POSTGRADUATE SYLLABUS OF THE DEPARTMENT OF LIFE SCIENCES

The Department of Life Sciences (previously Biological Science) in Presidency University was created by merging six pre-existing Departments of Botany, Zoology, Physiology, Molecular Biology, Biochemistry and Biotechnology. The concept of merging the departments follows a rationale of studying the different branches of life sciences with a holistic approach. The result is a dynamic, inter-disciplinary department with a mixture of young and experienced faculty providing a unique learning experience for the incumbents of the program. Students will have the opportunity of studying a multitude of inter-disciplinary branches of life sciences, and will also gain significant research experience by the completion of their studies. The postgraduate syllabus has been extensively re-structured to bear in mind the objective of the curriculum, which is to build future researchers and academicians. In this new 'Learner Centric' curriculum, there is significant emphasis on developing the critical thinking aptitude of students, and to encourage logical interpretation and analytical approach to problem- solving. The teaching methodology and pedagogical tool to be implemented in the new postgraduate curriculum is largely hands-on research oriented. Students will be accepted into the program either as a continuum from their B.Sc. curriculum based on merit, or as fresh entrants at the postgraduate level. Students with a B.Sc. (Honors) from any branch of Life Sciences can apply to enrol in the Masters in Life Sciences program at Presidency. There will be a total of four semesters in the Masters program, of which the first two semesters (PG Semester 1 and 2) will be common papers for all students. These modules will comprise mostly of the fundamentals of Life Science, ranging from diversity and evolution to biochemistry and genetics. There will be laboratory/ field study based practical modules related to the theoretical papers. These common compulsory modules are essential for understanding the different biological processes and indispensable for their future career goals. The final two semesters (PG Semester 3 and 4) are entirely research based, and students will get the unique opportunity of working in a research lab for their dissertation for a whole year. Students will opt for specialization in different Faculty Research Groups (FRGs) which have been created on common academic interestswiththe 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. There will be no stratification of students based on their previous semester grades. Ultimate settlement of choice will be done through lottery if needed. The department aims at developing in every student a researcher capable of rational thinking and analytical interpretation, irrespective of their academic performance.. During the third semester, students across FRGs will have a common theoretical module highlighting the general principles of research. The rest of the Semester 3 and 4 syllabus will be FRG specific, and include both theory and research papers. At the end of the curriculum, students will be proficient in presenting scientific research, critically discussing scientific publications, writing reviews and research proposals. After completion of all 4 semesters, the successful students will be awarded with a M.Sc. degree in Life Sciences.

The structure of the curriculum and the details are provided below.

PG SEMESTER -1

BIOS 0701(Theoretical) [50 marks; 4 credits]

Methods and Experimental Design

BIOS 0702 (Theoretical) [50 marks; 4 credits]

Part 1- Advanced Cellular Biology [30 marks]

Part 2- Developmental Biology [20 marks]

BIOS 0703(Theoretical) [50 marks; 4 credits]

Part 1- Advanced Biochemistry [25 marks]

Part 2- Advanced Molecular Biology [25 marks]

BIOS 0791(Practical corresponding to BIOS 0702) [50 marks; 4 credits]

BIOS 0792(Practical corresponding to BIOS 0703) [50 marks; 4 credits]

PG SEMESTER – 2

BIOS 0801(Theoretical) [50 marks; 4 credits]

Part 1- Advanced Microbiology [25 marks]

Part 2- Immunology [25 marks]

BIOS 0802 (Theoretical) [50 marks; 4 credits]

Part 1-Advanced Genetics [30 marks]

Part 2- Environmental Science [20 marks]

BIOS 0803 (Theoretical) [50 marks; 4 credits]

Part 1- Emerging Trends in Life Sciences [25 marks]

Part 2- Homeostasis of Systems [25 marks]

BIOS 0891(Practical corresponding to BIOS 0801) [50 marks; 4 credits]

BIOS 0892(Practical corresponding to BIOS 0802) [50 marks; 4 credits]

PG SEMESTER -3

PG Semester 3 and 4 will be a research-centric curriculum. The following Faculty Research Group (FRG)-specific modules will be offered to the students. Advisory Committee will guide regarding selection of research laboratories and FRGs. The Department will reserve the right to limit the number of students for a particular FRG as well as fix the maximum number of students performing dissertation under a particular supervisor.

