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)
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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
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