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UNIVERSITY OF DELHI

MASTER OF SCIENCE (BIOPHYSICS)

(M.Sc. Biophysics)

(Proposed to be effective from Academic Year 2021-22)

PROGRAMME BROCHURE

Approved by

Committee of Courses: 16-Aug-2021

FIAS: 19-Aug-2021

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I. About the Department

1. Historical Background of Department

The Department of Biophysics was established in 1985. The department started functioning with one faculty member; Professor U.N. Singh, who joined the department in 1985. In absence of any infrastructure and laboratory facilities the department began research activities in Theoretical & Mathematical Biology. Later in 1988, Dr. SubhenduGhosh joined the department as a Lecturer followed by Dr. DinkarSahal (lecturer). While infrastructure & laboratory facilities started building up the department started working along with other small departments under the Faculty of Interdisciplinary & Applied Sciences (FIAS) by sharing equipment, space and participating in teaching. During this phase, the Department of Biophysics combined with the Department of Biochemistry & other departments in University of Delhi South Campus (UDSC) organized a series of talks by eminent invited speakers/ scientists, a number of symposia and workshops, e.g. National Symposium on Liposome Research, International Conference on Cell Surface Macromolecules, International Congress of Biochemistry & Molecular Biology (IUPMB), National Conference on Evolution of Life. The Department of Biophysics was part of the formation of Liposome Research Centre along with the Department of Biochemistry, UDSC. In 1990, Dr. Sudipto Das joined as a Reader and set up a sophisticated electrophysiology facility, e.g. patch-clamp & bilayer electrophysiology (BLM). In the due course of time Prof. U.N. Singh superannuated in 1995. Also, Dr. Sahal and Dr. Das left the department for other jobs/assignments. Dr. Madhusudan joined the department in 2005 as a professor and left after a year. After completing the tenure Prof. SubhenduGhosh has superannuated in 2020. At present there are two faculty members in the Department, Dr. ManishaGoel (Associate Professor) and Dr. Manish Kumar (Associate Professor).

The Department offers Ph.D. programme in Biophysics. It also actively participated in the M.Phil. (Biotechnology) programme, which was being run jointly by the Departments of Biophysics, Biochemistry, Microbiology and Genetics. The department has started M.Phil. Biophysics from the Academic Year 2018-19. The department offers research opportunities in the areas of structural biology and bioinformatics. The Department is equipped with electrophysiological set up (patch clamp and bilayer systems), which are the most sensitive tools to study such channels. The experimental work is supported by extensive mathematical and computational analysis, e.g. Mathematical modeling, Neural Network. The objective of structural biology work is to understand the structure-function-evolution relationship in proteins from various organisms, particularly extremophiles using various biophysical techniques like CD spectroscopy and X-ray crystallography. The department is also involved in research in the areas of metagenomics and molecular modeling. The thrust area of bioinformatics is genome and protein sequence analysis particularly in relation to function.

2. About the programme

Biophysics is a rare discipline, which bridges two major spheres of natural sciences, physical sciences (physics, chemistry, mathematics) and biological sciences, which have been kept separate for ages. However, it has been realized that these spheres of knowledge need to be connected, efforts have been made for the last hundred years in this direction and these have been found to complement each other immensely. Despite being a very popular branch of interdisciplinary science in the global scenario, in India it is mainly confined as a research activity in institutes and universities. There Are only a few places where post-graduate courses on Biophysics are being offered. Keeping this in view, the Department of Biophysics proposes to introduce a post-graduate course highlighting various applications of physical sciences to biology. The proposed course is referred asM.Sc. Biophysics henceforth.

3. About the process of course development involving various stakeholders at different stages.

The department of Biophysics has been trying to develop this course for quite some time. For this purpose the following steps were followed.

i. The faculty members had regular meetings to discuss the structure and contents of the course.
ii. The next step was to interact with students & teachers of the institutes/ universities where such programs are running, e.g. All India Institute of Medical Sciences (New Delhi), JamiaMilliaIslamia (New Delhi), Jawaharlal Nehru University (New Delhi), Calcutta University (Kolkata).
iii. The third step was to get opinions of experts from various institutions/ universities on the draft syllabus. Several experts in the field of Biophysics were requested to review the draft syllabus. Feedback was received from experts of Calcutta University & IIT Bombay. Their suggestions were incorporated in the revised syllabus.
iv. The fourth step was to discuss the revised draft syllabus in the Committee of Courses, which comprises 3 departmental faculty members, 3 Delhi University faculty members (outside the department) along with 2 subject experts from outside the Delhi University. Their suggestions were also incorporated in the syllabus.
v. The course thus prepared was uploaded on the departmental website and feedback was invited from various stakeholders. The syllabus was reviewed in light of the comments received and presented to the committee of courses again.
vi. The final draft of the syllabus as approved by the Committee of Courses (in the CBCS format) was submitted to the Faculty of Interdisciplinary and Applied Sciences for approval.

