in clinical diagnosis, drug design, vaccine development, pharmaceutical industry, teaching, research, environmental monitoring.

PSO3: Use various bioinformatics tools for training in the basic theory and application of programs used for database searching, protein and DNA sequence analysis and prediction of protein structures.

PSO4: Effectively communicate scientific reasoning and data analysis in both written and oral forms.

PSO5: Gain knowledge of ethical and good laboratory practices.

Teaching-Learning Processes

The programme of B.Sc. in Biological Science is designed to encourage the acquisition of disciplinary/subject knowledge, understanding the skills and achieve academic and professional skills required for biology -based professions and jobs. Learning experiences are designed and implemented to foster active/participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. A variety of approaches to the teaching-learning process, including lectures (online/offline, chalk and board method, powerpoint presentation), oral discussion sessions in the class, seminars, tutorials, short group project-based learning, field-based learning, visit to Zoo/Museum/Botanical garden, substantial laboratory-based practical experiments and surveys will be adopted to achieve this. Problem-solving skills, analytical reasoning skills will be encouraged through adopting appropriate teaching strategies.

Assessment Methods

The assessment of students' achievement in Biological Science 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.

Semester-wise Modules of the Undergraduate Course in Biological Science (Hons.)/Major under CBCS
Department of Life Sciences, Presidency University, Kolkata

Semester	Course Type			
	Core Course	**Department Specific Elective**	**Generic Elective**	**Skill Enhancement Course**
First	BIOS01C1: Chemistry		BIOS01GE1: World of Animals	
	BIOS01C2: Light and Life			
Second	BIOS02C3: Biophysics		BIOS02GE2: Economic applications of plant and microbial biotechnology	
	BIOS02C4: Biodiversity			
Third	BIOS03C5: Proteins and Enzymes		BIOS03GE3: Modern Lifestyle, Behaviors and Ailments	BIOS03SEC1: A or B
	BIOS03C6: Cell Biology			
	BIOS03C7: Ecology			
Fourth	BIOS04C8:Systems Physiology		BIOS04GE4: Macromolecules of Life	BIOS04SEC2: A or B
	BIOS04C9:Molecular Biology			
	BIOS04C10:Metabolism and Integration			
Fifth	BIOS05C11:Growth and Reproduction	BIOS05DSE1: A or B		
	BIOS05C12: Genetics	BIOS05DSE2: A or B		
Sixth	BIOS06C13:Defense Mechanisms	BIOS06DSE3: A or B		
	BIOS06C14: Evolutionary Biology	BIOS06DSE4: A or B		

Academic Session: Each Semester shall contain at least 16 Teaching Weeks

Odd Semesters: Semesters One, Three and Five - July to December
Even Semesters: Semesters Two, Four and Six- January to June

Credit Allocation and Marks Distribution for the Undergraduate Course in Biological Science (Hons.)/Major under CBCS

Department of Life Sciences, Presidency University, Kolkata

Semester	Course Type	Paper Code	Course Name	Credits				Marks			
				Theory	Practical	Tutorial	Total	Theory	Practical	Tutorial	Total
First	Core Course	BIOS01C1	Chemistry	4	2		6	70	30		100
First	Core Course	BIOS01C2	Light and Life	4	2		6	70	30		100
First	Generic Elective	BIOS01GE1	World of Animals	4	2		6	70	30		100
First	Ability Enhancement Course		ENVS/ English Commination	4			4	100			100
Second	Core Course	BIOS02C3	Biophysics	4	2		6	70	30		100
Second	Core Course	BIOS02C4	Biodiversity	4	2		6	70	30		100
Second	Generic Elective	BIOS02GE2	Economic applications of plant and microbial biotechnology	4	2		6	70	30		100
Second	Ability Enhancement Course		ENVS/ English Commination	4			4	100			100
Third	Core Course	BIOS03C5	Proteins and Enzymes	4	2		6	70	30		100
Third	Core Course	BIOS03C6	Cell Biology	4	2		6	70	30		100
Third	Core Course	BIOS03C7	Ecology	4	2		6	70	30		100
Third	Generic Elective	BIOS03GE3	Modern Lifestyle, Behaviors and Ailments	4	2		6	70	30		100
Third	Skill Enhancement Course	BIOS03SEC1	A or B	4			4	100			100
Fourth	Core Course	BIOS04C8	Systems Physiology	4	2		6	70	30		100
Fourth	Core Course	BIOS04C9	Molecular Biology	4	2		6	70	30		100
Fourth	Core Course	BIOS04C10	Metabolism and Integration	4	2		6	70	30		100
Fourth	Generic Elective	BIOS04GE4	Macromolecules of Life	4	2		6	70	30		100
Fourth	Skill Enhancement Course	BIOS04SEC2	A or B	4			4	100			100
Fifth	Core Course	BIOS05C11	Growth and Reproduction	4	2		6	70	30		100
Fifth	Core Course	BIOS05C12	Genetics	4	2		6	70	30		100
Fifth	Department Specific Elective	BIOS05DSE1	A or B	4	2		6	70	30		100
Fifth	Department Specific Elective	BIOS05DSE2	A or B	4	2		6	70	30		100
Sixth	Core Course	BIOS06C13	Defense Mechanisms	4	2		6	70	30		100
Sixth	Core Course	BIOS06C14	Evolutionary Biology	4	2		6	70	30		100
Sixth	Department Specific Elective	BIOS06DSE3	A or B	4	2		6	70	30		100
Sixth	Department Specific Elective	BIOS06DSE4	A or B	4	2		6	70	30		100
				Total Credit			**148**	**Total Marks**			**2600**

CORE COURSES

Semester I:

BIOS01C-1: CHEMISTRY

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1 Chemical Thermodynamics and kinetics

Qualitative idea of thermodynamics. First Law of Thermodynamics: Calculation of work (w),heat (q), changes in internal energy (ΔE) and enthalpy (ΔH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w, q, ΔE, and ΔH for processes involving changes in physical states. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature Kirchhoff's Equation. Second law of thermodynamics, concept of entropy, Gibbs free energy and Helmoltz free energy. Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity, Gibbs Helmholtz equation. Maxwell's relations. Activation energy and transition-state theory; Different orders of chemical reactions, free energy and chemical reaction.

Unit 2 Chemical Bonding and Molecular Structure Ionic Bonding

Lattice energy and solvation energy. Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, Covalent Bonding: VB Approach, Lewis theory, VSEPR theory to explain the shapes of molecules, salient features of the Valence bond (VB) theory and the concept of hybridization, MO Approach: limitations of the VB approach, salient features of the MO theory. Rules for the LCAO method, bonding and anti-bonding MOs and their characteristics for s-s-, s-p and p-p combinations of atomic orbitals, nonbonding combinations of orbitals.

Unit 3 Fundamentals of Organic Chemistry

Hybridization in organic compounds, cleavage of covalent bond, homolysis and heterolysis, Electronic effects: Electronic effects and their applications – inductive, resonance and hyperconjugation effects. Structure and relative stability of reactive carbon species –carbocations, carbanions, free radicals and carbenes, Molecular Forces : types of intermolecular and intramolecular forces and their characteristics: dipole-dipole,Dipole Induced dipole and dispersion (London) forces. Hydrogen bond (both intramolecular and intermolecular, Aromaticity).

Unit 4 Stereochemistry

Stereochemistry and its importance. Geometrical isomerism, cis-trans and E/Z nomenclature. Optical isomerism – optical activity, plane polarized light, enantiomerism, chirality, specific molar rotation, Stereoisomerism with two chiral centers: Diastereomers, mesoisomers, Resolution of racemic modification. Projection diagrams of stereoisomers: Fischer, Newmanand Sawhorse projections. Relative Configuration: D/L designation. Absolute Configuration: R/S designation of chiral centres.

Practical

Credit : 2
Contact Hours per Week : 4

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture
2. Estimation of oxalic acid by titrating it with KMnO4.
3. Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator
4. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide
5. Separation of the components of a given mixture of two amino acids by paper chromatography.
6. Separation of sugars present in the given mixture by paper chromatography.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Revise their understanding of basic chemistry and will also learn various aspects of general chemistry that are fundamental and essential to understand almost every biological event or process such as- Solubility, pH, buffers, bonding and interactions between atoms, transition between work and heat, processes, equilibrium, entropy, feasibility of any process to happen, kinetics of any reaction, how stereochemistry of reactants determine the reaction mechanism and product specificity etc.
2. Learn to apply the acquired knowledge in basic chemistry to various biological events of life
3. Gain Hands on training in basic chemistry will enable the students to learn conducting an experiment alone and in a group, with rationale, and outcome.

SEMESTER – I

BIOS01C-2: LIGHT AND LIFE

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1

Nature of light, spectrum of light which is useful/ harmful (ionizing radiation) for various biological processes in life of plants and animals. Unit of light energy (Photon, quantum), Measurement of light (Lux). Introduction to pigments/receptors of light: chlorophylls, carotenoids, phycobiliproteins, bacteriochlorophylls, phytochromes Photoreception in animals, evolution of eye and visual processing in vertebrate retina.

Unit 2

Photosynthetic equation, Light and dark reactions, mechanism of photolysis of water and oxygen evolution, O2 evolving complex; C3, C4, CAM plants, structure of chloroplast and quantasome, Anoxygenic and oxygenic photosynthesis, reaction centers. Bacterial Photosynthesis.

Unit 3

Concept of bioluminescence: definition, diversity of organisms (plants and animals), General account of effect of light on morphology and physiology (stomatal opening and closing, transpiration, seed germination), Concepts of photoperiodism: LDP, SDP, DNP plants, vernalization. Light as an ecological factor affecting distribution of plants and animals (Phytoand Zoo geography), in terrestrial and aquatic ecosystems: Morphological, Anatomical, Physiological and Behavioural adaptations to extreme light conditions by organisms.

Unit 4

Behavioural aspects of ecology and physiology: circadian rhythms, jet lag, SAD, hormonal rhythms, melanocytes and skin colour, chromatophores and colour changes in animals, SCN and Pineal gland, Light as an inducer for biosynthesis of enzymes, hormones and other biomolecules.

Practical

Credit : 2
Contact Hours per Week : 4

1. Demonstration of
    a. Light and CO2 are essential for photosynthesis (Moll's half leaf experiment) and measure oxygen evolution during photosynthesis
    b. Oxygen liberation during photosynthesis using Hydrilla, Measurement of light using Lux meter

c. Berlese funnel experiment to demonstrate the effect of light on soil fauna
d. Animal migration in aquatic ecosystems during day and night (pictures only)

2. To study the estrous cycle of rat
3. Chemical separation of chloroplast pigments/Chromatographic separation of chloroplast pigments.
4. Demonstration of Blackman's law of limiting factors (using Hydrilla).
5. Study of the effect of red and blue light on seed germination
6. Photographs/slides/specimens of photoautotrophic and photosynthetic bacteria, chloroplast, quantasome, bioluminescent organisms (plants and animals)
7. To study the effect of light and darkness on the chromatophores of fish
8. To study the phototactic behavior of different larval instars of Spodoptera
9. To study the effect of light/darkness on development of insect (Spodoptera)
10. To test / survey for colour blindness using Ishihara charts
11. To study Diurnal variations in human body temperature

Course Outcomes:

After successfully completing this course, the students will be able to understand:

1. Physics of light, units and measurement of light energy and light intensity, pigments and receptors which are sensitive to light in bacteria, plants and animals.
2. Photosynthesis in plants and bacteria under different conditions - the reaction mechanisms and the reaction centres involved.
3. The concept of bioluminescence, diversity of plants and animals exhibiting bioluminescence; effect of light on the morphological and physiological processes of plants, effect of light as an ecological factor.
4. Concept of circadian rhythms, and maintaining biological rhythms.
5. Gain practical training on effects of different factors on photosynthesis and seed germination, effect of light on animal migration in aquatic ecosystems; cyclic activity such as estrous cycle in rats and diurnal variation of body temperature of humans.

SEMESTER - II

BIOS02C-3: BIOPHYSICS

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: Mechanics

Galilean invariance and Newton's Laws of motion. Dynamics of a system of particles, Conservation of momentum and energy, work energy theorem. Conservation of angular momentum, torque, Motion of a particle in central force field. Kepler's Laws, Satellite in circular orbit and applications (Synchronous satellite, GPS, Artificial gravity, apparent

weightlessness), Physiological effects of acceleration and angular motion. Special Theory of Relativity: Constancy of speed of light, postulate of Special theory of relativity, length contraction, time dilation, relativistic velocity addition, Mass-energy momentum relations.

Unit 2: Waves and Oscillations

Simple harmonic motion, damped and driven harmonic oscillator, coupled oscillator, energy relation and energy transfer, normal modes, Wave equation, Travelling waves, superposition principle, pulses, Doppler effect, effects of vibrations in humans, physics of hearing, heartbeat. Modern optics: Two slit Interference, Diffraction, Resolving power, Resolution of the eye, Laser characteristics, Principle, Population inversion, Application of laser in medical science, Polarization of EM wave.

Unit 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, Nernst Planck Equations, Diffusion, Osmosis, Donnan effect, permeability coefficient. Ionophores, membrane potential, water potential in context to ion-channels and aquaporins; gating mechanism.

Unit 4: Spectroscopic techniques

Basic principles of electromagnetic radiation, energy, wavelength, wave numbers and frequency. Review of electronic structure of molecules (Molecular Orbital theory), absorption and emission spectra. Beer-Lambert law, light absorption and its transmittance. UV and visible spectrophotometry-principles, instrumentation and applications. Fluorescence spectroscopy, static & dynamic quenching, energy transfer, fluorescent probes in the study of protein, nucleic acids, Infra-red spectroscopy, light scattering in biology, circular dichroism.

Practical

Credit : 2
Contact Hours per Week : 4

1. Verification of Beer-Lambert Law
2. Determination of Molar Extinction coefficient
3. Determination of concentration of nucleic acids through UV-Vis spectroscopy
4. Determination of concentration of proteins through UV-Vis spectroscopy
5. Effect of different solvents on UV absorption spectra of proteins.
6. Determination of CMC for a detergent
7. Osmosis experiment using potato.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn basic concepts of physics and apply them to study the physicochemical properties of biomolecules.

2. Learn to investigate the light absorption properties of biomolecules through spectrophotometry, for qualitative and quantitative analysis of biomolecules.
3. Learn the concepts related to mechanics of solids and liquids to understand the basic mechanisms of cell biology especially cell adhesion, migration and mechanotransduction.
4. Learn about the mechanism of transport of various ions/molecules across cell membranes and their significance in several biological processes.

SEMESTER – II

BIOS02C-4: BIODIVERSITY

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: Defining Biodiversity

Components of Biodiversity. Biodiversity crisis and biodiversity loss. Importance of biodiversity in daily life. Biodiversity and climate change. Types of Ecosystems: India as a megadiverse country. Hotspots and biodiversity in India. Biodiversity and Ecosystem functioning. Types of Biodiversity, microbial classification and diversity.

Unit 2: Modern Tools in the study of Biodiversity

Endemism, endemic plants and animals; Assessment of mapping of biodiversity; GIS/Remote sensing; Biotechnology and Conservation, IUCN; Germplasm banks, National Parks, Botanical Gardens; Wildlife Sanctuaries, Bio resources.

Unit 3: Crop Diversity

Wild relatives of cultivated plants; Domesticated diversity; Spice diversity; Forest diversity and wildlife.

Unit 4: Bio-prospecting

Representative type (one each) studies from Cryptogams, Phanerogams, Non-chordates and Chordates; Sacred flora and fauna. Bio-prospecting– Micro-organisms as a source of novel enzymes, antibiotics, antiviral agents; Immunosuppressive agents and other therapeutic agents. Botanicals for Biocontrol, Health and biodiversity.

Practical

Credit : 2
Contact Hours per Week : 4

1. Study of following specimens: Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, Hermit Crab, Daphnia, Millipede, Centipede, Beetle, Pila, Chiton, Dentalium, Octopus, Asterias, and Antedon.
2. Dissections/ Virtual demonstration: Digestive and nervous system of Cockroach; Mouth parts, salivary apparatus and ovary of cockroach; Unstained mount of Placoid scales.
3. Study of following specimens: Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Ichthyophis/Uraeotyphlus, Salamander, Rhacophorus,Draco, Uromastyx, Naja, Viper, any three common birds, Squirrel and Bat.
4. Study of a few endangered species of amphibians, reptiles, birds and mammals of India
5. To study the faunal composition (insects and mites) of soil samples. (Berley's funnel)
6. To study faunal composition of water samples (Lucky drop method)
7. Report on visit to National Park/Wildlife sanctuary/Botanical garden/ Zoological Garden. FLORA
8. Study through specimens/photographs/slides of (a) Keystone species (b) Ecads, Ecotypes, Ecophenes (c) Source of immunosuppressive and other therapeutic agents (d) Botanicals for biocontrol (e) Sacred flora (havan materials etc.)
9. Study through permanent slides and specimens (vegetative and reproductive structures) of Coleacheate, Vaucheria, Polysiphonia, Fucus (Fucus permanent slides only); Rhizopus, Penicillium and Agaricus; Riccia, Anthoceros, Funaria; Psilotum, Selaginella, Pteris; Cycas, Pinus, Gnetum

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand different components of biodiversity
2. Gain knowledge about modern tools in biodiversity assessment
3. Understand Crop biodiversity
4. Understand Bioprospecting
5. Perform identification of different model invertebrates and vertebrates animals
6. Perform dissection/virtual demonstration of different body parts of invertebrates.
7. Gain comprehensive knowledge about the faunal community from water and soil by means of a Study tour

SEMESTER – III

BIOS03C-5: PROTEINS AND ENZYMES

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Biomolecules- Diversity and distribution

Lipids: Role of lipids in cellular architecture and functions. Definition and classification of lipids. Structure and function of fatty acids, triacylglycerols, phospholipids and sterols. Lipid chemistry: Classification and properties of lipids with emphasis on saponification number, iodine number, acetyl number, Reichert-Meissel number, hydrogenation and rancidity of fats. Carbohydrates: Biological roles of carbohydrates ,Classification and properties of carbohydrates with emphasis on stereoisomerism, optical isomerism, epimerization, mutarotation and reducing action of sugars, monosaccharides- Hexoses and pentoses. Disaccharides-Sucrose, lactose, maltose. Storage and structural polysaccharides-Glycogen, starch and cellulose. Nucleic acid chemistry: elementary concept of nucleoside, nucleotide, polynucleotide; elementary concept of RNA. Nucleic acids: Role of nucleic acids in living system. Composition of nucleic acids-the purine and pyrimidine bases. Bonding interactions and factors stabilizing nucleic acid structures.