Modules offered: *Candidates would have to take **two** theoretical modules, a compulsory BIOS 901 and choice of one FRG-specific BIOS 902 as listed below*

BIOS 0901(Theoretical):General principles of research [50 marks; 4 credits]

Part 1: Research Bioethics and Good Laboratory Practice

Part 2:Taxonomy, Biodiversity, evolution and ethology

Part 3: Hands-on Training in Bioinformatics

BIOS 0902(A-H) (Theoretical Optional- choose **any one** from the following modules**)**[50 marks; 4 credits]

Serial #	Module	Course contents	Credits
1	BIOS 0902A	Research Frontiers in Proteo-genomics • Studying genomes • Regulation of genome activity • Molecular technologies • Gene therapy • Studying transcriptomes & proteomes	4
2	BIOS 0902B	Developmental Gene Program and Plasticity: • Developmental Genetics and Cell-Cell Communications • Developmental plasticity and organogenesis • Transcriptional regulation in Development • Medical aspects of developmental biology	4

3	BIOS 0902C	Advanced Macromolecular Structure Function Dynamics • Architecture of biological macromolecules • Macromolecular assemblies • Structural analysis of macromolecules and their complexes • Protein folding, mis-folding and aggregation • Protein engineering • Synthetic biology	4
4	BIOS 0902D	Cell death deregulation and diseases • Cell death mechanisms & its regulation • Biology of cancer • Cellular and molecular mechanisms of neurodegenerative diseases • Cellular damage from microbial pathogens • Experimental approach in studying disease biology	4
5	BIOS 0902E	Ecological Sustainability and Bioprospecting • Concept of Sustainability • Multidimensional challenges to Human sustainability • Mitigation of human impacts through technology • Biodiversity and Ecological Security • Ecological and Environmental Economics • Ethnopharmacology	4
6	BIOS 0902F	Endocrine Pathophysiology, Toxicology and Toxicity Management • Endocrine Pathophysiology • Associated research • Toxicology and toxicity management • Fundamentals • Toxic effects • Risk assessment and management	4

7	BIOS 0902G	Ergonomics, Occupational Health Management, Clinical Nutrition and Emerging Diseases • Ergonomics and Occupational Health Management: • Clinical Nutrition: • Emerging and Neglected Diseases:	4
8	BIOS 902H	Advances in crop improvement • Plant Tissue Culture • Basics tools in Plant Biotechnology and Transgenics • Crop stress and productivity • Molecular Plant Breeding	4

BIOS 0903: Journal club (at least three presentations) [50 marks; 4 credits]

BIOS 0991: Introduction and identification of research problem [50 marks; 4 credits]

BIOS 0992: Lab/ field work- standardization of protocols [50 marks; 4 credits]

PG SEMESTER-4

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

BIOS 1001: Project proposal for funding agency [50 marks; 4 credits]

BIOS 1002: Dissertation submission [50 marks; 4 credits]

BIOS 1003: Lab/ field work- methodology [50 marks; 4 credits]

BIOS 1091: Lab/ field work- interpretation and analysis of results [50 marks; 4 credits]

BIOS 1092: Dissertation presentation and interaction [50 marks; 4 credits]

PG SEMESTER -1

BIOS 0701 (Theoretical)[50 marks; 4 credits]

Methods and Experimental Design

1. Molecular biology and recombinant DNA methods: Isolation and purification of various RNA, DNA and proteins; different separation methods and principles of nucleic acids and proteins by gel electrophoresis; isoelectric focusing; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.

2. Expression of recombinant proteins using bacterial, animal and plant vectors; different PCR methods or isolation of specific DNA sequences; generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; in vitro mutagenesis and deletion techniques; gene knock out in bacterial and eukaryotic organisms.

3. Protein sequencing methods, detection of post translational modification of proteins; DNA sequencing and strategies for genomic sequencing, methods for analysis of gene expression at RNA and protein level, large scale expression analysis, such as micro array based techniques; isolation separation and analysis of carbohydrate and lipid molecules; RFLP, RAPD and AFLP techniques.

4. Histochemical and inmunocytochemical 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 using UV-visible, fluorescence, circular dichroism, and NMR spectroscopy. Structure determination of biomolecules using X-ray crystallography.

6. 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.

7. 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.

8. 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 (Theoretical) [50 marks; 4 credits]

Part 1- Advanced Cellular Biology [30 marks]

1. 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.Regulation of cellular activities, quality control (autophagy, degradative pathways).