II. Introduction to CBCS (Choice Based Credit System)

1. Choice Based Credit System:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on a student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enables the potential employers in assessing the performance of the candidates.

2. Definitions:

i. ‘Academic Programme’ means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre

ii. ‘Course’ means a segment of a subject that is part of an Academic Programme

iii. ‘Programme Structure’ means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission

iv. ‘Core Course’ means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course

v. ‘Elective Course’ means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre

vi. ‘Open Elective’ means an elective course, which is available for students of all programmes, including students of the same department. Students of other departments will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

vii. ‘Credit’ means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course

viii. ‘SGPA’ means Semester Grade Point Average calculated for an individual semester.

ix. ‘CGPA’ is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

x. ‘Grand CGPA’ is calculated in the last year of the course by clubbing together the CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversion of Grand CGPA into %age marks is given in the Transcript.

III. Programme Details:

1. Programme Objectives (POs):

The main objective of the M.Sc. program in Biophysics is to give exposure and orientation of different aspects of biophysics to the students coming with a background of physical and biological sciences. During this process of orientation, the students will acquire the knowledge of the links between physical and biological sciences including Molecular Biology and Biological Physics. Also, adequate emphasis will be given to the applications of physics, chemistry, mathematics, statistics and computer science to biological sciences. On the whole, the students completing M.Sc. Biophysics should be able to understand the interface between physical science and biological sciences, apply knowledge of the former to the latter and design research and industrial projects. Detailed Course Objectives and Outcomes specific to each paper constituting the M.Sc. syllabus have been appended to the respective papers.

2. Programme Specific Outcomes (PSOs):

The students completing M.Sc. Biophysics should be able to apply the principles of physical sciences to understand and solve biological complexities. Using the knowledge gained during the course, students should be able to address the academic and industrial research problems.

3. Programme Structure:

The M.Sc. Biophysics Programme is a two-year course divided into four semesters. A student is required to complete 96 credits for the completion of course and the award of degree.

		Semester	**Semester**
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV

4. Course Credit Scheme

Semester	Core Courses			Elective Course			Open Elective Course			Total Credits
	No. of papers	**Credits (L+T/P)**	**Total Credits**	**No. of papers**	**Credits (L+T/P)**	**Total Credits**	**No. of papers**	**Credits (L+T/P)**	**Total Credits**	
I	4 T + 1P	16 L + 8P	24	0	0	0	0	0	0	24
II	3T + 1P	12 L + 8P	20	1	4L	4	0	0	0	24
III	3T + 1P	12 L + 8 P	20	1	4L	4	0	0	0	24
IV	1 T + 1 Pj	4 L + 16 P	20	0	0	0	1	4L	4	24
Total Credits for the Course			84			8			4	96

- For each Core Course and Elective Course, there will be 4 lecture hours of teaching per week.
- Open Electives to the maximum total of 4 credits.
- Duration of examination of each paper shall be 3 hours.
- Each paper will be of 100 marks out of which 70 marks shall be allocated for semester examination and 30 marks for internal assessment.
- In the above table, following abbreviations are used:

T = Theory paper

P = Practical paper

Pj = Dissertation /Project

5. Semester wise details of M.Sc. Biophysics Course

Semester I				
Number of core courses	**Credits in each core course**			
Course	**Theory**	**Practical**	**Tutorial**	**Credits**
BPCC101: Introductory Biology (for students with Physical Science background) OR **BPCC102:**Introductory Physics &Chemistry (for students with Biological Science background)	4	0	0	4
BPCC103: Mathematics and Statistics for Life Sciences	4	0	0	4
BPCC104: Concepts of Biochemistry	4	0	0	4
BPCC105: Computer Applications in Biology	4	0	0	4
BPCC106: Practicals-I (Based on BPCC104 and BPCC105)	0	8	0	8
Total credits in core courses	**24**			
Number of elective courses	**Credits in each elective course**			
Credits in each elective course	**Theory**	**Practical**	**Tutorial**	**Credits**
NIL				0
Total credits in elective courses	**0**			
Number of Open Electives	**Credits in each open elective**			
	Theory			**Credits**
NIL				0
Total credits in open elective	**0**			
Total credits in Semester I: 24				

Semester II				
Number of core courses	**Credits in each core course**			
Course	**Theory**	**Practical**	**Tutorial**	**Credits**
BPCC201: Molecular Biophysics	4	0	0	4
BPCC202: Physical Methods in Biology	4	0	0	4
GENCC204: RECOMBINANT DNA TECHNOLOGY(from Department of Genetics, University of Delhi South Campus)	4	0	0	4
BPCC203: Practicals-II (Based on Papers BPCC201, BPCC202, GENCC204)	0	8	0	8
Total credits in core course	**20**			
Number of elective courses	**Credits in each elective course**			
Credits in each elective course	**Theory**	**Practical**	**Tutorial**	**Credits**
BPEC201: Photo-Biophysics, Radiation & Environmental Biophysics	4	0	0	4
BPEC202: Programming and Data Analytics	4	0	0	4
Total credits in elective courses	**4**			
Number of Open Electives	**Credits in each open elective**			
	Theory			**Credits**
NIL	0			0
Total credits in open elective	**0**			
Total credits in Semester II: 24				