Unit 2: Proteins

Classification of proteins on the basis of composition, conformation and function-functional diversity of proteins. The amino acid building blocks-classification, structure and physical properties of the standard amino acids. Proteinaceous and non-proteinaceous, essential and non-essential amino acids. Primary, secondary, tertiary and quaternary structure of proteins. Properties of proteins with emphasis on isoelectric pH, salting in and out, biuret test and heat coagulation. Structure of myoglobin and hemoglobin. Molecular physiology of myoglobin and hemoglobin, Bohr effect, Hill's coefficient. Concerted and sequential models for allosteric proteins.

Unit 3: Enzymes

Enzymes as biological catalysts. Enzyme classification and nomenclature. Chemical nature of enzymes, ribozymes. Concept of active site, specificity. Coenzymes, cofactors and prosthetic groups. Kinetics of enzyme catalyzed reactions –Michaelis Menten equation. Determination of Km and Vmax. Factors influencing the rate of enzyme catalyzed reactions. Enzyme inhibitions- competitive, non-competitive and uncompetitive inhibition. Catalytic mechanism of lysozyme or chymotrypsin. Regulation of enzyme activity allosteric enzymes, feedback inhibition with ATPase as an example.

Unit 4: Isolation and purification of enzymes

Methods of enzyme isolation and purification. Introduction to enzyme immobilization.

Unit 5: Role of Metal ions in Biology

Metalloprotein, Metalloenzymes, metal base drug interaction and inhibition; metalloporphyrins, Fe-S cluster - the multipurpose redox cofactors.

Practical

Credit : 2
Contact Hours per Week : 4

1. Preparation of buffers
2. Determination of PKa value for acetic acid
3. Identification of substances of biological importance by biochemical tests.
4. Estimation of proteins by Biuret method
5. Estimation of proteins by Lowry's method
6. Estimation of glucose / sucrose / lactose in milk by Benedict's method
7. Separation of sugars by Thin Layer chromatography
8. Effect of pH on the activity of an enzyme
9. Determination of Michaelis Menten parameters of an enzyme

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn the basic concepts regarding the building blocks of biological system
2. Understand the basic concepts related to enzymes which are the major players of our biological system: kinetics, inhibition, regulations, mechanism of its action, its purification from cells
3. Learn the involvement of metal ions in biology
4. Gain hands-on training on biochemical analysis of biological important components.

SEMESTER – III

BIOS03C-6: CELL BIOLOGY

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: An Overview of Cells

History, Cell theory, Overview of Prokaryotic and Eukaryotic Cells, Plant and Animal cells, exceptions to cell theory, Phages, Virioids, Mycoplasmas, Viruses, Prions, hierarchy in cell structure and cell molecules (inorganic elements,

building blocks, macromolecules, supramacromolecules, cell organelles, cells, tissues, organs, organisms etc.), Cell cycle and its regulation.

Unit 2: Tools and techniques in cell biology

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, Spectrophotometry, Mass spectrometry, X-ray diffraction, Chromatography: Paper, TLC, gel-filtration, ion-exchange, affinity and HPLC.

Unit 3: Cell wall, extracellular matrix and cell interactions

Cell wall, distribution, chemical composition, functions and variations in prokaryotic and eukaryotic cells (primary and secondary wall), Glycocalyx, Cell-cell interactions/ Junctions, pit connections in plants and animals.

Unit 4: Cell membrane

Structure and functions, active and passive transport, proton pumps associated (Na-K, Ca-calmodulin etc. and their distribution), phagocytosis, pinocytosis, exocytosis, endocytosis.

Unit 5: Nucleus

Nuclear envelope, structure of nuclear pore complex, nuclear lamina, transport across nuclear membrane, Nucleolus, rRNA processing.

Unit 6: Mitochondria, Chloroplasts, Lysosomes, Glyoxysomes and Peroxisomes

Structural organization, function, marker enzymes of the above organelles, biogenesis of mitochondria and chloroplasts, brief account of transport in mitochondria and chloroplasts (Tim/Tom; Tic/Toc) and semiautonomous nature of mitochondria and chloroplast, lysosomes and quality control in the cell.

Unit 7: Cytoskeleton

Structure and organization of actin, myosin and intermediate filaments, microtubules, and their role in cellular traffic and cell cycle.

Unit 8: Protein sorting and Transport

Structure and functions of Endoplasmic reticulum and Golgi apparatus, GERL.

Unit 9: Cell signaling

Signaling molecules and their receptors, functions; intracellular signal transduction pathways (with special reference to some selected pathways); signaling networks and cross talk; bacterial signal transduction (two component system).

Unit 10: Cancer

Programmed Cell Death; Biology and elementary knowledge of development and causes of cancer; Tumor viruses, Oncogenes and suppressor genes, Cancer treatment-Molecular approach, Stem cells and therapeutic cloning.

Practical

Credit : 2
Contact Hours per Week : 4

1. Separation of nucleic acid bases by paper chromatography.
2. Study of different stages of meiosis by temporary preparation/ permanent slides of onion flower buds.
3. Study of different stages of mitosis by temporary preparation/ permanent slides of onion root tips.
4. Demonstration of ciliary movements and staining of fresh tissues like epithelial, connective, muscular and nervous tissues.
5. Staining of fixed tissue sections by hematoxylin - eosin method.
6. Preparation of temporary slides of the following (Onion epidermal peel/ root tips or any other suitable available material like Crinum, Wheat caryopsis etc.): Cytochemical staining of DNA by Feulgen, Cytochemical staining of RNA by Methyl Green, PyroninCytochemical staining of polysaccharides by PAS.
7. Cytochemical staining of proteins by Bromophenol blue, Cytochemical staining of histones by fast green
8. Vital staining of mitochondria by Janus green B in cheek epithelial cells; bacterial staining
9. Identification and study of types of cancer, cancer cells by permanent slides/ photographs.
10. Study of the following microscopic techniques by photographs: Fluorescence microscopy, autoradiography, positive staining, negative staining, freeze fracture, freeze etching, shadow casting
11. Study of ultrastructure of cell (Cell wall, Primary and secondary pits, Plasmodesmata, Gap junctions, Tight junctions, Plasma membrane, Nucleus, Nuclear Pore Complex, Chloroplast, Mitochondrion, Golgi bodies, Lysosomes, SER and RER), Prokaryotic and Eukaryotic cell, Plant and Animal Cell, Phages: TMV and Bacteriophage, Viroids and Prions (Mad Cow's / Kuri/ PSV disease), Mycoplasmas through electron micrographs/photographs.

Course Outcomes:

After successfully completing this course, the students will be able to learn

1. How the world inside the cell operates.
2. How wonderfully all the workloads of a cell are distributed in various compartments and how all these organelles cooperate with each other inside the cell for its survival.
3. How beautifully the cell organizes its survival and death machinery and also increases its number with proper segregation of its genetic materials.

4. How the cell on the one hand compartmentalizes itself from its surroundings and on the other hand constantly maintains connections to the outside world and responds instantly to the stimuli.
5. Learn different staining procedures and understand cellular diversity, cell measurement methods, cell division through different laboratory exercises.

SEMESTER – III

BIOS03C-7: ECOLOGY

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: Introduction to Ecology

Relevance of studying ecology, History of ecology, Autecology and synecology, levels of organization, major biomes (role of temperature and precipitation). Laws of limiting factors (Leibigs law of minimum, Shelfords law of tolerance), ecological range (Eury, Steno). Ecological factors (abiotic and biotic): detailed study of temperature and light as physical factors. Soil- characteristics and horizons.

Unit 2: Population Ecology

Population : Unitary and Modular populations, metapopulation : Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion; carrying capacity, population dynamics (exponential and logistic growth equation and patterns), r and K selection, density-dependent and independent population regulation; Competition, Niche concept, Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition and Predation – Introduction.Phenotypic and genotypic plasticity, Species interactions.

Unit 3: Ecosystem and Community Ecology

Concept, components, types of ecosystem with one example Pond ecosystem in detail (abiotic and biotic components, BOD, eutrophication). Energy flow (Grazing and Detritus food chain), linear and Y-shaped energy flow model, food web. Ecological pyramids and Ecological efficiencies.Nutrient cycle with one example of Nitrogen cycle. Community ecology: Community structure: Dominance, diversity, species richness, abundance, stratification; Diversity indices; Ecotone and edge effect; Community dynamics (succession): Viewpoint of succession, Primary and secondary succession, Hydrarch and xerarch succession. Climax: monoclimax and polyclimax concepts (preclimax, postclimax, disclimax etc.). Concept of keystone, indicator, umbrella and flagship species.

Unit 4: Behavioral ecology

Social, reproductive & territorial behavior, kin selection. Evolution of optimal life history, trade-offs, semelparity and iteroparity, reproductive structure and mating system. Four questions of Niko Tinbergen, Communication: pheromone and bee-dance.

Practical

Credit : 2
Contact Hours per Week : 4

1. Study through specimens/photographs/slides of Parasitic angiosperms, Saprophytic angiosperms, VAM fungi, Root nodules, Coralloid roots, Mycorrhizal roots, Velamen roots, Different types of lichen.
2. Principle and function of Sechi disc, Atmometer, Anemometer, Hygrometer, Hair hygrometer, Luxmeter, Rain gauge, Soil thermometer, Min-Max thermometer
3. To determine a minimal quadrat area for sampling in the given simulation sheet
4. To determine density/frequency/abundance of the vegetation by quadrat method in the field or on given simulation sheet
5. To determine soil texture, soil density, bulk density, particle density and pore space.
6. To determine water holding capacity and percolation rate of soil.
7. To determine pH, Cl, SO_4 , NO_3, base deficiency, organic matter, cation exchange capacity in the soil.
8. Plotting of survivorship curves from hypothetical life table data.
9. To estimate dissolved oxygen content of given water sample using Winkler's method and free CO_2
10. Study of animal behavior in natural habitat (Forest/ aquatic ecosystem).

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand about conservation of the ecosystem, prevent extinction of species, understand the interrelationships among organisms and habitats, reduce pollution, inculcate thoughtfulness towards the environment among the future generations.
2. Learn about employment of scientific methodology via lab and field studies to understand how the different organisms grow, populate, how they interact with other organisms either as parasites, predators, how the organisms die out as well as how they evolve or adapt to changing climatic and environmental situations.
3. Using the principles of ecology, students learn to predict, counteract and prevent potentially adverse effects we might have on the earth due to our undying greed for more, and thus safeguarding our wellbeing and survival on this planet.

SEMESTER - IV

BIOS04C-8: SYSTEMS PHYSIOLOGY

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: Movements and Bulk Transport

Cellular movements, ciliary and flagellar structure and function; Introduction to musculo-skeletal system; Terrestrial, aquatic and aerial locomotion; Locomotory cost; Long distance transport of water and nutrients in plants (xylem and phloem transport) ; General plan and physiology of circulatory system in vertebrates and invertebrates; Blood and body fluids - composition, haemopoiesis, haemoglobin, hemostasis, blood transfusion, anaemia; circulation in humans. Cardiovascular system -cardiac cycle, cardiac output, electrocardiography and arrhythmias.

Unit 2: Gas exchange in animals & humans

Role of respiratory pigments, significance of different lung volumes and capacities ; Generation and utilization of energy, Exchange in unicellular organisms and plants; Respiratory organs in aquatic and terrestrial systems ; Physiology of aquatic breathing and aerial breathing; Feeding patterns, physiology of human digestive system, regulation of digestion and absorption of foods.

Unit 3: Regulatory Physiology

Mechanism of opening and closing of stomata. Regulation of water and solutes in aquatic and terrestrial animals; Osmoregulatory organs Renal regulation of osmolarity,. Transpiration in plants; Excretion of nitrogenous wastes in animals and humans; Countercurrent multiplier and exchanger, Patterns of Thermoregulation: Ectotherms, Endotherms and homeotherms and their mechanism; Concept of Q10, Structural and functional adaptation to stress.

Unit 4: Integrative Physiology

An overview of the nervous system, Neurone -structure, types, properties and propagation of nerve impulse; Sensory physiology - receptors- types and potentials.Reflex action- types and properties. Endocrine systems in animals and humans and their physiological effects; Plant hormones and their physiological effects; Regulation of metabolism and response to environmental cues.

Practical

Credit : 2
Contact Hours per Week : 4

1. Effect of isotonic, hypotonic and hypertonic salines on erythrocytes
2. Identification of different histological sections. Identification of blood cells and differential counts.

3. Estimation of total count of WBC & RBC using haemocytometer.
4. Identification of megakaryocytes from bone marrow and measurement of its diameter.
5. Pneumographic recording of respiratory movements under different experimental conditions.
6. Studies on the movements of the heart and intestine.
7. Study of the effect of various environmental factors on transpiration in an excised twig/ leaf.
8. Calculation of the stomatal index, stomatal frequency and percentage of leaf area open through stomata in mesophytes and xerophytes.
9. Study of the mechanism of stomatal opening and closing.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Get a comprehensive overview of the workings of bulk transport in human, animal and plant systems
2. Understand the unique role of various organs and organ systems in performing various vital functions.
3. Understand gas exchange, temperature and salt balance, appreciate the importance of homeostasis in different systems
4. Understand sensory systems and regulation by hormones in plants and animals including humans.
5. Learn to apply critical thinking and integrate scientific knowledge to understand the basic physiological principles which led to diverse evolutionary adaptations.

SEMESTER - IV

BIOS04C-9: MOLECULAR BIOLOGY

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Genes and genomic organization

Definition of a gene, organization of genes in viruses, bacteria and eukaryotes. Complexity of eukaryotic genes and chromosomes, Cot Curve analysis, supercoiling of DNA and its importance, linking number, topoisomerases, inhibitors of topoisomerases and their application in medicine, Nucleosome structure and packaging of DNA into higher order structures.

Unit 2: Replication of DNA

Features of DNA Replication, chemistry of DNA synthesis, the replication fork, origin of replication, stages of DNA replication, enzymes and proteins involved in DNA replication, *E coli* DNA polymerases, replication in eukaryotes,

telomeres and telomerase. Comparison of replication in prokaryotes and eukaryotes. Regulation of DNA replication in prokaryotes and eukaryotes

Unit 3: DNA repair

Mutations and cancer, mismatch repair, base excision repair, nucleotide excision repair, direct repair, recombination repair, Non-homologous end joining (NHEJ), error-prone translesion DNA synthesis, SOS repair in bacteria

Unit 4: DNA-dependent synthesis of RNA

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.

Unit 5: RNA processing

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.

Unit 6: Proteins Synthesis

The genetic code, 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-tRNAsynthetases, initiation in prokaryotes and in eukaryotes, elongation, termination, folding and processing, inhibitors of protein synthesis and their application in medicine.

Unit 7: Regulation of gene expression

Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains. Regulation of gene expression in bacteria, lac operon and trp operon, induction of SOS response, synthesis of ribosomal proteins, riboswitches. Overview of regulation of gene expression in eukaryotes, heterochromatin, euchromatin, chromatin remodeling, DNA binding activators and co-activators, regulation of galactose metabolism genes in yeast, post-transcriptional gene-silencing by RNA interference.

Practical

Credit : 2
Contact Hours per Week : 4

1. Estimation of DNA by DPA method.
2. Estimation of RNA by Orcinol method.

3. Separation of nucleotide bases by paper chromatography/Plasmid DNA isolation.
4. Extraction of total nucleic acids from plant tissue/animal cells/ yeast.
5. Isolation of RNA from plant tissue/animal cells/ yeast.
6. Isolation of chromosomal DNA from *E. coli* / yeast/ animal cells.
7. Measure Purity of isolated DNA by A260/A280 Ratio.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn about the structure of DNA, about genome organization in various life forms
2. Learn about the mechanism of DNA replication along with regulation in prokaryotes and eukaryotes.
3. Learn about the process of transcription, RNA processing and translation in prokaryotes and eukaryotes.
4. Learn about the various ways in which the DNA can be damaged leading to mutations and lesions and different ways to repair DNA damage.
5. Learn about the various ways in which these biological processes are regulated and its significance

SEMESTER – IV

BIOS04C-10: METABOLISM AND INTEGRATION

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 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.

Unit 2: Metabolic Pathways

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). 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 Nutritional disorder-PEM (Kwashiorkor and Marasmus), Obesity. Metabolic disorders-saturated and unsaturated fatty acids, synthesis of triglycerides and cholesterol, lipoproteins-

synthesis, transport and its disorders. Diabetes. Inborn errors of metabolism- i) Protein-PKU, Alkaptonuria and Maple syrup and Gaucher's disease. Protein catabolism - Transamination and deamination, Urea cycle, glucogenic and ketogenic amino acids, biosynthesis and catabolism of amino acids (glycine, phenylalanine, glutamic acid) Nucleotide metabolism: Biosynthesis and catabolism of purines and pyrimidines (Adenine and cytosine). Porphyrin metabolism: Biosynthesis and degradation of porphyrins, biosynthesis of bile pigments.

Unit 3: Metabolic Integration

Metabolic changes during starve-feed cycle, exercise, diabetes and alcohol abuse.

Unit 4: Oxidative phosphorylation

Components, properties and function of electron transport system, chemiosmotic hypothesis, inhibitors and uncouplers of the electron transport system, Shuttle systems.

Unit 5: Microbes and Metabolism

Role of microbes in metabolic tasks- alternate metabolic cycles. Carbon metabolism of intracellular bacterial pathogens, environmental cleansing, metabolic handling of xenobiotics and drug resistance, photo and lithotrophic metabolic capabilities; Myporia.

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.
7. Identification of organelles by marker enzymes – SDH, LDH and acid phosphatase.