2. Cell Wall, Extracellular matrix and Cell interaction: Cell-cell interaction; Cell-matrix interaction.

3. Cell communication – Signaling molecules; Receptors: G- protein coupled receptor, Receptor Tyrosine Kinase, Cytokine receptors; Pathways of Intracellular Signal Transduction

4. Cytoskeleton - Microfilaments; Microtubules; Intermediate filaments; Molecular motors.

5. Nuclear Transport –Import and Export of protein; Export of different RNAs

6. Eukaryotic Cell Cycle - Cyclin and Cyclin-dependent Kinase; Molecular mechanisms of Checkpoint regulation.

7. Stem cells and differentiation

8. Apoptosis – Caspase; Pathways of Apoptosis; Distinctive features in insects, nematodes and mammals.

9. Cancer – Phenotypic characters of cancer cells; Genetic basis of cancers: Protooncogene, Oncogene, Tumor suppressor genes; Oncogenesis;Cancer Immunotherapy

Part 2- Developmental Biology [20 marks]

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, genesis and differentiation in both animals and plants

3. Molecular biology of stem cell and its regulatory molecules, emerging trend and clinical applications;

4. Germ cells, nuclear programming and gene networks.

5. Genomic equivalence and the cytoplasmic determinants.

6. Axis determination in plant and animal, non-coding RNA s in development, non-cell autonomous signaling in plant development

7. Imprinting, mutants and transgenics in analysis of development.

8. Gametogenesis and fertilization

9. Morphogenesis and organogenesis

i) Animals - cell aggregation and differentiation, patterning and shaping of the early embryo, axes and pattern formation in *Drosophila*, amphibia and chick, Organogenesis - vulva formation in *Caenorhabditis elegans*, eye lens induction, limb

development and regeneration in vertebrates, neurogenesis, environmental regulation of normal development, sex determination.

ii) Flower development, floral and inflorescence meristems, different physical and physiological factors including flower induction, ABC model and beyond. Genetics of flower development in monocotyledonous flowers, floral asymmetry and gametogenesis

BIOS 0703 (Theoretical) [50 marks; 4 credits]

Part 1- Advanced Biochemistry [25 marks]

1. **Enzymology and enzyme technology**:

i) Enzyme regulation- allosteric enzyme, definition and example, allosteric modulators, 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

ii) 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.

iii) 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 enzyme.

2. **Overview of protein-ligand interaction and their analyses.**

3. **Metabolic diseases**

i) Intermediary metabolism

ii) 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.

iii) Disorders of Lipids - Plasma lipoproteins, cholesterol, triglycerides and phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann- Pick disease, ketone bodies, Abetalipoproteinemia.

iv) Inborn Errors of Metabolism - Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia.

v) Abnormalities in Nitrogen Metabolism - Uremia, hyperuricemia, porphyria and factors affecting nitrogen balance.

4. **Plant Biochemistry**

i) Photosynthesis - Light harvesting complexes; mechanisms of electron transport;

ii) Photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways.

iii) Nitrogen metabolism - Nitrate and ammonium assimilation.

iv) Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

v) Stress metabolism in plants - Environmental stresses, salinity, water stress, heat, chilling, anaerobiosis, pathogenesis, heavy metals, radiations and their impact on plant growth and metabolism, criteria of stress tolerance.

5. **Microbial Biochemistry**

i) Bacterial cell membrane - structural diversity including Archaea.

ii) Membrane transport in prokaryotes- group transport, binding protein transport.

iii) Fermentation- lactic acid, ethanolic, propionic acid, butanediol, mixed acids, amino acid.

iv) Biosynthesis - peptidoglycan, lipopolysaccharide, poly-p-hydroxybutyric acid.

v) Microbial photosynthesis (photoautotrophy)- light absorption, difference in photosynthetic pigments, oxygenic and anoxygenic photosynthesis.

vi) Alternative bacterial biochemical pathways- EntnerDoudoroff pathway, methylglyoxal pathway, reductive TCA cycle, hydroxypropionate pathway.

vii) Assimilation of organic C1 compounds - methanotrophy, methylotrophy.

Part 2- Advanced Molecular Biology [25 marks]

1. **Genome organization**: Organization of genomes in prokaryotes and eukaryotes, Chromatin organization and packaging; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; 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.

2. **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.

3. **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).

4. **Protein synthesis and processing**: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination,

genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNAsynthetase, translational proof-reading, translational inhibitors, post- translational modification of proteins (Emphasis on eukaryotic machinery).