Semester III				
Number of core courses	**Credits in each core course**			
Course	**Theory**	**Practical**	**Tutorial**	**Credits**
BPCC301: Cellular Biophysics & Bioenergetics	4	0	0	4
BPCC302: Physiological Biophysics	4	0	0	4
MBCC301: Molecular Biology (from Department of Microbiology, University of Delhi South Campus)	4	0	0	4
BPCC303: Practicals-III (Based on BPCC301, BPCC302, MBCC303)	0	8	0	8
Total credits in core course	**20**			
Number of elective courses	**Credits in each Elective course**			
Credits in each elective course	**Theory**	**Practical**	**Tutorial**	**Credits**
BPEC301: Methods in High-throughput Biology	4	0	0	4
BCCC302: Developmental Biology (from Department of Biochemistry, University of Delhi South Campus)	4	0	0	4
Total credits in elective courses	**4**			
Number of Open Electives	**Credits in each open elective**			
	Theory			**Credits**
NIL	0			0
Total credits in open elective	**0**			
Total credits in Semester III: 24				

Semester IV				
Number of core courses	**Credits in each core course**			
Course	**Theory**	**Practical**	**Tutorial**	**Credits**
BPCC401: Membrane Biophysics and Neuro-Biophysics	4	0	0	4
BPCC402: Dissertation/ Project	0	16	0	16
Total credits in core course	**20**			
Number of elective courses	**Credits in each Elective course**			
Credits in each elective course	**Theory**	**Practical**	**Tutorial**	**Credits**
NIL	0	0	0	0
Total credits in elective courses	0			
Number of Open Electives	**Credits in each open elective**			
	Theory			Credits
BPOE401: Theoretical& Mathematical Biology	4			4
Total credits in open elective:	**4**			
Total credits in Semester IV: 24				

6. List of Elective Course

i. BPEC201: Photo-Biophysics, Radiation & Environmental Biophysics
ii. BPEC202: Programming and Data Analytics
iii. BPEC301: Methods in High-throughput Biology
iv. BCCC302: Developmental Biology

7. Selection of Elective Courses:

Core elective: Students are encouraged to opt for courses of their interest, both in second and third semester. However a core elective course will be offered only if the student strength is at least 1/3rd of the total seats of the programme.

Open elective: This course is open to all students of DU who are pursuing post-graduate degree in any subject under the faculty of sciences, mathematics or inter-disciplinary and applied sciences, who have studied mathematics at least up till 10+2 level.

M.Sc. (Biophysics) students are encouraged to choose any open elective among the options available in University of Delhi subject to fulfillment of eligibility criteria laid down by the department offering the course.

8. Teaching:

The faculty of the Department is primarily responsible for organizing lectures and practicals for M.Sc. Biophysics programme. Allotment of project and dissertation advisor will be done according to the interest of the student and his/her combined merit of 1st and 2nd semester, subject to the availability of seats with each faculty member. During project work, students are expected to interact with their supervisors on regular basis to seek advice to consistently enforce best standards of rigor and academic conduct that model the best practices in research and scholarship in their work discipline.

9. Eligibility for Admissions:

i. **Mode of Admission:** Entrance exam

ii. **Eligibility Criteria:** Bachelor's degree under 10+2+3 pattern of education in Physical, Biological, Agricultural, Veterinary and Fishery Sciences or equivalent, OR 4-years undergraduate degree of Pharmacy/Engineering/Technology, OR M.B.B.S./B.D.S. or equivalent with at least 55% marks.

iii. **Syllabus of Entrance Test:**

BIOLOGY

- ***General Biology***: Taxonomy; Heredity; Genetic variation; Conservation; Principles of ecology; Evolution; Techniques in modern biology.
- ***Biochemistry and Physiology***: Carbohydrates; Proteins; Lipids; Nucleic acids; Enzymes; Vitamins; Hormones; Metabolism - Glycolysis, TCA cycle, Oxidative Phosphoryation; Photosynthesis. Nitrogen Fixation, Fertilization and Osmoregulation; Vertebrates-Nervous system; Endocrine system; Vascular system; Immune system; Digestive system and Reproductive System.
- ***Basic Biotechnology*****:** Tissue culture; Application of enzymes; Antigen-antibody interaction; Antibody production; Diagnostic aids.
- ***Molecular Biology***: DNA; RNA; Replication; Transcription; Translation; Proteins; Lipids and Membranes; Operon model; Gene transfer.
- ***Cell Biology*****:** Cell cycle; Cytoskeletal elements; Mitochondria; Endoplasmic reticulum; Chloroplast; Golgi apparatus; Signaling.
- **Microbiology**: Isolation; Cultivation; Structural features of virus; Bacteria; Fungi; Protozoa; Pathogenic micro-organisms.