Course Outcomes:

After successfully completing this course, the students will be able to understand:

1. The basic concept of metabolism and the experimental techniques used to study metabolic pathways.
2. The principles of bioenergetics and the molecules involved in energy transfer in metabolic reactions.
3. The different metabolic pathways of carbohydrate, protein, fat, nucleic acid and porphyrin metabolism.
4. Different disorders associated with defects in carbohydrate, protein, fat and nucleic acid metabolism.
5. Metabolism during starve-feed cycle, diabetes exercise, obesity and alcohol abuse.
6. Oxidative phosphorylation - components ,reactions couplers and uncouplers of the electron transport chain,

7. Alternate metabolic pathways in bacteria, role of microbes in environmental cleansing; xenobiotic metabolism and drug resistance.
8. Gain hands-on training on estimation of different blood components of clinical importance such as glucose, proteins, cholesterol, SGOT, SGPT, etc.

SEMESTER – V

BIOS05C-11: GROWTH AND REPRODUCTION

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: Introduction

General growth patterns in animals and plants. The role of cell wall in cell growth; extension growth of multicellular organs in plants. Primary meristem: concept of stem cell; shoot apical meristem- dynamics of shoot apical meristem; homeobox genes and meristem identity; root apical meristem as an organized structure; Post - embryonic meristems in plants with special reference to Arabidopsis embryogenesis. Analysis of plant growth: kinetics and kinematics. Senescence, ageing, abscission and programmed cell death: a general account, with special reference to hyperplasia and hypertrophy in animals and tumours in plants. Factors regulating growth in animals with emphasis on hormones).

Unit 2: Pre Fertilization Changes

Alternation of generations and reproductive patterns in animals and plants; Asexual and sexual reproduction- an overview (regeneration, archegonium, heterospory, siphonogamy, apogamy, apospory, apomixis etc.). Pre-fertilization events- gametogenesis- (spermatogenesis, oogenesis) and folliculogenesis, types of eggs in animals, menstrual cycle, hormonal changes during adolescence.

Unit 3: Post Fertilization Changes and Early Development

Post Fertilization Events; Types of Cleavages; Blastula; Fate Maps, Morphogenetic movements during gastrulation; Gastrulation in frog and chick and humans; Fate of Germ layers; Neural tube formation, brief account on embryonic induction, Extra Embryonic membranes in chick and mammal, Placenta: Functions and types. Sex determination, changes during pregnancy, parturition and lactation. Plant development biology-embryogenesis, organogenesis, plant regulation, protoplast technology.

Unit 4: Differentiation

Organogenesis: Formation of CNS, Organogenesis of secondary girth.

Practical

Credit : 2
Contact Hours per Week : 4

1. Study of whole mounts of chick- early developmental stages
2. Study of chick development from live eggs (window viewing)
3. Study of section of chick embryo through selective developmental stages
4. Videos showing selective embryonic events like cleavage; gastrulation
5. Measurement of animal/plant cell size using ocular and stage micrometer.
6. Micro and mega sporogenesis in higher plants-slides only
7. Pollen germination in vivo and in vitro
8. Embryo development in flowering plant-slides only; dissection of endosperm and embryo
9. Survey of dispersal mechanisms of seeds
10. Fixing and staining of different stages of rat embryo (post implantation stages).

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn the mechanisms of growth and the factors regulating growth including nutrition, hormones etc.
2. Get a comprehensive knowledge regarding basic male and female reproductive organs, their histopathological architecture, molecular mechanisms involved in production of male and female germ cells,
3. Understand the mechanism of union of germ cells and development of a next progeny.
4. Visualize and appreciate concepts learnt in theory and apply experimental approaches to understand these developmental events in the laboratory.

SEMESTER – V

BIOS05C-12: GENETICS

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: Mendelian Genetics and Extensions

Model organisms in genetic analysis, Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information. Principles of Inheritance, Chromosome theory of inheritance, Laws of probability, Pedigree analysis, Incomplete dominance, co-dominance, Overdominance, Multiple alleles, pseudoallele, Lethal alleles, Penetrance & expressivity, Epistasis, Pleiotropy, Phenocopy, gene transfer in bacteria, Benzer's cis-trans complementation experiment

Unit 2: Linkage, Crossing over and Chromosomal Mapping

Linkage and Crossing over, cytological basis of crossing over, Molecular mechanism of crossing over. Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and Coincidence, Chromosome Mapping in Prokaryotes & Eukaryotes.

Unit 3: Mutations

Chromosomal mutations, Structural (Deletion, Duplication, Inversion, Translocation) and numerical aberration (Aneuploidy and Polyploidy) of chromosomes and associated disorders in Human; Gene mutations: Induced v/s Spontaneous, Back v/s Suppressor mutations. Molecular basis of mutations in relation to UV light and chemical mutagens, Detection of mutations: ClB method, Attached X-method, DNA repair mechanisms.

Unit 4: Extra chromosomal Inheritance

Chloroplast mutation/Variegation in four 'o clock plant and Chlamydomonas, Mitochondrial mutations in Neurospora and yeast, Maternal effects, Pattern of shell coiling in snail, Infective heredity-Kappa particles in Paramecium.

Unit 5: Genome Dynamics-Transposable Genetic Elements

Sex determination and dosage compensation in Drosophila and human. Prokaryotic transposable elements-IS elements, Composite transposons, Tn-3 elements; Eukaryotic transposable elements- Ac-Ds system in maize and P-elements in *Drosophila*; Uses of transposons.

Unit 6: Genomics, Bioinformatics and Proteomics

Genomes of bacteria, Drosophila and Humans; Human genome project; Introduction to Bioinformatics, Gene and Protein databases, sequence similarity and alignment, Gene feature identification. Gene Annotation and analysis of transcription and translation; Posttranslational analysis-Protein interaction.

Unit 7: Population and Evolutionary Genetics

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, Genetic drift. Speciation.

Practical

Credit : 2
Contact Hours per Week : 4

1. Study of Linkage, recombination, gene mapping using marker based data from *Drosophila*.
2. Study of Phlox/ Allium Karyotype (normal and abnormal).
3. PTC testing in a population and calculation of allele and genotype frequencies.

4. Study of abnormal human karyotype and pedigrees (dry lab).
5. Isolation of plasmid DNA from *E.coli* and restriction enzyme digestion of plasmid DNA.
6. Estimation of size of a DNA fragment after electrophoresis using DNA markers.
7. Construction of Restriction digestion maps from data provided.
8. Demonstration of DNA fingerprinting.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand the concept of genotype and phenotype, describe the basic principles of Mendelian genetics and appreciate the various factors that confer genotypic and phenotypic variability.
2. Understand the inter relationship between environment versus inheritance in determining the conversion of genotype to phenotype.
3. Learn to use the concepts of bacterial and viral genetics to understand resistance patterns and to create linkage and genetic maps.
4. Learn to describe population structure by genetic variation, pedigree analysis and develop broad and balanced knowledge and understanding of key biological concepts, principles and theories related to evolution, genetic change and speciation.
5. Learn to apply the principles of transmission and inheritance in real life situations.

SEMESTER – VI

BIOS06C-13: DEFENSE MECHANISMS

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1 Introduction

Overview of defense mechanisms in plants and animals; Hematopoiesis, cells and organs of the immune system, primary and secondary lymphoid organs and tissues.

Unit 2: Innate immunity in plants and animals

Plants - Chemical and morphological defense in plants; elicitors, receptors , Basal resistance and innate biochemical host defenses Animals - Anatomical barriers, cell types of innate immunity, Pattern Recognition Receptor (PRR), connections between innate and adaptive immunity, cell adhesion molecules, chemokines, leukocyte extravasation, localized and systemic response. Complement activation by classical, and alternate pathway, biological consequences of complement activation.

Unit 3: Adaptive Immunity in Plants and Animals

Plants - Biotic- interactions with symbionts, pathogens. Biochemical host defenses, Basal resistance and basic compatibility; Gene for gene concept; interaction in host-pathogen systems, receptor-elicitor model, plant gene-gene interaction. Cytological protection and induced resistance. Passive and active defenses. Animals - Antigens and haptens, Factors that dictate immunogenicity, B and T cell epitopes. Structure and distribution of classes and subclasses of immunoglobulins (Ig), Ig fold, effector functions of antibody, antigenic determinants on Ig and Ig super family. Generation of antibody Diversity. Monoclonal antibodies; Immunological methods- Antigen-antibody interactions; Histocompatibility antigens - MHC, HLA and Disease; T and B cell - Maturation, activation and effector response, Positive and Negative selection, APC and Antigen Presentation, Cytokines and Chemokines.

Unit 4: Immune dysfunction and applications

Immunological tolerance; Immunological disorders – Hypersensitivity and Autoimmune diseases. Immunodeficiencies; Transplantation Immunology; Immune response against major classes of pathogens. Applications in agriculture, pharmaceuticals, and biopest control.

Practical

Credit : 2
Contact Hours per Week : 4

1. Survey of structural plants defenses: viz. cuticle, wax, lignin, bark, thorns, prickles, trichomes.
2. Immunodiffusion – SRID. Rocket IEP
3. Spleen cell isolation and counting.
4. ABO and Rh blood grouping
5. Latex agglutination assay
6. Quantitative immunoprecipitation assay

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Get an overview of the immune system and learn about the various cells, organs and tissues of the immune system.
2. Learn the basic defense mechanisms of the human body, learn how our body differentiate self from non self and thus successfully eliminate any danger from outside
3. Understand the cellular and molecular pathways of humoral and cell-mediated immune responses and appreciate the importance of immune system in health and disease.
4. Learn about the various preexisting structural and induced defenses in plants and how pathogens can cause disease in plants, and understand the genetic basis of plant-pathogen interaction.
5. Learn how immunodeficiency makes us vulnerable and how vaccine is essential to protect us from infectious diseases.

SEMESTER – VI

BIOS06C-14: EVOLUTIONARY BIOLOGY

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Historical Review of Evolutionary Concept

Pre-Darwinian ideas – List of contributors influencing Darwin indicated as a timeline. Lamarckism – Merits and demerits. Darwinism – Merits and demerits, Post-Darwinian era – Modern synthetic theory; biomathematics and the theory of population genetics leading to Neo-Darwinism

Unit 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. Biogeny – Cellular evolution based on proto-cell models (coacervates and proteinoid micro-spheres). Origin of photosynthesis – Evolution of oxygen and ozone buildup. Endosymbiotic theory – Evolution of Eukaryotes from Prokaryotes.

Unit 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). Taxonomic– Transitional forms/evolutionary intermediates; living fossils. Phylogenetic – a) Fossil based – Phylogeny of horse as a model. b) Molecule based – Protein model (Cytochrome C); gene model (Globin gene family)

Unit 4: Sources of Evolution – Variations as Raw Materials of Change

Types of variations – Continuous and discontinuous; heritable and non-heritable. 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.

Unit 5: Forces of Evolution – Qualitative Studies Based on Field Observations

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, Polymorphism, Heterosis and Balanced lethal systems. 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.

Unit 6: Forces of Evolution –Quantitative Studies Based on Biomathematics

Quantitative Studies Based on Biomathematics, 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.

Unit 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.

Unit 8: End of Evolution – Extinction

Periodic extinctions, Mass-scale extinctions – Causes and events

Unit 9: Evolution of Plants and Fungi

Origin of land plants – Terrestrial algae and Bryophytes; alternation of generations. Early vascular plants – Stelar evolution; Sporangium evolution. Angiosperms – Phylogeny of major groups.

Unit 10: 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

Practical

Credit : 2
Contact Hours per Week : 4

1. Evidences of fossils
    a. Study of types of fossils (e.g. trails, casts and moulds and others) and Index fossils of Palaeozoic era
    b. Connecting links/transitional forms - Eg. Euglena, Neopilina, Balanoglossus, Chimaera, Tiktaalik, Archaeopteryx, Ornithorhynchus
    c. Living fossils - Eg. Limulus, Peripatus ,Latimeria, Sphenodon
    d. Vestigial, Analogous and Homologous organs using photographs, models or specimen
2. Variations.
    a. Sampling of human height, weight and BMI for continuous variation

   b. Sampling for discrete characteristics (dominant vs recessive) for discontinuous variations E.g hitch-hiker's thumb, dexterity, tongue rolling, ear lobe (data categorization into 16 groups based on the combination of 4 traits; assigning each subject to the respective group)
3. Selection Exemplifying Adaptive strategies (Colouration, Mimetic form, Co-adaptation and co-evolution; Adaptations to aquatic, fossorial and arboreal modes of life) using Specimens
4. Neo-Darwinian Studies
   a. Calculations of genotypic, phenotypic and allelic frequencies from the data provided
   b. Simulation experiments using coloured beads/playing cards to understand the effects of Selection and Genetic drift on gene frequencies
5. Phylogeny
   a. Digit reduction in horse phylogeny (study from chart),
   b. Study of horse skull to illustrate key features in equine evolution
   c. Study of monkey and human skull - A comparison to illustrate common primate and unique Hominin features

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn about the compelling evidences in favour of evolution like fossils, comparative anatomy and molecular homologies.
2. Learn about the processes of evolution by mutation, migration, selection and genetic drift
3. Understand how biodiversity is generated by repeated speciations and lost over time due to mass extinctions.
4. Learn about the Neutral Theory of Molecular Evolution
5. Understand key concepts of Population Genetics in terms of Hardy-Weinberg Law , understand micro-evolutionary changes and speciation

DISCIPLINE SPECIFIC ELECTIVES (DSE)

SEMESTER – V

BIOS05DSE-1A: BIOSTATISTICS & BIOINFORMATICS

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit1: Biostatistics

Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Overview of testing of hypothesis, errors of inference and distribution types.
Distribution-free test - Chi-square test, G-test.
Product moment Correlation- assumptions, properties, computations and applications, Spearman's rank correlation coefficient, Point biserial r, Biserial r, contingency coefficient.
Properties and computations of simple linear regression.

Unit 2: Bioinformatics

Bioinformatics spectrum: Introduction to Genomic Data and Data Organization; Information from nucleic acid/protein sequences and structures.
Protein and Nucleic Acid Sequence Data Banks – NBRF-PIR, SWISSPORT, GenBank, EMBL.
Structural data bank – PDB, SCOP, CATH, CSD
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.
Basics of systems biology.

Practical

Credit : 2
Contact Hours per Week : 4

Bioinformatics Practical:

1. Sequence Alignment (BLAST/ ClustalW/ FASTA)
2. Primer Designing (IDT tools) and sequencing data analysis
3. Accessing sequence and structure databases and information retrieval
4. Image J
5. Phylogenetic Cluster Analysis
6. Gene Prediction

7. Prediction of protein structure
8. Viewing three dimensional Structures of Macromolecules by Rasmol
9. Protein- Protein Interactions (STRING)

Biostatistics Practical:

1. Plotting of graphs.
2. Computation of Mean, median, mode, standard deviation
3. Testing of hypothesis by z and t test.
4. Chi square analysis
5. Computation of correlation statistics
6. Computation of regression equation.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Gain a comprehensive knowledge regarding statistical presentation and evaluation of multiparametric data
2. Recognize the importance of data collection and its role in determining scope of inference.
3. Learn about hypothesis testing.
4. Choose and apply appropriate statistical methods for analyzing one or two variables.
5. Understand the basics of bioinformatics and develop awareness of the interdisciplinary nature of this field.
6. Learn about Biological Databases and the types of databases.
7. understand protein structure using visualization softwares , learn about gene prediction program
8. Understand sequence alignments and analyze phylogeny using alignment tools.

SEMESTER – V

BIOS05DSE-1B: PLANT SCIENCE AND PLANT BIOTECHNOLOGY

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Evolution from Archegoniatae to Angiosperms.

Transition to land habit and Alternation of generations, Sporangial evolution, Heterospory and seed habit.
Botanical nomenclature, concept of taxa, rank and naming, author citation, Type specimens; Herbarium
Concept of chemotaxonomy, numerical, molecular taxonomy, Gene bank and DNA Barcoding, Chloroplast and Mitochondrial markers, Clustering and Phylogenetic tree, DNA Bank for conservation strategy.

Unit 2: Paleobotany; Anatomy and Reproductive morphology of higher plants.

Geological time scale and emerging plant groups; Fossilization processes; Fossil types and fossil dating, Forensic palynology.
Organization of Root and Shoot apex, wood anatomy (primary and secondary growth);
Inflorescence, Floral parts, Male and female gametophytes.

Unit 3: Plant Metabolism & Plant Cytogenetics.

Mineral uptake and nutrition, Important elements (macro and micronutrients), mineral deficiency symptom;
Biosynthesis and breakdown of carbon compounds: Sucrose, Starch, Cellulose, Lipids
Nitrogen fixation, Ammonia assimilation and transamination; Sulphur and phosphorus metabolism.
Genomic variation in chromosomes and inheritance in plants: Aneuploidy (monosomics, trisomics, nullisomics) and Polyploidy (autopolyploidy, allopolyploidy, segmental allopolyploidy, autoallopolyploidy); Chromosomal structural aberration: Deletion, Duplication, Translocation and Inversion.
Repetitive DNA sequence, tandem and interspersed, Homoeotic gene in plants (ABCE Quartet model of flowering).

Unit 4: Plant Breeding, Tissue culture, and Plant Biotechnology

Domestication, and Selection: Pureline and mass selections, applications. Heterosis or hybrid vigour, Male sterility: concept, types and applications. Apomixis and self-incompatibility and their role in plant breeding. Use of molecular markers.
Marker assisted selection, Dominant and recessive marker, RFLP, RAPD, SCAR, CAPS, AFLP, SSR, ITS, Physical map vs. genetic map
Basics of Plant Tissue Culture: Concept of totipotency, Explants, Various sterilization and explant preparation techniques, Plant tissue culture media composition: macro and micro-nutrients and plant growth regulators used in plant tissue culture media;
Micropropagation and clonal fidelity; Somatic embryogenesis and synthetic seeds,
Protoplast isolation and fusion: Protoplast isolation technique; Different protoplast fusion methods: Chemical fusion, Electrofusion; Cybrids.
Different types of vectors, restriction enzymes, DNA ligase, Plant selection markers, reporter genes.
Different gene delivery methods: particle bombardment, microinjection, *Agrobacterium* mediated transformation, Ti plasmid, Ri plasmid.