5. **Molecular evolution**: Concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence, Speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution

BIOS 0791 (Practical corresponding to BIOS 0702) [50 marks; 4 credits]

BIOS 0792 (Practical corresponding to BIOS 0703) [50 marks; 4 credits]

PG SEMESTER – 2

BIOS 0801 (Theoretical) [50 marks; 4 credits]

Part 1- Advanced Microbiology [25 marks]

1. **Life cycle:** Entry, replication and egress of DNA and RNA viruses.
2. **Phage genetics**: Lytic and lysogenic cycles of bacteriophage; Virulent and Temperate phage, Prophage; Study of plaque morphology; mapping of phage chromosome by phage crosses.
3. **Transfer of genetic material and recombination in bacteria** molecular aspects of transformation, conjugation, transduction. Chromosome mapping by interrupted mating experiment.
4. **Bacterial photosynthesis, biogeochemical cycling of sulfur and nitrogen** (with special emphasis on nitrogen assimilation by free living and symbiotic bacteria and nif genes).
5. **Host pathogen interaction**: mechanism of microbial pathogenesis (bacteria and virus),genetics of pathogenicity and virulence.
6. **Antimicrobials**: types and mode of action.
7. **Bioremediation**: use of microbes for treating pollutants (hydrocarbons, oils, heavy metals).
8. **Microbes in commerce**: source, production process and uses of - vaccines (attenuated and live virus), antibiotics, biopolymers, biosensors, biopesticides and biofuels.
9. Use of microbes in genetic engineering.

Part 2- Immunology [25 marks]

1. **Introduction to Cellular and Molecular immunology**: Innate immune response, adaptive immune response, B and T cell activation, Complement pathway, Vaccine strategies.

2. **Advanced Immunological techniques:** FACS, Immunofluorescence, Immunoblotting, ELISA
3. **Transplantation Immunology**: Distribution, structure, function and genetic control of MHC, glycoproteins; HLA typing; Mechanisms of graft rejection; Basic concept of bone marrow transplantation; Foetus as an allograft and survival of foetus against maternal graft rejection mechanisms.
4. **Tumor Immunobiology**: 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.
5. **Immune deficiency disorders**: Concept of primary immune deficiency with reference to Di George syndrome, agammaglobuninemia and SCID; etiology, symptoms and treatment of AIDS.

BIOS 0802 (Theoretical) [50 marks; 4 credits]

Part 1-Advanced Genetics [30 marks]

1. Model systems in genetic analysis: *E. coli*, *Neurosporacrassa*, yeast, Arabidopsis, Maize, Drosophila, *C. elegans*, Zebra fish.
2. Quantitative Genetics: Multilocus control; QTL analysis; Quantitative inheritance in plants and human.
3. Population Genetics: Hardy- Weinberg equilibrium and assumptions; Extension to Multiple allele and Sex-linked allele; Variables of Hardy – Weinberg equilibrium – Mutation, Migration, Small population size, Natural selection.
4. Regulation of Gene expression in bacteria and Bacteriophages: Operon in bacteria (lac, trp, ara).
5. Regulation Gene expression in eukaryotes: Gene rearrangement (Ig gene ; Yeast mating type; Trypanosome VSG gene); Chromatin remodeling. Gene silencing (Telomere, DNA methylation, Genomic imprinting), Histone code; Epigenomics, mRNA translation control, RNA interference (miRNA & siRNA).
6. Genetic analysis of Development: Sex determination and Dosage compensation in Mammals and Drosophila, Genetic regulation of Development of Drosophila Body plan, Role of miRNAs in development.

Part 2- Environmental Science [20 marks]

1. Basic concept of ecology and environment
2. Environmental pollutants and pollution: classification of pollutants and mechanism of action; source, effects and control measures of pollution- (Air, Water, Noise and Radiation)
3. Environmental toxicity: Concept of acute and chronic toxicity; Concept of dose response relationship (LDso, LCso, TL V); roots of entry of toxicants- mechanism and resistance; concepts of biomagnifications 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.

4. 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.
5. Environmental impact assessment: Environmental impact assessment (EIA) general guide lines for preparation of environmental impact statement (EIS)
6. Environmental biotechnology: concept and broad outlines of various aspects of biotechnology waste treatment, biofuel production, biofertilizer, concepts of integrated pest management and biopesticides.