CHEMISTRY

Atomic Structure: Bohr's theory and other atomic models; Periodic Table & properties of elements; Chemical bonding; Properties of s, p, d and f block elements; Complex formation; Coordination compounds; Chemical equilibrium; Chemical thermodynamics; Chemical kinetics (zero, first, second and third order reactions); Photochemistry; Electrochemistry; Acid-base concepts; Stereochemistry of carbon compounds; Inductive, electromeric, conjugative effects and resonance; Chemistry of Functional Groups: Hydrocarbons, alkyl halides, alcohols, aldehydes, ketones, carboxylic acids, amines and their derivatives; Aromatic hydrocarbons, halides, nitro and amino compounds, phenols, diazonium salts, carboxylic and sulphonic acids; Mechanism of organic reactions; Soaps and detergents; Synthetic polymers; Biomolecules - amino acids, proteins, nucleic acids, lipids and carbohydrates (polysaccharides); Instrumental techniques - chromatography (TLC, HPLC), electrophoresis, UV-Vis, IR and NMR spectroscopy, mass spectrometry.

MATHEMATICS

Sets, Relations and Functions, Mathematical Induction, Logarithms, Complex numbers, Linear and Quadratic equations, Sequences and Series, Trigonometry, Cartesian System of Rectangular Coordinates, Straight lines and Family, Tangents &Normals, Circles, Conic Sections, Permutations and Combinations, Probability & Statistics, Binomial Theorem, Exponential and Logarithmic Series, Mathematical Logic, Three Dimensional Geometry, Vectors, Matrices and Determinants, Boolean Algebra, Functions, limits and Continuity, Differentiation, Application of Derivatives, Maxima & Minima, Definite and Indefinite Integrals, Ordinary & Partial Differential Equations.

PHYSICS

Physical World and Measurement, Elementary Statics and Dynamics, Kinematics, Newton's Laws of Motion, Work, Energy and Power, Heat & Thermodynamics, Entropy, Hamilton's & Lagrange's equations, Electrostatics, Current electricity, Magnetic Effects of Current and Magnetism, Electromagnetic Induction and Alternating Current, Principles of Communication, Motion of System of Particles and Rigid Body, Gravitation, Mechanics of Solids and Fluids, Heat and Thermodynamics, Kinetic Theory, Oscillations, Waves, Sound, Electromagnetic waves, Laws of Optics & applications, Planck's theory, photoelectric effect, Dual Nature of Matter and Radiations, Heisenberg's uncertainty principle, Schrödinger wave equation, Particle in a box & well, Hydrogen atom, Atomic Nucleus, Solids and Semiconductor Devices, radio-activity, Principles of Relativity, Distribution Laws & Statistical physics.

10.Assessment of Students' Performance and Scheme of Examinations:

1. English shall be the medium of instruction and examination.
2. Assessment of students' performance shall consist of:

   Theory Paper:
      a. Internal Assessment: 30%
      b. End Semester Exam: 70%

   Practical Paper:
      a. Internal Assessment: 30% (based on continuous evaluation of the work and lab records)
      b. End Semester Exam: 70% (viva-voce: 30% +practical examination 40%).

   Project work:
      a. Internal Assessment: 30% (based on continuous evaluation of the work and lab records, evaluated by the supervisor)
      b. End Semester Exam: 70% (final presentation:40% +dissertation: 30%). Evaluation during the end semester examination will be done by all teachers of the Department of Biophysics and external examiner(s).
3. Pass Percentage & Promotion Criteria (Part I to Part II Progression): A per university norms
4. Conversion of Marks into Grades: As per University rules
5. Grade Points: Grade point table as per University Examination rule

6. CGPA Calculation: As per University Examination rule.
7. SGPA Calculation:
8. Grand SGPA Calculation:
9. Conversion of Grand CGPA into Marks: As notified by competent authority the formula for conversion of Grand CGPA into marks is:Final %age of marks = CGPA based on all four semesters × 9.5
10. Division of Degree into Classes: Post Graduate degree to be classified based on CGPA obtained into various classes as notified into Examination policy.
11. Attendance Requirement: As per University rules
12. Span Period: No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of four years from the date of admission to the Part-I/Semester-I of the M.Sc. Biophysics Programme.
13. Guidelines for the Award of Internal Assessment Marks M.Sc. Biophysics Programme (Semester Wise)

Sr. No.	Mode of evaluation	Weightage
1.	Attendance (Lectures including Interactive Periods and Tutorials)	5%
2.	Written assignments / tutorials / project reports/ Class Test(s) / Quiz(s)	25%

IV. Course Wise Content Details for M.Sc. Biophysics Programme:

Master of Science (Biophysics)

Semester I

BPCC101: Introductory Biology

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- understand the physiological features that are common to all life forms
- elaborate upon the specific differences between variant life forms.
- appreciate the interplay of evolution and genetics on living systems.