Practical:
Credit : 2
Contact Hours per Week : 4

1. Work out one Bryophytes (Hepatics/Moss) / one Pteridophytes (Lycopodium /Selaginella /Equisetum /Pteris/) /one gymnosperm (Cycas/Pinus)
2. Work out one dicot and monocot for taxonomic interpretations.
3. Anatomy of specimens (Hydrophytes/Xerophytes leaves)/ secondary growth from stem

4. Spectrophotometric estimation of total phenols by TPC
5. Separation of lipid classes by TLC from Mustard/Groundnut seeds
6. Work out on Mitotic metaphase / anaphase from root tip of Allium / meiosis from
7. Preparation and sterilization of Plant tissue culture media
8. Sterilization of explants
9. Isolation and estimation of genomic DNA
10. PCR with universal primers.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Appreciate the evolution of plants
2. Understand the development of the plant system
3. Understand the specifics of plant metabolism and cytogenetics
4. Appreciate and understand plant biotechnology

SEMESTER – V

BIOS05DSE-2A: ANALYTICAL TECHNIQUES IN IN BIOLOGY

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Imaging and related techniques

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; use of fluorochromes: Flow cytometry (FACS), applications of fluorescence microscopy. Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy, sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: Cell fractionation

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes

Use in biological research, auto-radiography, pulse chase experiment.

Unit 4: Spectrophotometry

Principle and its application in biological research.

Unit 5: Chromatography

Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids

Mass spectrometry; X-ray crystallography, NMR; Characterization of proteins and nucleic acids; Electrophoresis: PAGE, SDS-PAGE

Practical

Credit : 2
Contact Hours per Week : 4

1. Demonstration of ELISA.
2. Affinity chromatography
3. To separate chloroplast pigments by column chromatography.
4. To separate proteins using PAGE.
5. To separate DNA (marker) using AGE.
6. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
7. Preparation of permanent slides (double staining).

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Students will learn the principle of workings of various tools and techniques that are commonly used in biological research.
2. They will have hands-on experience with the workings of some instruments.

SEMESTER – V

BIOS05DSE-2B: ANIMAL MORPHO-ANATOMY AND HISTOLOGY

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

Unit 1: Animal Morpho-Anatomy

Aquiferous system and endoskeleton in Porifera.
Coral and coral reef formation

Nervous system in Annelida, Arthropoda and Mollusca.
Water vascular system in Echinodermata.
Larval forms of invertebrates.
Filter-feeding in protochordates; progressive and retrogressive metamorphosis in Chordata
Exoskeletal structure in amniotes.
Comparative anatomy of heart, kidney and aortic arch.
Ruminant stomach.

Unit 2 Animal Histology

Histology of mammalian stomach, liver, kidney, thyroid, pancreas and gonads

i. Stomach (Basic subdivision and histology. Gastric mucosa; glands and cell types. Synthesis and secretion of HCl by Parietal cells).
ii. Liver (Structural organization and blood supply. Liver lobules; classic lobule, portal lobule and liver acinus. Metabolic, exocrine and endocrine functions of liver)
iii. Thyroid (Thyroid follicle; basic structure, cell types and function. Thyroglobulin; role in synthesis of thyroid hormones).
iv. Pancreas (Basic structure and histology of exocrine and endocrine pancreas. Endocrine pancreas; cell types and function).
v. Kidney: (Basic structure and histology of cortex and medulla. Juxtaglomerular apparatus. Nephron; role in production of hypertonic urine)
vi. Gonads (basic structure, cell types and function of Ovary & testis)

Fixation - Non-additive and additive fixatives and their mode of actions
Histological dyes – physical and chemical classification of dyes, mordanting, metachromasia

Practical
Credit: 2
Contact Hours per Week: 4

1. Submission of project report on any topic of exoskeletal modifications in invertebrates/ vertebrates.
2. Collection/ demonstration of larval forms of hemimetabolous and holometabolous insects.
3. Staining and mounting of cycloid and ctenoid scales of fishes.
4. Dissection/ virtual demonstration of Weberian Ossicles and air bladder of fishes.
5. General demonstration for tissue fixation, block preparation and microtomy.
6. Staining of histological slides (ovary, testis, liver, kidney, pancreas and lung) and identifications of the section with reasons.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn the anatomy, structural adaptations and biology of important non-chordates and chordates.
2. Understand the comparative anatomies of organs

3. Learn the histological architecture of tissues and organs
4. Know the working principles and mode of actions of fixatives, dyes and stains
5. Develop concept of data collection in field work and surveys
6. Develop skills in tissue fixation, microtomy and histological staining of tissue sections.

SEMESTER – VI

BIOS06DSE-3A: STRESS BIOLOGY

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Defining stress

Acclimation and adaptation. Brief introduction to diverse stressors in plant, animals and human

Unit 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.

Unit 3: Stress sensing mechanisms

Role of nitric oxide. Phospholipid signaling, growth factors and arachidonate signalling.

Unit 4: Developmental and physiological mechanisms that protect plants, animals and human against environmental stress

Morphological, biochemical and genetic adaptation in plants in osmotic stress; Xenobiotics and biotransformation.

Unit 5: Redox imbalance, Reactive oxygen species, Production and scavenging mechanisms

Sources of ROS, quenching mechanisms in the cell, antioxidants.

Practical

Credit : 2
Contact Hours per Week : 4

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
2. Superoxide activity in seedlings in the absence and presence of salt stress.
3. Quantitative estimation of peroxidase and superoxide dismutase activity, catalase, glutathione reductase.
4. Estimation of superoxide anions.
5. Salt stress assay in plants
6. Assessment of different nutritional and physiological stress parameters in individuals involved in different workplace stressors.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand the various mechanisms of stress in animals and plants.
2. Understand the effect of stress in various systems.
3. Understand mechanisms of stress response at the cellular level and mechanisms of amelioration.

SEMESTER – VI

***BIOS06DSE-3B*: MICROBIOLOGY**

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: History of Microbiology, diversity and classification

History of development of microbiology as a discipline, development of various microbiological techniques, concept of fermentation, establishment of fields of medical microbiology, immunology and environmental microbiology. Microbial diversity: cellular (bacteria, algae, fungi, protozoa) and acellular (virus) microbes, polyphasic bacterial taxonomy, extremophiles. Architecture of bacteria and virus: comparison between eubacteria and archaebacteria. Molecular methods of assessing microbial phylogeny- molecular chronometer, phylogenetic trees.

Unit 2: Microbial Cell organization and metabolism

Cell size, shape and arrangement, glycocalyx, capsule, flagella, fimbriae and pili; Cell-wall: Composition and structure of Gram positive and Gram negative cell walls. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes; Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids; Endospore: Structure, formation, stages of sporulation. Microbial metabolism.

Unit 3: Microbial Nutrition and Growth

Nutritional types of microorganisms, growth factors, culture media, isolation of pure cultures, growth curves, mean growth rate constant, generation time; general concept of effect of environmental factors on growth of microbes; sterilization and disinfection.

Unit 4: Microbial Genetics

Genetic recombination in bacteria, basic concept of: transformation, conjugation, and transduction, gene mapping by interrupting mating technique. Bacterial plasmids - fertility factor, col plasmid; Bacterial conjugation- (Hfr, F`, F+ X F-); Transformation; Transduction- generalized and specialized.

Unit 5: Viruses

General properties of viruses; Structure of viruses. Isolation, purification and cultivation of viruses; Viral Taxonomy; Bacteriophages - diversity, classification, lytic and lysogenic cycles; Viral life cycle- entry, replication and egress. Detection of viruses.

Unit 6: Food and Microbiology

Overview of importance of microbiology in food and industrial microbiology; Microorganism growth in food; extrinsic and intrinsic factors for food spoilage; microorganisms causing food spoilage in fresh food, milk, and canned food; Preservation of foods by aseptic handling, high temperature, low temperature, dehydration, osmotic pressure, chemicals and radiations; preparation of fermented food products, fermented milk such as yoghurt, curd and cheese.

Unit 7: Industrial Microbiology

Microbiological processes in industry; Basic design of fermenter – continuous and discontinuous; treatment of wastewater (Municipal treatment plant) and sewage; Preparation of wine, beer, cheese; Single cell proteins.

Unit 8: Microbial diseases of plants and animals

Basics of microbial pathogenesis: host, pathogen, pathogenicity factors, Koch’s postulates, parasitism and synergism. Introduction to diseases caused by microbes.

Unit 9: Antimicrobial chemotherapy

Range of activity and mechanism of action of antibiotics.

Practical

Credit : 2
Contact Hours per Week : 4

1. To study disinfectants and sterilization techniques.
2. To study types of Media and perform media preparation.
3. To perform subculturing- streaking techniques (T streaking). .
4. To study Growth Curve of bacteria.
5. To study the effect of pH/temperature/UV light on bacterial growth.
6. To perform Gram's staining.
7. To perform Negative staining
8. To perform an Antibiotic resistance assay.
9. Enumeration of CFU of E.coli by serial dilution and spread plate method.
10. Conjugation experiment
11. Milk quality testing by Methylene Blue dye reductase test.
12. Isolation of bacteria from any natural sources (air/soil/water)
13. Endospore staining
14. Capsule staining
15. Water quality analysis by MPN method.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn the peculiarities in the structure and biochemistry of bacteria and viruses.
2. Understand the specialized nutritional requirements of bacteria
3. Understand the various applications of microbiology in industry and research
4. Gain a basic understanding of microbial diseases and their management
5. Learn basic microbial techniques.

SEMESTER – VI

BIOS06DSE-4A: **CLASSIFICATION, BIOSYSTEMATICS AND MOLECULAR PHYLOGENETICS**

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

Theory

Credit : 4
Contact Hours per Week : 4

Unit 1: Animal classification

Classification of Protozoa up to Phylum; Classification of non-chordates up to subclass; Classification of chordates up to order.

Unit 2: Plant Classification

A brief outline of Bentham and Hooker (1862-1883) and Angiosperm Phylogeny Group (APG Classification) of plants

Unit 3: Biosystematics and Molecular Phylogenetics

Concept of systematics and taxonomy, alpha, beta and gamma taxonomy, phenon, taxon, taxonomic category, Linnaean hierarchy
Nomenclature of animal and plant taxa and International code of Zoological and Botanical nomenclature
Type concept and its applications
Different species concept, their merit and demerits
Characters; OTU, Principles and theories of animal classification (Phenetics and Cladistics concept)
Phenogram and Cladogram constructions
Concept of cytotaxonomy, Biochemical taxonomy and Molecular Taxonomy
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. Herbarium preparation of plant samples collected from diverse geographical and ecological regions
3. Analysis of cytotaxonomic and biochemical taxonomic data. Construction of phylogenetic tree by using sequence data
4. Study of a few important plant families and their representative taxa.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Identify and classify different organisms.
2. Understand the systematic position of different organisms and any or all relationships among them.
3. Perform molecular analysis will help to develop knowledge on evolutionary relationships or phylogenetic relationships between different groups of organisms.

SEMESTER – VI

***BIOS06DSE-4B*: APPLIED HUMAN PHYSIOLOGY**

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

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Nutrition and Dietetics

Nutrition, health and malnutrition; Constituents of food and their significance. Basal metabolic rate Respiratory quotient. Calorific value of foods. Body calorie requirements – adult consumption unit. Dietary requirements symptoms of deficiency and excess. Balanced diet and principles of formulation of balanced diets for growing child, adult man and woman, pregnant woman and lactating woman. Nutrition for different occupations. Nitrogen balance. Biological value of proteins, supplementary value of protein. Protein efficiency ratio and net protein utilization of dietary proteins; Dietary fibers. Principle of diet survey. Composition and nutritional value of common foodstuffs. Physiology of starvation and obesity. Elementary idea of glycaemic index; functional foods, nutraceuticals, probiotics and food supplements. Food adulterants and food additives.

Unit 2: Skin, sensation and higher neural function

Structure and functions of skin. Cutaneous circulation. Sweat glands Sweat formation, secretion and its regulation. Regulation of body temperature in homeotherms, pyrexia, hyperthermia and hypothermia Sensory receptors and function, Classification of general and special senses. Receptors as biological transducers. Physiology of Olfaction and Gustation, Acoustic physiology, Physiology of vision, Emotion, sleep, speech and aphasia

Unit 3: Regulation of Human Physiology

Hypothalamus as a neuroendocrine organ. Pineal gland, Hormones in Metabolism. Neuro immunology, Human Embryology,

Unit 4: Social physiology

Population problem, principles and methods of family planning. IVF. Malnutrition deficiency diseases and their social implications. Implications of Diabetes, CHD**.** Principles and social importance of immunization against diseases. Epidemiology and prevention of common diseases. Integration of systemic physiology and metabolism in daily life and disease. Life style diseases and management.

Unit 5: Work, Exercise and Sports Physiology

Concept of work. Muscle tone, posture and regulation, servo control mechanism. Physical work—its definition and nature. Power and capacity relation, Classification of workload. Exercise inducing equipment –Aerobic and anaerobic

power—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,

Unit 6: Applied Physiology

Physiological basis of medical laboratory investigations. Cybernetic approach to physiology. Tools to detect genetic defects in the early stages of fetal development. Pathological cases to explain cardiac physiology, Disease markers.

Practical

Credit : 2

Contact Hours per Week : 4

1. Anthropometry, posture analysis, pain mapping-REBA, RULA, Nordid questionnaire
2. Muscle strength estimation
3. Co-analysis
4. Videography
5. Diet survey/ Nutritional assessment of any specific group
6. Survey of common diseases in population
7. Field study
8. Identification of common food adulterants in food items.
9. Identification of normal and abnormal constituents of urine.
10. Measurement of heart rate and blood pressure by sphygmomanometer
11. Study of daily variation of body temperature
12. Determination of colour blindness and visual field.
13. Basic concepts of thermal stress indices-WBGT

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand the various considerations for diet and nutrition for various populations based on their sex, physiology and occupation
2. Understand regulation of various physiological functions such as temperature regulation and metabolism
3. Gain insight into higher neuronal functions such as memory and sleep.
4. Understand the physiology of work and exercise
5. Understand the physiology of various diagnostic procedures.

SKILL ENHANCEMENT COURSES (SEC)

SEMESTER – III

BIOS03SEC-1A: PUBLIC HEALTH AND MANAGEMENT

Credits - 4: (Theory- 04)

Theory

Credit : 4

Contact Hours per Week : 4

Unit I: Introduction

Energetics of work- aerobic and anaerobic, Sources of Environmental hazards, hazard identification and accounting, fate of toxic and persistent substances in the environment, dose Response Evaluation, exposure Assessment.

Unit 2: Pollution

Air, water, noise pollution sources and their health effects

Unit 3: Waste Management and hazards

Types and characteristics of wastes, biomedical waste handling and disposal, Nuclear Waste Handling and disposal, Waste from thermal power plants. Case histories on Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident and their aftermath. Good Laboratory Practice, airborne and water borne diseases/ hazards

Unit 4: Disease Management

Social and economic factors of disease including role of health services and other organizations: Infectious (Common Bacterial; Viral- Protozoan); Lifestyle and Inherited/genetic diseases, Immunological diseases; Cancer; Diseases impacting on Western versus developing societies. Diet survey, Field study, survey on endemic diseases.

Unit 5: Basic pharmacology

Basic concepts on pharmacokinetics, pharmacodynamics and biotransformation.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn about pollution and the environment and diseases affecting humans by different pollutants and major environmental disasters in the world.
2. Learn about microbes and the microbial world and diseases infected the pathologies of infection and treatment modalities.

3. Get idea about some common pathophysiological disorders and their mode of treatment
4. Understand Common pharmacology
2. Learn about Waste management and its tools

SEMESTER – III
BIOS03SEC-1B: PLANT RESOURCE UTILIZATION
Credits - 4: (Theory- 04)

Theory
Credit : 4
Contact Hours per Week : 4

Unit 1: Plants as Industrial products.

Algae as food and source of phycocolloid (Agar-agar, Algin, Carrageenan), Diatomite, Potential microalgae for SCP, β-carotene, Biodiesel production.
Forest Resources: Fibre-plants, timber plants; Non-timber Forest Produces (NTFP); Bamboos, gums, dyes, decorative elements; Forest based cultural practices & Livelihood.
Other economically important plant products: Volatile oils: Clove, *Mentha, Eucalyptus, , Citronella*; *Taxus*, *Ephedra*, Resins: origin, chemistry and uses; Wax : origin and uses; Aroma product: Jasmine, Rose.

Unit 2: Ethnobotany, and Drug discovery

Ethnobotany: concept, field survey and applications. Ethnopharmacology, concept of polyherbals and synergism, Use of statistical indices in ethnobotany.
Systematic position and Medicinal properties and chemistry of active compounds of *Rauvolfia Serpentina, Adhatoda Vasica, Ocimum sanctum, Cannabis sativa, Azadiracthaindica, Withaniasomnifera, Trichopuszeylanicus.*
Biopiracy and Intellectual Property Rights

Unit 3: Plant Resources for Agriculture and Horticulture.

Biofertilizers and its application [*Rhizobium, Azospirillum, Azotobacter, Anabaena, Azolla];* Mycorrhizal symbiosis, rhizospheric microbial consortia of agricultural crops.
Cultivation and morphological characters of some plants with economic importance (Rice-Poaceae, Mustard-Brassicaceae, Brinjal-Solanaceae, Gourd-Cucurbitaceae)
Floriculture & Horticultural, Rose, Tuberose, Marigold, Gladiolus, Gerbera as cash-crop; plants for cottage industries; road-side trees, banana, genetic engineering for improvement of horticultural traits.

Unit 4: Plant Disease management and Pollution management.

Diverse plant pathogens, pathogenesis, disease triangle, disease detection and forecasting, Transmission and spread of plant diseases; strategies to prevent disease; Economic impact, symptom, disease cycle and control of Bacterial, Integrated Pest Management.

Phytoremediation, Afforestation, Environmental Impact Assessment (EIA).

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Appreciate the use of plants in a variety of different avenues such as in Industry, drugs, agriculture, horticulture.
2. Learn basic concepts in Plant disease management.
3. Learn how plants are used in pollution management.

SEMESTER – IV

BIOS04SEC-2A: RECOMBINANT DNA TECHNOLOGY

Credits - 4: (Theory- 04)

Theory

Credit : 4

Contact Hours per Week : 4

Unit 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.

Unit 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.

Unit 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.

Unit 4: Applications of RDT

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, problems with genetically modified plants, safety concerns. Introduction to DNA sequencing, genome sequencing, polymerase chain reaction, RT-PCR, expression vectors.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.
2. Get detailed knowledge of gene transfer methods and identify suitable hosts for cloning.
3. Acquire theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering.
4. Learn about the genome mapping and sequencing and methods for transgenesis in plants and animals.