BIOS 0803 (Theoretical) [50 marks; 4 credits]

Part 1-Emerging Trends in Life Sciences (25 marks)

1. **Nanotechnology**: Elementary concept of nanotechnology and its applications; cellular nanomachines; bio-inspired nanomaterials for a new generation of medicine; nanoscience in medicine, delivery system, and vaccine; nanoparticles in medical detection and diagnostics; synthesis of anyone inorganic or organic nanoparticles, characterization, and applications.
2. **Synthetic Biology**: Basic concepts of synthetic biology; concepts of synthetic genome, organelles, and minimal cell; metabolic engineering; bacterial drug factories; synthetic biology in clinic, and biosensor.
3. **Systems Biology**: Transcriptomics, proteomics, metabolomics, lipidomics, glycomics, and phosphoproteomics. High-throughput screening and sequencing (next-Gen).
4. **Quantitative Biology including various advanced PCR**.
5. **Personal Genomics, Computational biology, Structural biology**

Part 2-Homeostasis of Systems (25 marks)

1. **Neurobiology and Diseases:**

   Structure and function of nerve cells, Synapse and synaptic transmission, ion channels.

   Processing of neural signal in the sensory systems

   Diseases of Nervous System: Neurobiology of addiction, Autism Spectrum disorder (ASD), Viral encephalitis, Neurodegenerative disorders like Alzheimer's disease (AD) and Parkinson's disease (PD)

   Methods in Neurobiology: Single neuron recording, intracellular recording, extracellular recording, ECG, EEG, lesion and stimulation of brain, MRI, fMRI, PET, CAT, Morris water maze assay.

2. **Mammalian hormones and Plant Growth Regulators**-Endocrine glands, hormones, related disorders and diagnostics, growth regulation in plants.
3. **Gas exchange and associated diseases**-Normal physiology and adaptive responses, diagnostics procedures to pathologies.
4. **Transport of biomolecules in plants and mammals**-transport and uptake of biomolecules from soil, across membranes, from xylem and phloem. Mammalian circulatory system,

BIOS 0891 (Practical corresponding to BIOS 0801) [50 marks; 4 credits]

BIOS 0892 (Practical corresponding to BIOS 0802) [50 marks; 4 credits]

PG SEMESTER 3

BIOS 0901 General principles of research(Theoretical) [50 marks; 4 credits]

Part1: Research Bioethics and good laboratory practice (20 marks)

1. Introduction, Overview, and Research Misconduct, rules and regulations in India.
2. Data Management
3. Mentoring, mentor-mentee responsibilities
4. Authorship Guidelines, Publication and Peer Review
5. Intellectual property, plagiarism, patents
6. Collaboration
7. Reporting and representing research, representing images.
8. Bias, Conflicts of Interest
9. Ethical use of animal subjects
10. Protection of Human subjects
11. Stem Cell Ethics
12. The Ethics of Plant Use, transgenic crops
13. Agricultural Ethics
14. Ecosourcing-code of practice
15. Radioactive, chemical and biohazard safety, waste management and disposal
16. Social Responsibility and Whistleblowing

Part 2: Taxonomy, Biodiversity, evolution and ethology (20 marks)

1. Taxonomy:

i. Principles of phenetics and cladistics

ii. Character states and character state transition.

iii. Concept of cytotaxonomy and molecular taxonomy.

iv. Different methods of phylogenetic tree reconstruction (Cluster analysis, neighbor-joining method, bootstrap analysis, maximum parsimony, maximum likelyhood and Bayesian methods)

2. Biodiversity:

i. Importance of Biological interactions in the study of Biodiversity

ii. Major drivers of biodiversity changes

iii. Conservation strategies in the changing environment

3. Evolution:

i. Population as evolutionary unit with reference to Hardy-Weinberg law and factors affecting Hardy-Weinberg equilibrium.

ii. Evolution and tinkering.

iii. Punctuated equilibrium hypothesis.

iv. Concept of molecular clock and molecular drive.

4. Ethology:

i. Foraging behavior of animals with reference to cost and benefit analysis; Antipredator defences.

ii. Aggressive behavior – competition, territoriality and dominance hierarchy; Game theory and evolutionary stable strategy.

iii. Sexual selection; Fisher's runaway selection, handicap principle; Hamilton's rule

iv. Hormonal and genetic control of behavior with reference to role of androgen, prolactin

Part 3: Hands-on Bioinformatics (10 marks)

Sequence Alignment; Bioinformatics databases; Protein structure prediction; Protein-Protein Interactions; Visualization of three dimensional structure of biological macromolecules

BIOS 0902(A-H) (Theoretical Optional- choice any one from the following FRGs)

BIOS 0902A: (Theoretical) Research Frontiers in proteo-genomics [50 marks; 4 credits]

1. **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:** Chromatin modification and genome expression, DNA-protein interactions in gene expression, regulation of genome activity during development.
3. **Molecular technologies** – Genetic screening, molecular markers and molecular profiling, DNA fingerprinting, techniques for studying macromolecular interactions.
4. **Gene therapy -** Vectors for gene therapy, Embryonic stem cells and therapeutic cloning, Stem cells and translational medicine.
5. **Studying transcriptomes &proteomes** - Microarray, qPCR, ChIP, SAGE, 1 and 2 dimensional gel electrophoresis, multidimensional chromatography, biological mass spectrometry, etc.