COURSE OUTCOMES:

CO1: Should be able to appreciate the affect of evolution on generating genomic and phenotypic diversity
CO2: Should be able to understand the constituents and working of a cell as a whole
CO3: Should be able to enumerate the various cell organelles and their function
CO4: Should be able to describe various types of cell multiplications and divisions and differences between them
CO5: Should be able to enumerate the differences in cellular organization of various life forms
CO6: Should understand how evolution can be studied on genetic basis.

CONTENTS:

UNIT 1:
Origin of Life: Brief history & mechanism of evolution. Theories of evolution & inheritance

[4]

UNIT2:
Unity of Life: Definition and characteristic of life, conservation and genetic variation, genetic diversity and specification, molecular basis of living organisms, chemical organization of the cell, inorganic and organic constituents, micro and macromolecules in the cell.

[8]

UNIT 3:
Cellular Organization: Structures and functions of cell wall, plasma membrane, protoplasm and its colloidal nature, nucleus, chloroplast, mitochondria, endoplasmic reticulum, ribosomes, lysosomes, Golgi apparatus, centrioles, cilia, flagella and microtubules, microfilaments, intermediate filaments, cytoskeleton, cell shape and motility.

[10]

UNIT 4:

Cell cycles: Mitosis and meiosis, regulation, cellular excitability, cellular motility, cellular secretion, cellular immunity, cellular ageing and cell death, cellular respiration, cell permeability and endocytosis. Nucleo-cytoplasmic interactions, role of cell surface and microtubules.

[6]

UNIT 5:

Diversity of Life: Prokaryotic and Eukaryotic Cells, Introduction to micro-organisms like viruses, bacteria and protozoa, algae & fungi, their metabolism and genetic recombination.

{8]

(i) Plants: Plant diversification, Brief account of anatomical, embryological and morphological aspects. Life cycle of representative genera.

[8]

(ii) Animals: Diversification in animal kingdom, anatomical and embryological aspects, life cycle of representative genera, types of cells and their organization and function in tissues-muscle, epithelial, neuronal, skeletal, bone, adipose and blood, Organs and their functions – liver, kidney, heart, lung, brain, pancreas etc.

[8]

UNIT 6:

Concepts of Genetics: Mendel's Laws of Inheritance, Chromosome Theory of Inheritance, Gene Expression, Concepts of Linkage and Crossing Over, Gene Mapping, Organellar Genome, Sex- linked Inheritance, Determination of Sex, Chromosome Structure & Organization, Chromosomal Aberrations.

[8]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should be able to appreciate the affect of evolution on generating genomic and phenotypic diversity	Discussion on the various theories of evolution proposed and observations supporting them	MCQ type test.
2	Should be able to understand the constituents and working of a cell as a whole	Lectures	Short answer type test
3	Should be able to enumerate the various cell organelles and their function	Lectures + videos	Short presentation on each cell organelle (group activity)
4	Should be able to describe various	Lectures + videos	Short presentation (Group

	types of cell multiplications and divisions and differences between them		activity) on types of cell divisions
5	Should be able to enumerate the differences in cellular organization of various life forms	Lectures + Discussion	Short Presentation on various animal organ systems (individual activity)
6	Should understand how evolution can be studied on genetic basis.	Lectures + Discussion + Solving numerical aspects of genetics	MCQ type QUIZ including numericals

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Cell and Molecular Biology De By Robertis& De Robertis (Lippincott & Wilkins)
ii. Molecular Biology of the Cell By Alberts B et al. (Garland)
iii. Molecular Cell Biology By Lodish, H. et al. (Freeman)
iv. Concepts of Genetics Klug W. S. and Cummings M. R (Prentice-Hall)
v. Genetics-a Conceptual Approach Pierce B. A. (Freeman)
vi. Principles of Genetics Snustad D. P. and Simmons M. J. John (Wiley & Sons).
vii. Genes IX By Lewin B. (Pearson)

Master of Science (Biophysics)

Semester I

BPCC102: Introductory Physics & Chemistry

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should

- refresh knowledge of basic physics and chemistry
- appreciate how various laws of physics are applicable in our everyday life.
- apply physical principles in chemical reactions and physiological systems.