SEMESTER – IV

BIOS04SEC-2B: ECONOMIC ZOOLOGY

Credits - 4: (Theory- 04)

Theory

Credit : 4

Contact Hours per Week : 4

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.
8. Field training at protected area/poultry farm/fishery farm/ sericulture/apiculture/lac culture farm.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Develop skills and understanding of modern industrial applications of animal science
2. Generate skill and idea of agricultural pests and their control
3. Get accustomed to induced breeding and hybridization techniques in Fishes
4. Acquire field experience on economic farming like poultry, sericulture etc.

GENERIC ELECTIVES (GE)

These courses are inter-departmental courses, offered to students of other Departments of Presidency University. DLS students have a choice of courses offered by Humanities and Science Departments that are listed at the beginning of the semester to choose from.

BIOS01GE1: WORLD OF ANIMALS

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

Theory

Credit : 4
Contact Hours per Week : 4

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.

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.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand characteristic features of different animal life forms.
2. Understand basic concepts and importance of conservation of biodiversity.
3. Learn about the economically important Animal species

BIOS02GE2: ECONOMIC APPLICATIONS OF PLANT AND MICROBIAL BIOTECHNOLOGY

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

Theory

Credit : 4

Contact Hours per Week : 4

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

Practical

Credit : 2

Contact Hours per Week : 4

1. Field study on economically and or medicinally important plants from the same geographic region.
2. Herbarium preparation techniques.
3. Identification of some medicinal algae, bryophytes, pteridophytes and gymnosperms from permanent preparations.
4. Working principles of some laboratory instruments.
5. Basic techniques related to sterilization of plant and microbial samples.
6. Media preparation for microbial and plant culture.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Understand the economic importance of lower plant groups
2. Learn to identify different species of economically important plant species
3. Learn basic concepts of Applied Microbiology and Plant Biotechnology
4. Learn about the importance of secondary metabolites in plants
5. Gain hands on training in plant tissue culture techniques

BIOS03GE3: MODERN LIFESTYLE, BEHAVIOURS AND AILMENTS

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

Theory

Credit : 4
Contact Hours per Week : 4

1. Necessities and requirements in the recently adopted lifestyle with special emphasis on stresses, availability of fast food, micro family concept and dual income families. Awareness and necessary life style 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 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: AIDS, spread of viral diseases in the modern day society: Dengue, 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/ neighbours on modern lifestyle and public health issues discussed during the course. Analysis of data and its interpretation.
2. Biochemistry: estimation of cholesterol (different components) 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.

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Have an understanding of how stress contributes to common lifestyle diseases and how it can be managed.
2. Understand the physiology of various types of stress and their contribution to disease manifestations.
3. Develop an understanding of how behaviour, environment, microbes and diet affect disease pathology and prognosis.
4. Develop an understanding of the real life scenario by conducting surveys.

BIOS04GE4: MACROMOLECULES OF LIFE

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

Theory

Credit : 4
Contact Hours per Week : 4

1. **Proteins**: building blocks of life. Basic ideas 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. DNA computers – a new future?

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
4. Estimation of DNA / RNA by UV absorption spectroscopy

Course Outcomes:

After successfully completing this course, the students will be able to:

1. Learn the basic concepts regarding the building blocks of biological system
2. Understand the basic structure and function of nucleic acids, learn about isolation procedure from the cells
3. Understand the basic structure and function of proteins, lipids and carbohydrates
4. Gain hands-on training on biochemical analysis of biological important components.

ABILITY ENHANCEMENT COMPULSORY COURSE (AECC)

The AECC courses are inter-departmental courses and follow a central syllabus.

SUGGESTED READING

1. Aber, J.D.andMelillo 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
7. Barton, Briggs, Eisen, Goldstein and Patel. (2007) Evolution. Cold Spring HarborLaboratory Press Edition. Pearson Benjamin Cummings Publishing, San Francisco.
8. Berne and Levy Physiology
9. Brooker, R. J. (2014). Genetics: Analysis & principles.
10. Cooper G. M. Hausman R. E. 2009. The Cell: A Molecular Approach. 5th edition.ASM Press and Sunderland, Washington D. C.; Sinnauer Academic Press.
11. Carlson B.M. Patterns; Foundations of Embryology.
12. Cutter, S.L. (1999).Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi.
13. De Robertis, E. D. P. and De Robertis R. E. 2009. Cell and Molecular Biology, 8thedition. Lippincott Williams and Wilkins, Philadelphia.
14. David Randall, Eckert's Animal Physiology, W.H.Freeman and Co.
15. Deverall, Brain J. 1977. Defence mechanisms of plants, Cambridge University Press.
16. Elli Kohen, Rene Santus, Joseph G. Hirschberg: Photobiology Academic press.
17. Peter A. Ensminger: Life under the sun , Yale University Press
18. Futuyma, D. (1998) Evolutionary Biology. III Edn.Sinauer Assoc. Inc.
19. Guyton and Hall Text Book of Medical Physiology
20. Genetics - A Conceptual Approach (2012), 4th ed., Pierce, B.A., W.H. Freeman & Co.(New York), ISBN:13:978-1-4292-7606-1 / ISBN:10:1-4292-7606-1.
21. Genetics (2012) 6th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons.(Singapore), ISBN: 978-1-118-09242-2.
22. Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwellpublishing (Oxford, UK).
23. Harper's Biochemistry
24. Hoppe et. al., Biophysics, Translation of 2nd German Edition, Springer Verlag, 1983.
25. Hall, B. K. and Hallgrimson, B. (2008) Strickberger's Evolution. IV Edn. Jones and Barlett
26. Hawes C &Satiat-Jeunemaitre - 2001 Plant Cell Biology : Practical approach
27. Ingrowille, M Diversity and Evolution of land plants 1992 chapman and HallNelson, D. L. and Cox, M.M. (2008).Lehninger,
28. iGenetics: A Molecular Approach 3rd Edition, by Peter J Russell, Pearson Education Limited ISBN-13: 978-0321569769/ ISBN-10: 0321569768
29. J.D.Lee: A New Concise Inorganic Chemistry, E.L.B.S.
30. James E. Huheeyetal. : Inorganic Chemistry: Principles of Structure and reactivity,
31. Joseph, F. L. and Louver, B.D. (1997). Health and Environmental Risk Analysisfundamentals with applications, Prentice Hall, New Jersey.
32. Keith Wilson and John Walker, Principles and Techniques of Biochemistry andMolecular Biology, 6th Edition, Cambridge University Press, 2005.
33. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition,John Wiley &Sons.Inc.
34. K. Murphy, P. Travers, M. Walport. 2008. Janeway'sImmunobiology, GarlandScience, Taylor and Francis Group, LLC

35. Kolluru R., Bartell S., Pitblado R. and Stricoff, S. (1996). Risk Assessment andManagement Handbook. McGraw Hill Inc., New York.
36. Kofi, A.D. (1998). Risk Assessment in Environmental management, John Wiley and sons, Singapore.
37. Kuby Immunology
38. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H.Freeman& Company (New York), ISBN:13: 978-1-4292-3414-6 / ISBN:10-14641-0962-1.
39. Lewin's Genes XI by Jocelyn E. Krebs, Benjamin Lewin, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Publishers, 2014, ISBN-13: 978-1449659851 / ISBN-10: 1449659853
40. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann,A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York)
41. Molecular Biology of the Cell, 4th edition, Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter.New York: Garland Science; 2002, ISBN-10: 0-8153-3218-1ISBN-10: 0-8153-4072-9
42. Molecular Cell Biology by Lodish and Baltimore.
43. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010)4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC).
44. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann,A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor(New York), ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.
45. Odum, E.P., (2008). Fundamentals of Ecology.Indian Edition. Brooks/Cole Knut Schmidt-Nielsen , Animal Physiology , Cambridge University Press
46. P.W. Atkins: Physical Chemistry, Oxford University Press
47. Principles of Biochemistry, 5th Edition, W.H.Freeman and Company, N.Y., USA.
48. Philips Withers; Comparative Animal Physiology. Books Cole Publishers
49. Physical Biochemistry, David Freifelder, Applications to Biochemistry and MolecularBiology, 2nd Edition, W.H. Freeman and Company, 2005.
50. Peter W. Hochachka, George. N. Somero, Biochemical adaptation, Amazon PublishersGilbert S: Developmental Biology 9th Ed;
51. Plant Microtechnique and Microscopy (1999) Ruzin, S.E. Oxford University Press,(New York) U.S.A.
52. Plant Physiology (2015) Taiz, L., Zeiger, E., Muller, I.M. and Murphy, A
53. Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S.B., and Twyman, R. M., Blackwell publishing (Oxford, UK).
54. R.T. Morrison & RN.Boyd: Organic Chemistry, Prentice Hall
55. Randall, Burggren, French : Eckert , Animal Physiology-mechanisms and adaptations,W H Freeman and company
56. Ricklefs Economy of nature
57. Short Protocols in Molecular Biology (1995) 3rd ed., Ausubel, F., Brent, R.,Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. John Wiley & Sons.
58. Smith R.L. Elements of ecology
59. The Biology of Cancer - Robert A. Weinberg
60. T .J. Kindt, R. A. Goldsby, and B.A. Osborne. 2007. Kuby Immunology, W.H.Freeman and Co, New York.
61. Voet, D. and Voet, J.G. (2004). Biochemistry, 3rd Edition, John Wiley & Sons, Inc.USA.
62. Wilkenson DM - 2007 - Fundamental Processes in Ecology
63. Zimmer, C. and Emlen, D. J. (2013) Evolution: Making Sense of Life. Roberts & Co.

Structure and Detailed Syllabus

of the Postgraduate Course (M.Sc.) in Life Sciences

Department of Life Sciences

Presidency University

(Effective from Academic Year 2021-22)

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

Introduction:

The Department of Life Sciences is a dynamic interdisciplinary Department with a holistic approach towards the study of biology. Admixture of young and experienced faculty in the Department promises an outstanding academic experience to its students. The students will have the opportunity of learning a multitude of interdisciplinary subjects, and will also have research experience during the tenure of their studies. In the curriculum, there will be two semesters in each academic year and thus a student enrolled in the Masters of Science program will leave with a Master's Degree in Life Sciences after completion of four semesters. Students who have completed a B.Sc. Honours in any branch of Biology can enrol for the M. Sc. program. All students enrolled in the Masters of Science program will study the same compulsory course modules in the first three semesters (PG Semester 1, 2 and 3) and these modules will comprise mostly of the basic fundamentals of Biological Science. There will be laboratory / 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. The final semester (PG Semester 4) will be entirely research based, and students will get the unique opportunity of working in a research laboratory for their dissertation. Students will opt for specialization in different Faculty Research Groups (FRGs) which have been created on common specialized academic interests with the idea of promoting an interactive student- teacher platform. Simultaneously, it will also inculcate in students a deeper appreciation for all branches of life sciences. An advisory committee of Departmental faculty will assist students to select FRGs based on their interests and future career goals. Students will be selected into FRGs based on their preference/ availability of seats. At the end of the curriculum, students would be proficient in presenting scientific research, critically discussing scientific publications and writing reviews. After completion of all 4 semesters, the successful students would be awarded with a M.Sc. degree in Life Sciences.

Aims and Objectives:

Our M.Sc program essentially focuses on developing skills of students for a successful academic career.

A. The course structure emphasizes on theory as well as laboratory work so as to gain thorough knowledge of the subject.

B. The course includes a semester long dissertation project that would develop and nourish the scientific approach and research aptitude of the students.

C. The course work is essentially framed to acquaint the students with all the basic and recent advances in the field of Life Sciences.

D. It is compulsory and essential for our Masters students to read research papers, publications and deliver seminars that would better help them to know the recent advances in the subject and also develop the communication skills required to communicate effectively.

E. The program is designed in such a way that it is essential for the students to read original publications, put enough efforts in laboratory work for practicals and projects, be acquainted with all the recent advances in the field and develop all the skills for a successful career.

Learning Outcome-based Approach to Curriculum Planning in Life Sciences:

The fundamental premise underlying the learning outcomes-based approach to curriculum planning is that higher education qualifications such as Master's Degree programme in Life Sciences is awarded on the basis of demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and academic standards expected of the postgraduates in Life Sciences. Learning outcomes specify what students completing a particular programme of study are expected to know and be able to do at the end of their programme of study. The learning outcomes indicate the knowledge, skills, attitudes and values that are required to enable the students to effectively participate in knowledge production, improve national competitiveness in a globalized world and for equipping young people with skills relevant for Life Sciences related job opportunities.

Postgraduate Attributes in Life Sciences

The postgraduate attributes reflect the particular quality and feature or characteristics of an individual, including the knowledge, skills, attitudes and values that are expected to be acquired by a postgraduate through studies at Department of Life Sciences at Presidency University Kolkata. Some of the desirable attributes which a postgraduate student should demonstrate include the following:

Disciplinary Knowledge: Demonstrate comprehensive knowledge and understanding of major concepts in the field of Life Sciences, and knowledge and skills acquired from interaction with educators and peer group throughout the programme of study.

Communication Skills: Express thoughts and ideas effectively in writing and orally, communicate with others using appropriate media, demonstrate the ability to listen carefully, read, write and question analytically.

Critical Thinking: Apply analytic thought to a body of knowledge, analyse and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence, identify relevant assumptions or implications, formulate coherent arguments, critically evaluate practices, policies and theories by following scientific approach to knowledge development.

Problem Solving: Demonstrate capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge and apply one's learning to real life situations.

Analytical Reasoning: Demonstrate the ability to evaluate the reliability and relevance of evidence, identify logical flaws and holes in the arguments of others, analyse and synthesise data from a variety of sources, draw valid conclusions and support them with evidence and examples, and addressing opposing viewpoints.

Research-related Skills: Demonstrate a sense of inquiry and capability for asking relevant/appropriate questions, demonstrate the ability to recognize cause-and-effect relationships, define problems, formulate hypotheses, test hypotheses, analyze, interpret and draw conclusions from data and report the results of an experiment or investigation.

Collaboration/Cooperation/Team work: Demonstrate ability to work effectively and respectfully with diverse teams, facilitate cooperative or coordinated effort on the part of a group, and act

together as a group or a team in the interests of a common cause and work efficiently as a member of a team.

Scientific Reasoning using Quantitative/Qualitative Data: Demonstrate the ability to understand cause-and-effect relationships, apply scientific principles, analyze, interpret and draw conclusions from quantitative/qualitative data, and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.

Reflective Thinking: Demonstrate critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society.

Digital Literacy: Demonstrate capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources and to use appropriate software for analysis of data.

Self-Directed Learning: Demonstrate ability to work independently, identify appropriate resources required for a project, and manage a project through to completion.

Moral and Ethical Awareness/Reasoning: Demonstrate the ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, appreciate environmental and sustainability issues, and adopt objective, unbiased and truthful actions in all aspects of work.

Community Engagement: Demonstrate responsible behaviour and ability to engage in the intellectual life of the educational institution, and participate in community and civic affairs.

Lifelong Learning: Demonstrate the ability to acquire knowledge and skills that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development and adapting to changing demands of work place through knowledge/skill development/re-skilling.

Qualification
Descriptors in Life Sciences

The qualification descriptors reflect both disciplinary knowledge and understanding and generic/global skills and competencies that all students in Post graduate course of Life Sciences should acquire/attain. Some of the desirable outcomes which a postgraduate in Life Sciences should be able to demonstrate are as follows:

- Demonstrate (i) a systematic, extensive and coherent knowledge and understanding of Life Sciences as a whole and its applications, and links to related disciplinary areas(ii) practical knowledge that enables different types of professions related to Life Sciences, including research and development, teaching, entrepreneurship as well as industrial research abilities; government services.
- Demonstrate comprehensive knowledge about materials, including current research, scholarly literature, relating to essential and advanced learning areas pertaining to Life Sciences, and techniques and skills required for identifying Biological Science-related problems and issues.
- Demonstration of skills in collection of relevant data gathered by reading or experimentation and analysis and interpretation of the data using appropriate methodologies.
- Ability to communicate the results of studies undertaken in an academic field accurately in the form of a paper, oral presentation or report.
- Apply knowledge and skills gained, to new and unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.
- Demonstration of the ability to function in an effective manner both independently as well as a member of a team.
- Demonstrate Life Sciences-related and transferable skills that are relevant to employment opportunities.