BIOS 0902B: (Theoretical) 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 0902C: (Theoretical) Advanced macromolecular structure, function and dynamics [50 marks; 4 credits]

1. **Architecture of biological macromolecules:** structural motifs; understanding the association of structural motifs of macromolecules with conserved functions in the evolutionary hierarchy.
2. **Macromolecular assemblies:** Protein-ligand interactions; Membrane proteins: G-proteins GPCR, Chromatin nucleosome, Ribosome assemblies, secretion systems involved in pathogenesis.
3. **Structural analysis of macromolecules and their complexes.**
4. **Protein folding, mis-folding and aggregation:** Principles and correlation with diseases.

5. **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.

6. **Synthetic biology:** 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 0902 D: (Theoretical) 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. **Cell and molecular biology of neurodegenerative diseases:** Cellular neurobiology. Molecular basis of behavior including learning and memory.Molecular pathways to neurodegeneration. Pathogenesis of neurological disorders: Parkinson's disease, Alzheimer's disease, Huntington's disease, Amylotropic lateral sclerosis, Creutzfeldt-Jakob disease.
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 0902E: **(Theoretical) 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 0902F: (Theoretical) 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 0902G: (Theoretical) Ergonomics, Occupational Health Management, Clinical Nutrition and Emerging Diseases [50 Marks; 4 credits]

1. **Ergonomics and Occupational Health Management:**
   i. Application of different methods in the study of Ergonomics, use of biomechanics, EMG- ECG in ergonomics.
   ii. Cognitive ergonomics use and importance in assessing human efficiencies/ performance.
   iii. Role of ergonomics in sports, occupational health and safety management.
   iv. Biorhythm and shift work.
2. **Clinical Nutrition:**
   i. Studies on nutritional requirement in different stages / phases of human life
   ii. Knowledge on food sciences and importance of food technology in present day life.
   iii. Current research on nutritional genomics proteomics and metabolomics.
   iv. Therapeutic nutritional management strategies in diseases.
3. **Emerging and Neglected Diseases:**
   i. Global Burden of pathogenic diseases, Causes, prevention and diagnostics
   ii. Diseases of the current century-Obesity, Heart Disesase
   iii. Environmental toxicity study- Selection of methodology, assessment and interpretation of results, management strategies.

BIOS 0902H: (Theoretical) Advances in crop improvement [50 Marks; 4 credits]

1. **Plant Tissue Culture:**
   i) Medium composition and preparation.
   ii) Techniques in plant tissue culture.
   iii) Applications of tissue culture in plant improvement.

2. **Basics tools in Plant Biotechnology and Transgenics:**
   i) Genetic modifications in plants: tools and applications.
   ii) Issues related to genetically modified crops.
3. **Crop stress and productivity:**
   i) Different stresses: study of important pathways and genes.
   ii) Structural, functional and evolutionary analysis of stress induced biological macromolecules in crop plants.
   iii) Advances in crop improvement.
4. **Molecular Plant Breeding**
   i) Techniques - evolution of crop biotechnology from plant breeding to transgenics.
   ii) Utility of marker assisted selection (MAS) in crop improvement.

BIOS 0903: Journal club (at least three presentations) [50 marks; 4 credits]

BIOS 0991: Introduction and identification of research problem [50 marks; 4 credits]

BIOS 0992: Lab/ field work- standardization of protocols [50 marks; 4 credits]

PG SEMESTER-4

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

BIOS 1001: Project proposal for funding agency [50 marks; 4 credits]

BIOS 1002: Dissertation submission [50 marks; 4 credits]

BIOS 1003: Lab/ field work- methodology [50 marks; 4 credits]

BIOS 1091: Lab/ field work- interpretation and analysis of results [50 marks; 4 credits]

BIOS 1092: Dissertation presentation and interaction [50 marks; 4 credits]