COURSE OUTCOMES:

CO1: Should be able to solve the statics & dynamics of rigid bodies.
CO2: Should understand storage & flow of energy and their applications.
CO3: Should be able to apply laws of electricity & magnetism.
CO4: Should be able to apply laws of optics.
CO5: Should understand physical basis of microscopic structure of matter and chemical interaction.
CO6: Should be able to understand physical basis of chemical bonding, ion conduction and the chemistry of organic molecules and apply those to biology.

CONTENTS:

UNIT 1:
Mechanics: Motion, Flow and forces, acceleration, law of motion, gravitation, projectile motion, circular motion, rotational dynamics, friction, fluid statics and dynamics.

[8]

UNIT 2:
Heat & Thermodynamics: Concept of temperature, laws of thermodynamics, enthalpy and thermo chemistry: exothermic and endothermic reactions, free energy, entropy, Gibb’s equation, kinetic theory of gases, elements of statistical physics: canonical and grand canonical ensembles, partition function, Maxwell-Boltzmann distribution of kinetic energy of molecules and related applications, chemical kinetics: rate and order of reactions, theory of kinetics.

[10]

UNIT 3:
Electricity &Magnetism: Charge and matter in the electric field, electric potential, Gauss’s law, capacitors and dielectrics, current, resistance and conductance, electromotive force and circuits, ohm’s law, magnetic field, Ampere’s law, Faraday’s law, inductance, magnetic properties of matter, electromagnetic oscillations, electromagnetic waves.

[8]

UNIT 4:

Optics: Nature and propagation of light, reflection, refraction, interference, diffraction, polarization, quantum theory of light.

[6]

UNIT 5:

Atomic & Molecular Physics: Electronic structure of atoms and molecules, quantum mechanical principles, , de Broglie’s concept, Heisenberg’s principles, Schrödinger's equation, particle in a box problem, quantization of angular and spin momenta, solution for hydrogenic atoms, Electronic conduction, semiconductors, p-n junctions, solid state devices.

[10]

UNIT 6:

Nature of Chemical Bonding: Atomic orbitals, electronic configuration of atoms, Concept & theories of valency: Valency Bond theory, hybridization of atomic orbitals, Molecular Orbital Theory, Bond order.

[6]

Electrochemistry: Electrolytic cells, Arrhenius theory of ionic conduction, electrolysis, ion atmosphere, ionic diffusion, electrochemicals, Donnan equilibrium, Nernst equation.

[4]

Organic Chemistry: Aliphatic, aromatic, heterocyclic compounds, isomeric compounds, addition reactions, electrophilic &nucleophylic substitutions and their mechanisms, stereochemistry, optical isomers, biologically relevant organic molecules.

[8]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should be able to solve the statics & dynamics of rigid bodies.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving
2	Should understand storage & flow of energy and their applications.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving
3	Should be able to apply laws of electricity & magnetism.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving +Short presentation (group activity)
4	Should be able to apply laws of optics.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving +Short presentation (group

			activity)
5	Should understand physical basis of chemical bonding, ion conduction and the chemistry of organic molecules & apply those to biology.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving +Short presentation (group activity)
6	Should be able toapply principles of ion conduction.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving +Short presentation (group activity)

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Introductory Physics, Building Understanding by Jerold Touger (Wiley)
ii. Physics in Biology and Medicine by Paul Davidovits (Academic Press)
iii. Introduction to Biological Physics for the Health and Life Sciences by Kirsten Franklin, Paul Muir, Terry Scott, Lara Wilcocks, Paul Yates
iv. Intermediate Physics for Medicine and Biology by Russell K Hobbie, Bradley J Roth (Springer)
v. Essentials of Chemical Biology: Structure and Dynamics of Biological Macromolecules by Andrew D. Miller, Julian Tanner (Wiley)
vi. An Introduction to Chemistry for Biology Students by George I. Sackheim (Pearson)

Master of Science (Biophysics)

Semester I

BPCC103: Mathematics and Statistics for Life Sciences

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- understand the application of mathematical models to understanding physiological systems.
- solve and interpret the meaning of various types of differential equations
- choose and apply most relevant mathematics and statistical models to a given set of experimental data.

COURSE OUTCOMES:

CO1: Students should be able to refresh knowledge of simple mathematics, which they have learned at the school level.

CO2: Students will be able to solve problems related to vector & linear equations.

CO3: Students will be able to apply advanced calculus to dynamical systems including biological systems.

CO4: Students will be able to apply knowledge of probability & statistical methods

CO5: Students will be able to correlate mathematical & computational methods and apply to natural (biological) problems like time series, network analyses.

CONTENTS:

UNIT 1:

Refreshing Basic Mathematics: Algebra, e.g. equations, matrices, determinants, number systems, series summations, etc., Geometry, Co-ordinate Geometry, e.g. straight lines, circles, conic section, etc, Calculus, e.g. functions, limits, derivatives etc., Taylor and McLaurin series expansion.

[4]

UNIT 2:

Vectors: Vector algebra and vector calculus; concept of gradient, divergence, curl and laplacian operators.