Structure of the Curriculum

SEMESTER -1

BIOS 0701	50 marks; 4 credits	**Instrumentation and Methodologies**	**Theory**
BIOS 0702	50 marks; 4 credits	**Biochemistry and Biophysics**	**Theory**
BIOS 0703	50 marks; 4 credits	**Cell Biology**	**Theory**
BIOS 0791	50 marks; 4 credits	**Tools and Techniques in Biophysics and Biochemistry**	**Sessional**
BIOS 0792	50 marks; 4 credits	**Tools and techniques in Cell Biology and Grand Viva**	**Sessional**

SEMESTER – 2

BIOS 0801	50 marks; 4 credits	**Genetics and Molecular Biology**	**Theory**
BIOS 0802	50 marks; 4 credits	**Environment, Ecology & Evolution**	**Theory**
BIOS 0803	50 marks; 4 credits	**Microbiology & Immunology**	**Theory**
BIOS 0891	50 marks; 4 credits	**Genetics, Ecology and Environmental Science Practical**	**Sessional**
BIOS 0892	50 marks; 4 credits	**Microbiology, Molecular Biology, Immunology practical and Grand Viva**	**Sessional**

SEMESTER -3

BIOS 0901	50 marks; 4 credits	**Developmental Biology**	**Theory**
BIOS 0902	50 marks; 4 credits	**Systems Physiology**	**Theory**
BIOS 0903	50 marks; 4 credits	**Biostatistics and Bioinformatics**	**Theory**
BIOS 0991	50 marks; 4 credits	**Developmental Biology and Systems Physiology practical**	**Sessional**
BIOS 0992	50 marks; 4 credits	**Biostatistics, Bioinformatics practical and Grand Viva**	**Sessional**

SEMESTER-4: ***This semester will cover the dissertation projects and project related topics as well as developing research skills.***

BIOS 1001	50 marks; 4 credits	**Faculty Research Group (FRG) specific theory paper**	**Theory**
BIOS 1002	50 marks; 4 credits	**Research ethics and good laboratory practice, Entrepreneurship and Skill development/ Grant Proposal writing**	**Sessional**
BIOS 1003	50 marks; 4 credits	**Review writing and research article presentation (JC)**	**Sessional**

BIOS 1091	50 marks; 4 credits	**Dissertation submission**	**Sessional**
BIOS 1092	50 marks; 4 credits	**Presentation and defense of dissertation work**	**Sessional**

List of Faculty Research Group (FRG) specific theory papers

*Candidates have to take **any one** from the following theoretical modules; each of 4 credits*

Serial No.	Module	Course contents
1	BIOS 1001A	Research Frontiers in Proteo-genomics
2	BIOS 1001B	Developmental Gene Program and Plasticity
3	BIOS 1001C	Advanced Macromolecular Structure Function Dynamics
4	BIOS 1001D	Cell death Deregulation and Diseases
5	BIOS 1001E	Ecological Sustainability and Bioprospecting
6	BIOS 1001F	Endocrine Pathophysiology, Toxicology and Toxicity Management
7	BIOS 1001G	Ergonomics, Occupational Health Management, Clinical Nutrition and Emerging Diseases
8	BIOS 1001H	Biotechnological methods in crop improvement

Credit Allocation and Marks Distribution for the Postgraduate Course in Life Science

				Credits		Marks		
Semester	Course Type	Paper Code	Course Name	Theory	Practical/ Assessments	End-semester Examination	Continuous Evaluation	Total
First	Theory	BIOS 0701	Instrumentation and Methodologies	4		35	15	50
First	Theory	BIOS 0702	Biochemistry and Biophysics	4		35	15	50
First	Theory	BIOS 0703	Cell Biology	4		35	15	50
First	Sessional	BIOS 0791	Tools and Techniques in Biophysics and Biochemistry		4		50	50
First	Sessional	BIOS 0792	Tools and techniques in Cell Biology and Grand Viva		4		50	50
Second	Theory	BIOS 0801	Genetics and Molecular Biology	4		35	15	50
Second	Theory	BIOS 0802	Environment, Ecology & Evolution	4		35	15	50
Second	Theory	BIOS 0803	Microbiology & Immunology	4		35	15	50
Second	Sessional	BIOS 0891	Genetics, Ecology and Environmental Science Practical		4		50	50
Second	Sessional	BIOS 0892	Microbiology, Molecular Biology, Immunology		4		50	50

			practical and Grand Viva					
Third	**Theory**	**BIOS 0901**	**Developmental Biology**	**4**		**35**	**15**	**50**
Third	**Theory**	**BIOS 0902**	**Systems Physiology**	**4**		**35**	**15**	**50**
Third	**Theory**	**BIOS 0903**	**Biostatistics and Bioinformatics**	**4**		**35**	**15**	**50**
Third	**Sessional**	**BIOS 0991**	**Developmental Biology and Systems Physiology practical**		**4**		**50**	**50**
Third	**Sessional**	**BIOS 0992**	**Biostatistics, Bioinformatics practical and Grand Viva**		**4**		**50**	**50**
Fourth	**Theory**	**BIOS 1001**	**Faculty Research Group (FRG) specific theory paper**	**4**		**35**	**15**	**50**
Fourth	**Sessional**	**BIOS 1002**	**Research ethics and good laboratory practice, Entrepreneurship and Skill development/ Grant Proposal writing**		**4**		**50**	**50**
Fourth	**Sessional**	**BIOS 1003**	**Review writing and research article presentation (JC)**		**4**		**50**	**50**
Fourth	**Sessional**	**BIOS 1091**	**Dissertation submission**		**4**		**50**	**50**
Fourth	**Sessional**	**BIOS 1092**	**Presentation and defense of dissertation work**		**4**		**50**	**50**

Programme Outcomes (PO)

PO-1. Develop an understanding of major concepts in Life Sciences.

PO-2. Learning to think analytically, independently and draw a logical conclusion.

PO-3. Create an awareness of the impact of Biology on the environment, society, and development outside the scientific community.

PO-4. To inculcate the scientific temperament in the students for careers within and outside the scientific community.

Programme Specific Outcomes (PSO)

At the end of this course the students will be able to:

PSO-1. Gain the knowledge of Life Sciences through theory and practicals.

PSO-2. Employ critical thinking and the scientific knowledge to design experiments, carry out, record and analyze the results.

PSO-3. Demonstrate the safe and appropriate use of scientific instruments such as a microscope, centrifuge, micro pipette, electrophoresis, spectrophotometer, restriction enzymes etc.

PSO-4. Understand good laboratory practices and safety.

PSO-5. Develop research oriented skills, learn desired skills through six months mandatory internship program

Teaching-Learning Processes

The programme of M.Sc in Life Sciences is designed to encourage the acquisition of disciplinary/subject knowledge, understanding the skills and achieve academic and professional skills required for biology -based professions and jobs. Learning experiences are designed and implemented to foster active/participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. Additionally, a semester long mandatory internship program helps to develop research oriented skills , enabling them to ask relevant questions, formulate hypotheses, test hypotheses, analyze, interpret and draw conclusions from data and report the results of an experiment or investigation.

A variety of approaches to the teaching-learning process, including lectures (online/offline, chalk and board method, powerpoint presentation), oral discussion sessions in the class, seminars, tutorials, short group project-based learning, field-based learning, substantial laboratory-based practical experiments, review writing exercise, grant proposal writing exercise and an entire semester of internship in the final year will be adopted to achieve this. Problem-solving skills, analytical reasoning skills will be encouraged through adopting appropriate teaching strategies.

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; review of literature, grant proposal writing, individual dissertation project 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 theory papers will be assessed via 15 marks of internal assessments (quizzes/ assignments) as well as 35 marks of end semester examination. All sessional papers will be evaluated via continuous assessments by variety of methods mentioned earlier.

DETAILED SYLLABUS OF M.Sc (LIFE SCIENCES)

SEMESTER -1

BIOS 0701 (Theory): Instrumentation and Methodologies

[Theory: 50 marks; 4 credits]

1. **Methods in Molecular Biology I-Recombinant DNA Technology:** molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems, expression of recombinant proteins using bacterial, animal and plant vectors; Polymerase Chain Reaction, RFLP, RAPD and AFLP; generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; *in vitro* mutagenesis and deletion techniques; gene knockout in bacterial and eukaryotic organisms.
2. **Methods in Molecular Biology II-Characterization of Bio-molecules:** Isolation and purification of DNA, RNA and proteins; methods and principles of separation of nucleic acids and proteins-gel electrophoresis, isoelectric focusing, chromatographic techniques; protein sequencing methods, detection of post translational modification of proteins; DNA sequencing and strategies for genome sequencing.
3. **Methods in Molecular Biology III-Expression Profiling**: methods for analysis of gene expression at RNA and protein level, large scale expression analysis, such as microarray based techniques, proteome profiling.
4. **Histochemical and immunohistochemical techniques**: Antibody generation, detection of molecules using ELISA, RIA, Western Blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.
5. **Methods for structural analysis of biomolecules:** UV-visible, fluorescence, circular dichroism, NMR and IR spectroscopy. Structure determination of biomolecules using X-ray crystallography.

6. **Radiolabeling techniques**- Properties of different types of radioisotopes normally used in biology, their detection and measurement, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.
7. **Microscopic techniques-** Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM, image processing methods in microscopy.

BIOS 0702 (Theory): Biochemistry and Biophysics

[Theory: 50 marks; 4 credits]

1. Biomolecules

i. Classification of protein structure, dynamics of protein folding, role of molecular chaperones in protein folding, protein separation/characterization methods. Protein-ligand interaction and their analyses: protein-protein, protein-carbohydrate, protein-nucleic acid, protein-lipid, protein-small molecules interactions. Inborn errors of protein metabolism. Mechanical insights of proteins like ion-channels from a biochemical and biophysical perspective.

ii. Classification of nucleic acid structure, properties of DNA: buoyant density, viscosity, hypochromicity, denaturation and renaturation. DNA sequencing– chemical and enzymatic methods. Chemical synthesis of DNA. RNA– types and biological role. Secondary, tertiary structures of RNA, ribozymes, abnormalities in nitrogen metabolism.

iii. Lipids and their analysis: Classification, Structure of nonpolar (neutral lipid: TAG, DAG & MAG, Sterols & Wax) and polar lipid molecules: (glycolipid and phospholipids); Disorders of Lipid metabolism - Plasma lipoproteins, cholesterol, triglycerides and phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann- Pick disease, ketone bodies, A-beta lipoproteinemia.

iv. Structure and isomerism of carbohydrates; Disorders of Carbohydrate Metabolism-- Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia.

2. Enzymology and enzyme technology

i. Basics of Enzymes: Enzyme kinetics- concept of steady state kinetics, Michaelis-Menten equation, Significance of K_M & V_{Max}, double reciprocal plot, K_{cat}/K_M, enzyme catalyzed bi substrate reaction, sequential & ping pong reaction.

ii. Enzyme regulation- enzyme inhibition, allosteric enzyme (definition and example), allosteric modulators and feedback inhibition, kinetic properties of allosteric enzyme, Hill and Scatchard plots, regulation by covalent modification (like phosphorylation), regulation by proteolytic cleavage of protein, zymogens with example.

iii. Multienzyme system - Occurrence, isolation and their properties: Mechanism of action and regulation of pyruvate dehydrogenase and fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

iv. Enzyme technology - Large-scale production of enzymes, enzyme reactors, immobilization of enzymes by chemical and physical methods, effect of partition of kinetics and on changes in pH and hydrophobicity. Industrial and clinical applications of enzymes.

3. Plant System

i. Photosynthesis - Light harvesting complexes; mechanisms of electron transport; Photoprotective mechanisms (Xanthophyll cycle).

ii. Carbon assimilation: CO_2 fixation-C3 and regulation of calvin cycle, C4 and CAM pathways, C2 cycle.

iii. Plant Glycolysis, TCA cycle; Pentose phosphate pathway, Glyoxylate cycle for oil seeds, Sulphate assimilation.

iv. Nitrogen metabolism - Nitrate and ammonium assimilation.

v. Secondary metabolites and impact of stress on growth - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles; MEP, Mevalonic, Malonic and Shikimic acid pathway.

vi. Photosensory receptors - chemistry, structure and function.

BIOS 0703 (Theory): Cell Biology

[Theory: 50 marks; 4 credits]

1. **Biological membrane, structure, and assembly:** constituents, bacterial cell envelope, asymmetry flip-flop effect, and its cellular function.
2. **Protein trafficking pathways in the cell:** Protein sorting mechanisms in the cell, secretory and endocytic pathways.
3. **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.
4. **Regulation of cellular activities:** quality control (autophagy, degradative pathways). Cellular responses to stress.
5. **Cell junctions and interactions:** cell-cell interaction, cell-matrix interaction, Cell migration.
6. **Cytoskeleton**: Microfilaments; Microtubules; Intermediate filaments; Molecular motors, Cilia and Flagella.

7. **Cell communication:** Signalling molecules; pathways of intracellular signal transduction.
8. **Nuclear Transport:** import and export of protein; export of different RNAs.
9. **Cell Cycle and regulation:** Cell cycle checkpoints and its regulation. Cell cycle experiments, chromosome segregation error and aneuploidy, cytokinesis.
10. **Cell death and senescence:** Apoptosis– caspase; pathways of apoptosis; distinctive features in insects, nematodes and mammals; Senescence.
11. **Cancer**: Phenotypic characters of cancer cells; genetic basis of cancers: protooncogene, Oncogene, tumor suppressor genes; oncogenesis; aberrant signalling in cancer. Tumor viruses, concept of cancer stem cells, metastasis, and cancer immunotherapy.

BIOS 0791 (Practical): Tools and Techniques in Biophysics and Biochemistry

[Sessional: 50 marks; 4 credits]

1. Analysis of protein sample using SDS-PAGE.
2. Estimation of DNA, RNA and protein concentration using UV absorption spectroscopy.
3. Determination of protein concentration using visible absorption spectroscopy (with Bradford reagent).
4. Analysis of protein-ligand interaction using fluorescence spectroscopy.
5. Biochemical analysis of serum glucose, cholesterol, creatinine, SGOT and SGPT.
6. Quantification of total phenolic content from plant samples.
7. Neutral Lipid analysis from commercial oil seeds by TLC.

BIOS 0792 (Practical): Tools and techniques in Cell Biology and Grand Viva

[Sessional: 50 marks; 4 credits]

1. Preparation of step density gradients.
2. Isolation of nuclear, mitochondrial, chloroplast, from plant/animal tissues via differential centrifugation.
3. Assessment of histopathological changes in liver sections upon induction of tissue toxicity in a rat model.
4. Mitotic and meiotic chromosomal analysis from plant and animal (Grasshopper testis and Drosophila salivary gland) tissues.
5. Fast Halo assay for assessment of DNA damage.
6. Demonstration of Fluorescent and confocal microscopes.
7. Confocal image analysis techniques such as fluorescence quantitation, pseudocoloring using ImageJ.
8. Assessment of apoptotic cell morphology by Wright-Giemsa staining.

Grand Viva based on BIOS 701, 702 and 703 and related practicals.

Course Outcomes

BIOS 701: Instrumentation and Methodologies

After successfully completing this course, the students will be able to:

CO-1: Understand different techniques (e.g. molecular biology, histology, and radiobiology) and the principle of their use.

CO-2: Understand how different instruments are used, their workings and applications.

CO-3: Understand how structural analysis of biomolecules are achieved.

CO-4: Have a grasp of basic techniques and their use in scientific research

BIOS 702: Biochemistry and Biophysics

After successfully completing this course, the students will be able to:

CO1: Understand the scopes and merits of two fundamental disciplines of Life Sciences - Biochemistry and Biophysics

CO-2: Impart knowledge at the most detailed molecular level across different systems of life.

CO-3: Help students to solve biological problems from chemical and physical science perspectives.

CO-4: Ability to design experiments to understand molecular level interactions and their relation to biological system

BIOS 703: Cell Biology

After successfully completing this course, the students will be able to:

CO-1: Understand the scope of cell biology.

CO-2: Understand the functioning of cells, their regulation of function and how coordination is achieved.

CO-3: Understand the relationship between cell structure and function.

CO-4: Understand and interpret experimental basis of studying cellular function

CO-5: Understand the cell cycle and know the importance of various cells in the body of organisms.

BIOS 791: Tools and Techniques in Biophysics and Biochemistry

On completion of this course, the successful student will be able to:

CO-1: Competently perform laboratory techniques

CO-2: Appropriately calibrate and use key equipment and record results

CO-3: Perform various biochemical assays for various biomolecules.

CO-4: Interpret and evaluate data

CO-5: Recognize and respond to ethical and health safety issues.

BIOS 792: Tools and techniques in Cell Biology and Grand Viva

On completion, the successful student will be able to:

CO-1: Competently perform laboratory techniques related to the study of cells and their organelles.

CO-2: Competently identify and stain tissue sections.

CO-3: Appropriately calibrate and use key equipment and record results

CO-4: Interpret and evaluate data

CO-5: Recognize and respond to ethical and health safety issues.

PG SEMESTER – 2

BIOS 0801 (Theory): Genetics and Molecular Biology

[Theory : 50 marks; 4 credits]

1. Genetics

i. **Pattern of Inheritance:** Concept of alleles, types of dominance, lethal alleles, multiple alleles, test of allelism, complementation; Genes and environment, penetrance and expressivity, types of quantitative traits, polygenic inheritance; epistasis; Pedigree analysis in humans; Extranuclear inheritance.

ii. **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

iii. **Sex determination & Dosage Compensation:** Genetic determination of sex in *Caenorhabditis elegans*, *Drosophila melanogaster*, mammals and flowering plants, various approaches of dosage compensation in *Caenorhabditis elegans*, *Drosophila melanogaster* and mammals, Lyon's hypothesis, genetic control of X-chromosome inactivation

iv. **Population Genetics:** Genetic variation, Random mating population; Hardy-Weinberg principle, Linkage and Linkage disequilibrium, gene frequencies, mutation; selection; migration; genetic drift.

v. **Regulation of Gene expression:** Operon in bacteria, Lytic and lysogeny in Bacteriophage lambda, Gene rearrangement; (Yeast mating type; Trypanosome VSG gene); Gene silencing (Telomere, DNA methylation, Genomic imprinting), Histone code; Epigenomics, mRNA translation control, RNA interference (miRNA & siRNA).

2. Molecular Biology

i. **Genome organization:** Organization of genomes in prokaryotes and eukaryotes, Chromatin organization and packaging; genome complexity, CoT curve analysis; Repetitive and unique sequences; Satellite DNA; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation, Telomeres and telomerase, DNA topology, Knots and links, Linking number, Writhing and twisting, DNA supercoiling, Topoisomers, Role of DNA topology in replication and transcription. DNA Topoisomerases in prokaryotes and eukaryotes, Topoisomerase as drug target.

ii. **DNA Replication, recombination, damage and repair:** Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, Homologous and non-homologous recombination, site specific recombination, Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination, different kinds of DNA damage, DNA repair mechanisms in prokaryotes and eukaryotes, Diseases due to failure of DNA repair.

iii. **RNA synthesis and processing:** RNA world and RNA replication; Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, RNA transport (Emphasis on eukaryotic machinery).

iv. **Protein synthesis and processing:** Genetic code, its discovery and properties; aminoacylation of tRNA, aminoacyltRNAsynthetases, tRNA-identity and the second genetic code, fidelity of aminoacylation and proof reading; Ribosome, role of mRNA, tRNA and rRNA in translation, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, Peptidyltransferase, fidelity of peptide bond formation and translation, termination of translation and ribosome recycling, translational inhibitors, post- translational modification of polypeptides, Translation-dependent regulation of mRNA and protein stability (Emphasis on eukaryotic machinery).

BIOS 0802 (Theory): Environment, Ecology & Evolution

[Theory : 50 marks; 4 credits]

1. Molecular evolution

i. Concepts of change in gene frequency through natural selection, migration and genetic drift.

ii. Concepts of neutral evolution, molecular divergence and molecular clocks.

iii. Molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis.

iv. Origin of new genes and proteins; gene duplication and divergence.

v. Speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.

vi. Classical & quantitative methods of taxonomy.