[2]

Linear Algebra: Vector space, linear independence, basis and dimension, linear transformations, inner product, orthogonality, Fourier series and transform

[3]

UNIT 3:

Application of Derivatives and Dynamical System: Stability and derivatives, the logistic dynamical system, optimization, approximating functions, Newton's method.

[7]

Differential Equations, Integrals & Applications: Linear differential equations and autonomous differential equations, methods of solutions and applications.

[6]

Introduction of Dynamical Systems: Biology and Dynamics: basic examples, functions describing growth and finding solutions, expressing solutions of population growth, power-law functions, modelling and graphical analysis of functions, linear & non-linear systems.

[8]

UNIT 4:

Probability Theory & Descriptive Statistics: Introduction to Probabilistic Models, Stochastic Models of Diffusion and other Biological Applications, Markov chains with Biological Applications.

[8]

Probability Models: Applications of the Binomial and Poisson Distribution, Applying the Normal Distribution to Biology, Monte-Carlo Methods.

[6]

Statistical Reasoning: Estimating Parameters, Confidence Limits, Estimating the Mean, Hypothesis testing, Comparing Experiments.

[8]

UNIT 5:

Discrete Mathematics: Fast Fourier Transformation and Applications, Graphs& Networking with Biological Applications.

[8]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Students will be able to refresh simple mathematics knowledge, which they have learned at the school level.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving
2	Students will be able to solve problems related to vector and linear equations.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving
3	Students will be able to apply advanced calculus to dynamical systems including biological systems.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving+Short presentation (group activity)
4	Students will be able to apply knowledge of probability & statistical methods	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving+Short presentation (group activity)

5	Students will be able to correlate mathematical & computational methods and apply to natural (biological) problems like time series, network analyses	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving+Short presentation (group activity)

SUGGESTED READING:

Latest editions of following books are recommended:

i. E. Kreyszig, Advanced engineering mathematics, 10th ed. Hoboken, NJ: John Wiley, 2011.

ii. G. B. Arfken, Mathematical methods for physicists: a comprehensive guide, 7th ed. Amsterdam ; Boston: Elsevier, 2013.

iii. J. B. Fraleigh, A first course in abstract algebra, 7th ed. Boston: Addison-Wesley, 2003.

iv. D. C. Lay, Linear algebra and its applications, 4th ed. Boston: Addison-Wesley, 2012.

v. B.Rosner, Fundamentals of biostatistics,7thed. Boston: Brooks/Cole, Cengage Learning, 20

Master of Science (Biophysics)

Semester I

BPCC104: Concepts of Biochemistry

Marks:100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- understand the various biochemical pathways involved in propagation of life.
- understand the working of enzymes as biocatalysts.
- understand the components involved in generating immunity in living systems.

COURSE OUTCOMES:

CO1: Should be able to appreciate the chemical composition of living cells

CO2: Should be able to understand the macromolecular constituents and their function in the living cells

CO3: Should be able to understand how macromolecules are synthesized and degraded

CO4: Should be able to describe various metabolic pathways enumerated so far in living systems

CO5: Should be understand the basic principles of the immune system

CONTENTS:

UNIT 1:

Introduction: Composition of living matter, comparison of bacterial animal and plant cells, concepts of acids, bases, pH and buffers, Water & its role in life.

[6]

UNIT 2:

Function of biological macromolecules: Concept of proteins structure and function, Nucleic Acids as genetic information carriers, metabolic activities and functions of carbohydrates and Lipids, Enzyme as bio-catalysts (classification, specificity, activity units, isozymes), Enzyme Kinetics (Michaelis-Menten equation determination of kinetic parameters), multistep reaction and rate limiting steps, enzyme inhibitions, principles of allosterism.

[12]

UNIT 3:

Cell Metabolism: Catabolic principles and break down of carbohydrates, lipids and proteins (schematics). Biosynthesis of macromolecules (schematics).Hormonal regulation of metabolism. Vitamins and their role as co-enzymes.

[12]

UNIT 4:

Metabolic Pathways: Glucose and glycogen metabolism, Citric acid cycle, photosynthesis, lipid metabolic pathways, amino acid metabolism, nucleotide metabolism

[22]

UNIT 5:

Immune system: Basic principles; Different types of immunoglobulins and antigens; Antigen-antibody interactions; complements, mechanism of generation of diverse antibodies in the same host, synthesis of antibodies; major disorders of the immune system, auto-immune diseases.

[8]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should be able to appreciate the chemical composition of living cells	Lectures + Videos	MCQ type test.
2	Should be able to understand the macromolecular functions of the living cells	Lectures + Videos	Short Test on Enzyme Kinetics
3	Should be able to understand how macromolecules are synthesized and degraded	Lectures	Short presentation on biosynthesis pathways using databases such as KEGG (group activity)
4	Should be able to describe various metabolic pathways enumerated so far in living systems	Lectures + Videos	Short presentation on biochemical pathways as described in databases such as BioCyc (group activity)
5	Should be understand the basic principles of the immune system	Lectures	MCQ type test.