2. Environmental Science

i. Environmental pollutants and pollution: classification of pollutants and mechanism of action; source, effects and control measures of pollution- (Air, Water, Noise and Radiation).

ii. Environmental toxicity: Concept of acute and chronic toxicity; Concept of dose response relationship (LD_{50}, LC_{50}, TLV); routes of entry of toxicants- mechanism and resistance; concepts of biomagnification and bioaccumulation, source of heavy metals and its mechanism of action; uptake of toxic substances by plants and animals- detoxification and excretion of toxic substances.

iii. Health and environment: occupational hazards and associated diseases, silicosis, anthrax and other lung diseases; WHO standards of working conditions; physical factors affecting occupational health (heat, cold and temperature); prevention of occupational diseases.

iv. Environmental impact assessment: Environmental impact assessment (EIA) general guidelines for preparation of environmental impact statement (EIS).

v. Environmental biotechnology: concept and broad outlines of various aspects of biotechnology waste treatment, biofuel production, biofertilizer, concepts of integrated pest management and biopesticides.

3. Ecology

i. Ecosystem Ecology: Ecosystem Structure and Function; concept of limiting factors; concept of productivity and energy flow through trophic levels; mineral cycling; major Indian biomes.

ii. Species interactions: Intra and interspecific competitions; coexisting pattern of competing species; Lotka-Volterra model; co-evolution of prey-predator interaction; Red-Queen hypothesis.

iii. Population and community ecology: Characteristics of a population; population growth curves; population regulation; metapopulations; population viability analysis; life history strategies (r & k strategies); niche concept; community structure and attributes; ecotone and edge effects; resource partitioning; character displacement; community dynamics (ecological succession).

iv. Applied ecology and Conservation Biology: Global environmental change; biodiversity monitoring and documentation; major drivers of biodiversity change; major approach to wildlife conservation and management; case studies on conservation/management strategies.

BIOS 0803 (Theory): Microbiology & Immunology

[Theory : 50 marks; 4 credits]

1. Microbiology

i. Structure of Bacterial cell membrane and cell wall; Membrane transport in prokaryotes.

ii. Bacterial photosynthesis, roles of bacteria in biogeochemical cycles; Photoautotrophy. Fermentation.

iii. Use of microbes in management of waste and different pollutants. Bioremediation. Microbes in commercial uses: source, production process and usage of microbes in vaccines, antibiotics, biopolymers, biosensors, biofertilizers, and biofuels. Use of microbes in genetic engineering.

iv. Principles of food spoilage and preservation, food and water borne diseases.

v. Concept of microbiome. Importance of microbiome in different physiological and pathological conditions, soil microbiome and climate change.

vi. Life cycle: Entry, replication, assembly and egress of DNA and RNA viruses. Common methods used for detecting viruses in clinical and laboratory settings.

vii. Host pathogen interaction: mechanism of microbial pathogenesis (bacteria and virus), genetics of pathogenicity and virulence.

viii. Antimicrobials: types and mode of action, mechanisms of acquiring resistance.

2. Immunology

i. Overview of adaptive immunity, B cell receptor, T cell receptor, B and T cell activation, distribution, structure, function and genetic control of MHC, Immunoglobulin gene rearrangements, HLA typing, molecular interactions between the T cell receptor and MHC molecules, immune synapse, polyspecificity of T cell receptor recognition, molecular mimicry and epitope spreading, T cell memory, peripheral tolerance and regulatory lymphocytes.

ii. Overview of Innate immunity, Complement system, role of cytokines, inflammation, Regulation of NK cell activity, type and function of dendritic cells and macrophages.

iii. Vaccines: history of vaccination, key developments, and ongoing challenges, types of vaccines, vaccine design, development, and safety.

iv. Infection and immunity, Hypersensitivity Disorder.

v. TumorImmunobiology: Evasive mechanisms of tumor cells; Tumor specific antigens; Immunosuppression in tumor microenvironments; Immunotherapy of cancer using monoclonal antibody and cytokines; NK cells and Dendritic cell therapy of cancer; Vaccine against human cervix cancer.

vi. Animal models in Immunology Research: BALB/c, C57BL6, Nude mice, SCID mice, concept of humanised mice.

vii. Advanced Immunological techniques: FACS, Immunofluorescence, Immunoblotting, ELISA.

BIOS 0891 (Practical): Genetics, Ecology and Environmental Science Practical

[Sessional: 50 marks; 4 credits]

1. Fly pushing: maintenance of fly stock and setting up of crosses.
2. SNP Analysis.
3. CpG methylation analysis.
4. Studies of important physicochemical parameters of aquatic ecosystems.
5. Concept of dose response relationship (by LD_{50}, LC_{50} etc.).
6. Biodiversity assessment and indices of an ecosystem.
7. Estimation of productivity in aquatic ecosystems.
8. Qualitative and quantitative estimation of zooplankton, macrobenthos and meiobenthos.
9. Field Excursion.

BIOS 0892 (Practical): Microbiology, Molecular Biology, Immunology practical and Grand Viva

[Sessional: 50 marks; 4 credits]

1. Isolation and identification of bacterial strains by culture-dependent methods.
2. Genomic DNA isolation.

3. Plasmid DNA isolation.
4. Polymerase chain reaction.
5. ELISA.
6. Western blot.
7. Viral titer determination using plaque assay.
8. Determination of viral DNA copy number by qPCR.

Grand Viva based on BIOS801, BIOS0802 and BIOS0803 related practicals.

Course Outcomes

BIOS 801: Genetics and Molecular Biology

At the completion of this course, successful students should be able to

CO-1: Explain the nature of inheritance, the genetic material and how it results in phenotype, variation in genetics, and relationship between these concepts.

CO-2: Use the concepts of Classical, Molecular and Population genetics to analyze data and solve novel genetics problems.

CO-3: Design and carry out genetics experiments, and participate in the generation and evaluation of genetic knowledge.

CO-4: Learn the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function.

CO-5: Understand structural organization of genes and the control of gene expression.

CO-6: Gain insight into the most significant molecular biology-based methods used today to expand our understanding of biology.

BIOS 802: Environment, Ecology & Evolution Biology

After successful completion of this course, students will be able to learn, understand and interpret:

CO-1: Processes of conservation of the ecosystem, extinction of species, interrelationships among organisms and habitats.

CO-2: Thoughtfulness towards the environment among the future generations.

CO-3: Scientific methodology via lab and field studies to understand growth, reproduction and interaction with other organisms either as parasites, predators.

CO-4: Predict, counteract and prevent potentially adverse effects of pollution.

CO-5: Mechanisms by which evolution occurs.

CO-6: Processes of evolution by mutation, migration, selection and genetic drift

CO-7: Various theories of evolution

CO-8: Neutral Theory of Molecular Evolution

CO-9: Key concepts of Population Genetics in terms of Hardy-Weinberg Law

CO-10: Micro-evolutionary changes and speciation

BIOS 803: Microbiology & Immunology

At the completion of this course, students should be able to

CO-1: Understand the biology of bacteria and viruses, their structural adaptations and biology.

CO-2: Know about the use of microbes in Industry, medicine and research.

CO-3: Learn about Host-pathogen interaction.

CO-4:Understand about Antimicrobials, their mechanism of action and development of resistance

CO-5: Understand basics of innate and adaptive immune response

CO-6: Learn about tumor biology and understanding of advanced immunological techniques

BIOS 891: Genetics, Ecology and Environmental Science Practical

On completion of this course, successful students will be able to:

CO-1: Competently perform laboratory techniques related to various genetic analysis in different models.

CO-2: Learn basic pharmacological tests.

CO-3: Develop concept of data collection in field work and surveys

CO-4: Interpret and evaluate data

CO-5: Recognize and respond to ethical and health safety issues.

BIOS 892: Microbiology, Molecular Biology, Immunology practical and Grand Viva

On completion of this course, successful students will be able to:

CO-1: Learn basic microbiological and immunological techniques and methods

CO-2: Develop the concept of good microbiological practice and related health, safety and ethical concerns.

CO-3: Learn to operate and use related instruments

CO-4: Interpret and analyze data.

PG SEMESTER -3

BIOS 0901 (Theory): Development Biology

[Theory : 50 marks; 4 credits]

1. Basic concept of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; role of reference organisms in developmental processes.
2. Cell fate and cell lineages, stem cell-types, meristems, genesis and differentiation in both animals and plants.
3. Stem cells and differentiation: Overview of Stem Cell Biology Stem cells in plants and other model organisms. 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.
4. Germ cells, nuclear programming, gene networks, Genetic regulation of Development, Genomic equivalence and the cytoplasmic determinants, Imprinting, mutants and transgenics in analysis of development.
5. Axis determination in plant and animal, Role of non-coding RNAs in development, non-cell autonomous signalling in plant development, concept of polarity.
6. Gametogenesis, fertilization and placentation.
7. 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, Organogenesis - vulva formation in *Caenorhabditiselegans*, eye lens induction, limb development and regeneration in vertebrates, neurogenesis, Post embryonic development, environmental regulation of normal development, sex determination.

8. Morphogenesis and organogenesis in Plants: Role of hormones in plant organogenesis, Embryogenesis, root development- primary and lateral, shoot and leaf development- abaxial vs. adaxial identity, phyllotaxy, Flower development, different environmental and physiological factors controlling flower induction, photoperiodic, vernalization, autonomous and physiological age pathways, circadian clock, genetics of floral organ differentiation- ABCDE model in dicotyledonous and monocotyledonous plants, homeotic and MADS box genes, floral asymmetry, development and germination of seeds.

BIOS 0902 (Theory): Systems Physiology

[Theory : 50 marks; 4 credits]

1. Movements and Bulk Transport

i. Regulatory mechanisms in the musculo-skeletal system in terrestrial, aquatic and aerial beings; musculo-skeletal disorders.

ii. Long and short distance transport of water and nutrients in plants (xylem and phloem transport); Membrane transport proteins.

iii. Physiology of the circulatory systems in vertebrates and invertebrates; haemopoiesis, disorders of blood and their remediation.

iv. Cardio-vascular Physiology, electrocardiography and arrhythmias, cardiac remodeling, regenerative capacity of heart, angiogenesis, maintenance of vascular tone, heart diseases, cardiac metabolism and energetics, cardiac work, heart transplantation/ artificial Heart.

2. Gas exchange and nutrition

i. Exchange in unicellular organisms and plants; Respiratory organs and physiology in aquatic and terrestrial systems; Regulation of respiration (Neural and chemical), respiratory disorders and adaptations to special environments. Lung volumes, capacities and their pathophysiology.

ii. Feeding patterns, regulation of digestion and absorption of foods, immune function of G.I. tract. Liver function tests and their significance.

3. Regulatory Physiology

i. Regulation of water and solutes in aquatic and terrestrial animals; osmoregulatory organs, renal regulation of osmolarity. Excretory and non-excretory functions of kidney, renal failure, kidney function tests and artificial kidney.

ii. Transpiration in plants.

iii. Patterns of Thermoregulation: Ectotherms, Endotherms and homeotherms and their mechanism. Concept of Q10.

iv. The circadian clock: role of SCN in the human, role of melatonin and other neurotransmitters in circadian control. Disorders of circadian rhythms: jet lag, work-shift syndrome, and delayed and advanced sleep-phase syndrome.

4. Integrative Physiology

i. An overview of the nervous system and structure, properties of neuron, physiology of nerve impulse transmission. Mechanisms of neuro disorders, common brain disorders. Cognitive behavior of senses, emotions, memory, learning and speech.

ii. Sensory motor neurobiology. Types of sensory receptors in somatosensation, olfaction, gustation, auditory and visual systems. Deafness, audiometry, defects of vision. Concepts of ascending and descending pathways. Spinal and cranial nerves. Cortical areas for sensory processing. The sense of balance, control of posture and movement, weightlessness. Ataxia, Parkinson's, Huntington's and ALS.

iii. Experimental neurobiology: Ablation and stimulation studies, extracellular and intracellular electrophysiological recordings, common diagnostic procedures, optogenetic and chemogenetic manipulation of brain circuits.

iv. Endocrine systems in animals and humans; Hypothalamic and andsuprahypothalamic control of endocrine functions. Endocrine functions and their pathophysiology. Bioassay and immunoassay.

v. Plant hormones –Auxin: Physiological effects of auxin- Cell Elongation, Phototropism and Gravitropism, Auxin receptors and signal transduction pathways. Gibberellins: Physiological mechanisms of gibberillin induced growth, Gibberillin receptors signal transduction. Cytokinins- physiological effects rec. Ethylene- developmental and physiological effects, cellular and molecular modes of action. Abscisic acid- developmental and physiological effects, cellular and molecular modes of action, Strigolactone and other plant growth regulators- physiological role in plant development.

vi. Reproductive Physiology: Sex determination and differentiation, cell biology of the oocyte and oogenesis, development and regulation of spermatogenesis, sperm-egg interaction, parturition and lactation, assisted reproductive technology.

BIOS 0903 (Theory): Biostatistics and Bioinformatics

[Theory : 50 marks; 4 credits]

1. Biostatistics

i. Numerical and graphical presentation of data; Types of variables (measurement, continuous, discrete, nominal, ordinal), Statistics & Parameters, Sample vs. Population.

ii. Measures of central tendency; Measures of dispersion; Skewness & Kurtosis.

iii. Sample distributions & Probability distributions (Normal, Student's t distribution, and Chi-Square distributions).

iv. Principles of testing of hypothesis, level of significance, one-tail and two-tail tests, parametric vs. non-parametric tests, degrees of freedom, errors of inference, sampling errors. Testing of significance of hypothesis by student's t-test, paired t-test; Distribution-free test-Chi-square test, G-test.

v. Product moment Correlation-assumptions, properties, computations and applications, Spearman's rank correlation coefficient, Point biserial r, Biserial r, partial correlation. contingency coefficient; Regression analysis.

vi. Analysis of variance; Post-hoc test; Mann-Whitney U test, Kruskal–Wallis one-way analysis of variance.

vii. Statistical analysis using softwares.

2. **Bioinformatics**

i. Introduction to Bioinformatics.

ii. Bioinformatics databases- bibliographic, sequence (GenBank/ EMBL/ DDBJ; PIR-PSD/ SwissProt/ TrEMBL) and structure (PDB, SCOP, CATH).

iii. Understanding genomic data and data organization- emergence of next generation sequencing. Understanding gene-expression data. Gene identification by sequence inspection. Clustering methods and phylogeny.

iv. 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.

v. Structural Bioinformatics- an overview.

vi. Modeling populations of organisms - ecological modeling.

vii. Image processing and analysis.

BIOS 0991 (Practical): Developmental Biology and Systems Physiology practical

[Sessional: 50 marks; 4 credits]

1. Histology: Histological studies in various mammalian tissues and organs under different experimental conditions using different staining methods (H/E, Trichrome).

2. In vitro study of the movements of isolated mammalian (rat) small intestine and the effects of ions, neurotransmitters and temperature variations.
3. Determination of circadian rhythm of different physiological parameters.
4. Determination of physical fitness index by Astride Jump Test (AJT) and Treadmill test.
5. Biochemical estimation of plant hormones.
6. Avian heart development.
7. Development studies in zebrafish/ *C. elegans* model.
8. Development stages of *Arabidopsis*.

BIOS 0992 (Practical): Biostatistics, Bioinformatics practical and Grand Viva

[Sessional: 50 marks; 4 credits]

1. Sequence Alignment (BLAST/ ClustalW/ FASTA)
2. Accessing sequence and structure databases and information retrieval
3. Phylogenetic Cluster Analysis
4. Viewing three dimensional Structure of Macromolecules using RASMOL
5. Protein Protein Interactions (STRING)
6. Gene Prediction program
7. Introduction to ImageJ
8. Testing of Hypothesis.
9. Problems related to t-test, z-test, correlation, regression, ANOVA, non-parametric analyses.

Grand Viva based on BIOS901, BIOS0902 and BIOS0903 related practicals.

Course Outcomes

BIOS 901: Developmental Biology

After successfully completing this course, the students will be able to:

CO-1: Gain a comparative understanding between plant and animal development

CO-2: Understand basic concepts on STEM cell and their potential application in medical biology.

CO-3: Understand basic concepts regarding organogenesis and morphogenesis in plants and animals.

CO-4: Understand principles of Genetics and biochemistry that regulate growth and development of plants and animals.

BIOS 902: Systems Physiology

After successfully completing this course, the students will be able to:

CO-1: Gain a comprehensive understanding of the regulation of musculo-skeletal movement, vascular transport in plants and animals.

CO-2: Understand Gaseous exchange processes and their regulation.

CO-3: Gain insights into the regulation of excretory processes, thermoregulation, circadian rhythm.

CO-4: Understand Sensory motor and endocrine regulation in plants and animals.

BIOS 903: Biostatistics and Bioinformatics

After successfully completing this course, the students will be able to:

CO-1: Perform simple statistical calculations and analysis of parametric and non-parametric data, demonstrate competence in handling and statistical analysis of data

CO-2: Develop understanding of when a particular statistical test is applicable.

CO-3: Acquire knowledge of various databases of proteins, nucleic acids, Analysis tools for sequence data banks

CO-4: Make phylogenetic predictions or prediction of structure of proteins and nucleic acids

CO-5: Develop understanding about genomic data and data organization

CO-6: Understand modeling of populations of organisms

BIOS 991: Developmental Biology and Systems Physiology practical

After successfully completing this course, the students will be able to:

CO-1: Develop skills in histological staining of tissue sections.

CO-2: Develop concepts in basic tests of physiological parameters in rat model and human subjects.

CO-3: Visualize different developmental stages in chick and fish models.

CO-4: Learn to operate and use related instruments.

CO-5: Understand records and analyses of data.

CO-6: Understand ethical principles related to animal and human subject work.

BIOS 992: Biostatistics, Bioinformatics practical and Grand Viva

After successfully completing this course, the students will be able to:

CO-1: Develop skills in basicbioinformatic analysis of DNA, proteins and interactome analysis.

CO-2: Develop skills in use of appropriate statistical tests and softwares.

CO-3: Develop *in silico* analysis skills in structure preparation, phylogenetic analyses, image data

PG SEMESTER-4

This semester will cover the dissertation projects and project related topics as well as developing research skills.

BIOS 1001 (Theory): FRG specific theory paper

[Theory : 50 marks; 4 credits]

BIOS 1001A: (Theory) Research Frontiers in proteo-genomics

[50 marks; 4 credits]

1. Understanding Genomics: Studying genomes, Techniques for mapping genomes, Genome sequencing, Structural and functional genomics, Locating genes in genome sequence, Determining gene function, Comparative genomics.
2. Regulation of genome activity, studying DNA-protein interactions in gene expression.
3. Human Molecular Genetics: Genetic screening, molecular markers and molecular profiling, techniques for studying macromolecular interactions.
4. Functional Proteo-Genomics: Studying transcriptomes and proteomes - Microarray, qPCR, ChIP, SAGE, 1 and 2-dimensional gel electrophoresis, multidimensional chromatography, biological mass spectrometry, cancer proteo-genomics.
5. Gene therapy, miRNAs, RNAi and CRISPR functional screens.

BIOS 1001B: (Theory) Developmental Gene Program and Plasticity [50 marks; 4 credits]

Discussion on recent advances on the following topics

1. Developmental Genetics and Cell-Cell Communications.
2. Developmental plasticity and organogenesis.
3. Transcriptional regulation in Development.

4. Medical aspects of developmental biology.

BIOS 1001C: (Theory) Advanced macromolecular structure, function and dynamics

[50 marks; 4 credits]

1. Structural analysis of macromolecules and their complexes.
2. Macromolecular assemblies: Protein-ligand interactions; Membrane protein like G-proteins GPCR, Chromatin nucleosome, Ribosome assemblies, secretion systems involved in pathogenesis.
3. Protein folding, mis-folding and aggregation: Principles and correlation with diseases.
4. Protein engineering: definition, steps involved, applications; Features or characteristics of proteins that can be engineered (definition and electives methods of study)–affinity and specificity; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc.; directed evolution; incorporation of non-natural amino acids in the protein; uses for metabolic engineering.
5. Overview of systems and synthetic biology: Basic concept, concepts of synthetic genome, organelles, and minimal cell; metabolic engineering; bacterial drug factories; synthetic biology in clinical applications, and biosensor.Understanding biological parts and their respective properties; behaviour of basic network motifs in cellular and synthetic systems; structure of biological networks; risk, opportunities, ethical and social challenges associated with synthetic biology.

BIOS 1001D: (Theory) Cell death deregulation and diseases

[50 Marks; 4 credits]

1. Cell death mechanisms and its regulation.

2. Biology of cancer: Oncogenic viruses, oncogenes, tumor suppressor genes, chemical carcinogenesis, Cell Cycle control, Metastasis, Angiogenesis, Tumor microenvironments, Inflammation and Cancer, Therapeutic strategies.
3. Cellular and Molecular Neurobiology and diseases of the nervous system: Cellular neurobiology and Neuroimmunology; Neurological infections; Discussion on common neurological/ neurodegenerative disorders of adults and children.
4. Cellular damage from microbial pathogens: Infectious diseases such as bacteria, viruses, fungi, protozoa, arthropods, and prions. Host defense against pathogens. Molecular pathogenesis. Detection and diagnosis. Hospital infection, sterilization, and disinfection.
5. Experimental approach to studying disease biology.

BIOS 1001E: (Theory) Ecological Sustainability and Bioprospecting

[50 Marks; 4 credits]

1. Concept of sustainability: sustainable development in a developing country; Future perspectives of a sustainable world.
2. Multidimensional challenges to human sustainability: challenge of population growth, global warming, scarcity of resources, etc.
3. Mitigation of human impacts through technology: biodiesel, biofuel, biocontrol, carbon-free energy sources, sustainable agriculture.
4. Biodiversity and ecological security.
5. Ecological and environmental economics.
6. Ethnopharmacology; bioprospecting and biopiracy; natural product research.

BIOS 1001F: (Theory) Endocrine Pathophysiology, Toxicology and Toxicity Management

[50 Marks; 4 credits]

1. Endocrine pathophysiology: associated research- fundamentals/ basis of development, designing of models and methodologies adopted, interpretation of results based on available information, future designing and the social implication
2. Toxicology and toxicity management: Fundamentals- studies on toxicodynamics, toxicokinetics and biotransformation; toxic effects- designing the studies from system to molecular level; risk assessment and management- components of risk assessment, Selection of molecular biomarker of adducts (carcinogen-DNA, carcinogen-protein and DNA-protein).

BIOS 1001G: (Theory) Ergonomics, Occupational Health Management, Clinical Nutrition and Emerging Diseases

[50 Marks; 4 credits]

1. Ergonomics and occupational health management: application of different methods in the study of ergonomics, use of biomechanics, EMG- ECG in ergonomics; cognitive ergonomics use and importance in assessing human efficiencies/ performance; role of ergonomics in sports, occupational health and safety management; biorhythm and shift work.
2. Clinical Nutrition: studies on nutritional requirements in different stages / phases of human life; knowledge on food sciences and importance of food technology in present day life; current research on nutritional genomics, proteomics and metabolomics; therapeutic nutritional management strategies in diseases.
3. Emerging and neglected diseases: global burden of pathogenic diseases, causes, prevention and diagnostics; diseases of the current century-obesity, heart disease; environmental toxicity study- selection of methodology, assessment and interpretation of results, management strategies.

BIOS 1001H: (Theory) Biotechnological methods in crop improvement

[50 Marks; 4 credits]

1. Plant Tissue Culture: Medium composition and techniques, use of different organs (somatic and reproductive) in plant tissue cultures to overcome the limitations involved in the conventional methods for crop improvement. Somatic embryogenesis and synthetic seed production.

2. Genetic Transformations: Techniques used in genetic transformations of plants, Applications of transgenic techniques to develop abiotic and biotic stress tolerant/resistant plants with examples. Biosafety rules and implications involved in release of transgenic plants.

3. Stress Biology and Crop Improvement: Molecular mechanisms including signal transduction pathways involved in immune responses. Role of Next-Generation Sequencing (NGS) to reveal genes involved in conferring resistance/susceptibility against the specific stress and subsequent development of stress tolerant crop plants using suitable technology including gene editing using CRISPER-Cas system.

4. Molecular Plant Breeding: Generation of different molecular markers and their uses in marker assisted plant breeding.

BIOS 1002(Theory): Research ethics and good laboratory practice and Entrepreneurship and Skill development/ Grant Proposal writing

[Sessional: 50 marks; 4 credits]

1. Research Bioethics and good laboratory practice

i. Introduction, Overview, and Research Misconduct, rules and regulations in India.

ii. Data Management

iii. Mentoring, mentor-mentee responsibilities

iv. Authorship Guidelines, Publication and Peer Review

v. Intellectual property, plagiarism, self plagiarism, similarity reports, patents

vi. Collaboration

vii. Reporting and representing research, representing images.

viii. Bias, Conflicts of Interest

ix. Ethical use of animal subjects

x. Protection of Human subjects

xi. Stem Cell Ethics

xii. The ethics of plant use, transgenic crops, biosafety rules in plants

xiii. Agricultural Ethics

xiv. Ecosourcing- code of practice

xv. Radioactive, chemical and biohazard safety, waste management and disposal

xvi. Social Responsibility and Whistleblowing

2. Entrepreneurship and Skill development/ Grant Proposal writing

BIOS 1003 (Theory): Review writing and research article presentation (Journal Club)

[Sessional: 50 marks; 4 credits]

BIOS 1091 (Practical): Dissertation submission

[Sessional: 50 marks; 4 credits]

BIOS 1092 (Practical): Presentation and defense of dissertation work

[Sessional: 50 marks; 4 credits]

Course Outcomes

BIOS 1001A: Research Frontiers in Proteo-genomics

CO-1: Provide the knowledge and practical skills of functional genomics and proteomics

CO-2: Learn the techniques used in functional genomics such as microarrays, NGST, mRNA expression and miRNA expression.

CO-3: Understand the concepts of tools and techniques employed in human molecular genetics like genetic screening, molecular profiling.

CO-4: Learn gene therapy and other tools to alter gene expression like RNAi and CRISPR

CO-5: Impart skills to understand RNA biogenesis and RNA based therapeutics

BIOS 1001B: Developmental Gene Program and Plasticity

After successful completion of this course, students would

CO-1: learn about recent advances in Developmental Genetics and Cell-Cell Communications.

CO-2: get insights about the field of Developmental plasticity and organogenesis.

CO-3: Learn about transcriptional regulation in Development.

CO-4. Learn about medical aspects of developmental biology.

BIOS 1001C: Advanced Macromolecular Structure Function Dynamics

CO-1: Introduces students to the advanced aspects of science that includes synthetic biology, systems biology as well as protein engineering.

CO-2: Learn to adopt a holistic approach to address potential biological problems.

BIOS 1001D: Cell death deregulation and diseases

CO-1: Understand cell death mechanisms and their regulation.

CO-2: Understand the mechanism of pathophysiology of cancer and neurodegenerative diseases.

CO-3: Learn modern trends in the study of pathogens and the diseases they cause.

BIOS 1001E: Ecological Sustainability and Bioprospecting

Students will be able to learn, understand and interpret:

CO-1: Ecology-ecogeographic rules

CO-2: Environmental pollution and toxicity

CO-3: Human health and environment

CO-4: Environmental Impact Assessment

CO-5: Environmental biotechnology: Biofuel, biofertilizer, Integrated pest management

CO-6: Species interaction

CO-7: Evolutionary ecology

CO-8: Molecular and Chemical ecology

CO-9: Microbial ecology

CO-10: Resource ecology and field ecology

CO-11: Ethnopharmacology and bioprospecting, biopiracy

CO-12: Sustainable development and Conservation ecology

BIOS 1001F: Endocrine Pathophysiology, Toxicology and Toxicity Management

CO-1: Understanding the impact of hormonal imbalance on the normal physiology/normal life.

CO-2: Understand the harmful effects of various natural/synthetic/engineered chemicals/particles on the hormonal systems.

CO-3: Learn to assess risks or adverse health effects from various hazardous materials.

CO-4: Students will gather knowledge about "science of safety". By sharing their knowhow with family/others, they can play an important role to protect public health.

BIOS 1001G: Ergonomics, Occupational Health Management, Clinical Nutrition and Emerging Diseases

CO-1: Understanding ergonomic principles in occupational health management

CO-2: Clinical nutrition and understanding of pathophysiology

CO-3: Concepts in emerging and neglected diseases

BIOS 1001H: Biotechnological methods in crop improvement

CO-1: Basic and applied concepts on plant tissue culture

CO-2: Fundamental knowledge on different tools and techniques used in plant biotechnology

CO-3: Knowledge on crop stress biology and their impact on crop productivity.

CO-4: Knowledge on molecular plant breeding

BIOS 1002: Research ethics and good laboratory practice and **Entrepreneurship and Skill development/ Grant Proposal writing**

CO-1: Understanding ethical principles involved in authorship, publication, collaborations, image presentation and mentor-mentee relationships

CO-2: Good laboratory practice

CO-3:Principles of ethics in research involving biohazards, animals and human

CO-4: Understand the basic principles of developing entrepreneurship skills

CO-5: Understand grantsmanship- the practice of writing hypothesis driven scientific grants for funding applications.

BIOS 1003: Review writing and research article presentation (JC)

CO-1. Learn to read scientific articles and gain a critical understanding of their contents.

CO-2. Learn to deliver oral and written presentations of scientific topics and research results.

BIOS 1091: Dissertation submission

CO-1: Develop the practice of writing a thesis on the work achieved during dissertation, following principles of scientific integrity..

CO-2: Write and present results to convey information on the work that has been achieved.

BIOS 1092: Presentation and defense of dissertation work

CO-1: Develop oral presentation skills, communicate about data and conclusions from research understandably, using adequate indicators, images, tables, and graphs

CO-2: Learn to formulate research questions and hypotheses, and create a research plan adequate to the research question

CO-3: Gain experience with presenting as well as defending the dissertation work achieved to external examiners.

REFERENCE BOOKS:

The list is only a general list of reference books that are often followed. However class discussion often includes research papers and review articles relevant to various aspects of the topics being covered.

1. Aber, J.D.andMelillo 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. Tata McGraw-Hill Publishing Co. Ltd. (New Delhi).
2. Buchanan B, Gruissem G & Jones R - 2000 - Biochemistry and Molecular Biology of Plants.
3. Bjorn, Lars Olof (Editors) , Photobiology: The science of light and life, Springer
4. Becker W. M., Kleinsmith L.J. and Bertni G. P. 2009. The World of the Cell.
5. Barton, Briggs, Eisen, Goldstein and Patel. (2007) Evolution. Cold Spring Harbor Laboratory Press Edition. Pearson Benjamin Cummings Publishing, San fransisco.
6. Berne & Levy Physiology, Bruce M Koeppen, MD PhD, Bruce A Stanton, PhD · 2017, Elsevier Health Sciences
7. Cooper G. M. Hausman R. E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press and Sunderland, Washington D. C.; Sinnauer Academic Press.
8. Patten's Foundations of Embryology, Bradley Merrill Patten, Bruce M. Carlson · 1988, McGraw-Hill Book Company
9. Cutter, S.L. (1999).Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi.
10. De Robertis, E. D. P. and De Robertis R. E. 2009. Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia.
11. David Randall, Eckert's Animal Physiology, W.H.Freeman and Co.

12. Deverall, Brain J. 1977. Defence mechanisms of plants, Cambridge University Press.
13. Elli Kohen, Rene Santus, Joseph G. Hirschberg: Photobiology Academic press
14. Peter A. Ensminger: Life under the sun , Yale University Press
15. Futuyma, D. (1998) Evolutionary Biology. III Edn.Sinauer Assoc. Inc.
16. 18.Guyton and Hall Textbook of Medical Physiology, 13th Edition, John E. Hall, John Edward Hall, Arthur C. Guyton · 2011, Saunders/Elsevier
17. Genetics - A Conceptual Approach (2012), 4th ed., Pierce, B.A., W.H. Freeman & Co. (New York), ISBN:13:978-1-4292-7606-1 / ISBN:10:1-4292-7606-1.
18. Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell publishing (Oxford, UK).
19. Harper's Illustrated Biochemistry 31 Ed., Victor W. Rodwell, David A. Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil · 2018, McGraw-Hill Education
20. Hoppe et. al., Biophysics, Translation of 2nd German Edition, Springer Verlag, 1983.
21. Hall, B. K. and Hallgrimson, B. (2008) Strickberger's Evolution. IV Edn. Jones and Barlett
22. Hawes C &Satiat-Jeunemaitre - 2001 Plant Cell Biology : Practical approach
23. Ingrowille, M Diversity and Evolution of land plants 1992
24. iGenetics: A Molecular Approach 3rd Edition, by Peter J Russell, Pearson Education Limited ISBN-13: 978-0321569769/ ISBN-10: 0321569768
25. J.D.Lee: A New Concise Inorganic Chemistry, E.L.B.S.
26. James E.Huheeyetal. : Inorganic Chemistry: Principles of Structure and reactivity,
27. Joseph, F. L. and Louver, B.D. (1997). Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey.
28. Keith Wilson and John Walker, Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition, Cambridge University Press, 2005.

29. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition, John Wiley &Sons.Inc.

30. K. Murphy, P. Travers, M. Walport. 2008. Janeway'sImmunobiology, Garland Science, Taylor and Francis Group, LLC

31. Kolluru R., Bartell S., Pitblado R. and Stricoff, S. (1996). Risk Assessment and Management Handbook. McGraw Hill Inc., New York.

32. Kofi, A.D. (1998). Risk Assessment in Environmental management, John Wiley and sons, Singapore.

33. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman & Company (New York), ISBN:13: 978-1-4292-3414-6 / ISBN:10-14641-0962-1.

34. Lewin's Genes XI by Jocelyn E. Krebs, Benjamin Lewin, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Publishers, 2014, ISBN-13: 978-1449659851 / ISBN-10: 1449659853

35. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann,A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York)

36. Molecular Biology of the Cell, 4th edition, Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter.New York: Garland Science; 2002, ISBN-10: 0-8153-3218-1ISBN-10: 0-8153-4072-9

37. Molecular Cell Biology by Lodish and Baltimore.

38. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC). ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.

39. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole Knut Schmidt-Nielsen. Animal Physiology , Cambridge University Press

40. P.W. Atkins: Physical Chemistry, Oxford University Press

41. Principles of Biochemistry, 5th Edition, W.H.Freeman and Company, N.Y., USA.

42. Philips Withers; Comparative Animal Physiology. Books Cole Publishers

43. Physical Biochemistry, David Freifelder, Applications to Biochemistry and Molecular Biology, 2nd Edition, W.H. freeman and Company, 2005.

44. Peter W. Hochachka, George. N. Somero, Biochemical adaptation, Amazon Publishers Gilbert S: Developmental Biology 9th Ed;

45. Genetics (2012) 6th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.

46. Plant Microtechnique and Microscopy (1999) Ruzin, S.E. Oxford University Press, (New York) U.S.A.

47. Plant Physiology (2015) Taiz, L., Zeiger, E., Muller, I.M. and Murphy, A

48. Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S.B., and Twyman, R. M., Blackwell publishing (Oxford, UK).

49. R.T. Morrison &R.N.Boyd: Organic Chemistry, Prentice Hall

50. Randall, Burggren, French : Eckert , Animal Physiology-mechanisms and adaptations, W H Freeman and company

51. Ecology- The Economy of Nature, Rick Relyea, Robert E. Ricklefs · 2019, W. H. Freeman

52. Short Protocols in Molecular Biology (1995) 3rd ed., Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidm

53. Elements of Ecology, Thomas M. Smith, Robert Leo Smith · 2014, J.G., Smith, J.A., Struhl, K. John Wiley & Sons. Pearson Education

54. The Biology of Cancer, Robert Allan Weinberg · 2014, Garland Science

55. T .J. Kindt, R. A. Goldsby, and B.A. Osborne. 2007. Kuby Immunology, W.H. Freeman and Co, New York.

56. Voet, D. and Voet, J.G. (2004). Biochemistry, 3rd Edition, John Wiley & Sons, Inc. USA.

57. Wilkenson DM - 2007 - Fundamental Processes in Ecology, OUP Oxford

58. Evolution= Making Sense of Life, Carl Zimmer, Douglas John Emlen, Alison E. H. Perkins · 2016

59. Principles of Virology. Jane Flint, Glenn F. Rall, Vincent R. Racaniello, Anna Marie Skalka, Lynn W. Enquist