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Textbook of Biochemistry with Clinical Correlations By Thomas M. Devlin (Wiley)
ii. Biochemistry By Jeremy M. Berg, John L. Tymoczko&LubertStryer (W.H. Freeman)
iii. Lehninger Principles of Biochemistry, David Lee Nelson, Michael M. Cox. (W.H. Freeman)
iv. Principles of Biochemistry by DonaldVoet, Charl, Judith G. Voet – (Wiley)

v. Molecular Cell Biology by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Angelika Amon, Matthew P. Scott, (W.H. Freeman),

Master of Science (Biophysics)

Semester III

BPCC105: Computer Applications in Biology

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- find and access relevant information from variety of available databases
- apply various algorithms to predict the structure and function of biological macromolecules .
- use the information gathered to generate a hypothesis on the sequence-structure-function-evolution relationship of macromolecules in biological systems.

COURSE OUTCOMES:

CO1: Should be able to know different molecular biology databases and formats in which data is stored.

CO2: Should be able to understand the concept of different forms of sequence alignment methods and selection of appropriate alignment method

CO3: Knowledge of the mechanisms of molecular evolution. Will be able to draw phylogenetic inference and will be able to reconstruct phylogenetic trees based on several molecular markers, applying the State-of-the-Art bioinformatics tools

CO4: Describe features that can be annotated on a DNA sequence of interest. Interpret sequence analysis results and what functional regions mean biologically

CO5: Extract information relevant to a protein structure of interest from difference structure databases e.g. PDB.

CO6: Appreciate different levels and organization of protein structures and their prediction

CO7: Describe and discuss the relationship between the structure and function of proteins

CONTENTS:

UNIT 1:

Biological Databases: Introduction; Types of databases in terms of biological information content; Protein and gene information resources;Specialized genomic resources; Different formats of molecular biology data.

[4]

UNIT 2:

Sequence Alignment: Global and local alignment; Methods and algorithms of pairwise and multiple sequence alignment; Alignment scoring matrices; Database similarity searching; Different approaches of motif detection; Concept and use of protein families.

[4]

UNIT 3:

Molecular Phylogenetics: Concept of orthology, paralogy and homology in gene and protein sequences. Methods and tools for phylogenetic analysis; Creation, evaluation and interpretation of evolutionary trees; Advantages and disadvantages of phenetic and cladistic approaches.

[8]

UNIT 4:

Genomics and Gene Annotation: Organization and structure of prokaryotic and eukaryotic genomes; Genome annotation and databases; Automated *in-silico* methods of finding gene and relevant features.

[10]

UNIT 5:

Protein Structure Databases and Visualization: Understanding structures from Protein Data Bank (PDB); Accessing and mining other protein structure classification databases such as SCOP, CATH; Tools for viewing and interpreting macromolecular structures e.gDeepView, PyMol.

[12]

UNIT 6:

Protein Structure Prediction and Comparison:*Ab-initio* and homology based methods, Algorithms and programs for superimposition of protein structures; RMSD calculations, multiple structure alignment; Flexible structural alignment;Concept and methods of homology modeling, threading and fold recognition; Concept and available methods for *ab-initio* protein structure prediction.

[12]

UNIT 7:

Inferring Function from Protein Structure: Using evolutionary information; Gene neighbor-hood; Phylogenetic profiles; Gene fusion; Catalytic templates; Prediction and analysis of binding cavities for function prediction. How new fold and functions evolve- convergent and divergent evolution.

[10]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should be able to know different molecular biology databases and formats in which data is stored.	Comparison of details available in different biological data resources.	Short presentation on differences among different databases
2	Should be able to understand the concept of different forms of sequence alignment methods and	Making alignment of two sequences	MCQ type

	selection of appropriate alignment method		
3	Knowledge of the mechanisms of molecular evolution. Will be able to draw phylogenetic inference and will be able to reconstruct phylogenetic trees based on several molecular markers, applying the State-of-the-Art bioinformatics tools	Lectures + videos	Short presentation on each cell organelle (group activity)
4	Describe features that can be annotated on a DNA sequence of interest. Interpret sequence analysis results and what functional regions mean biologically	Lectures + videos	Short presentation (Group activity) on types of cell divisions
5	Extract information relevant to a protein structure of interestfrom difference structure databases e.g. PDB.	Lectures + Discussion	Short presentation (Group activity) on types of cell divisions
6	Appreciate different levels and organization of protein structures and their prediction	Discussion + hands-on	MCQ type QUIZ
7	Describe and discuss the relationship between the structure and function of proteins	Lectures + Discussion + hands-on	MCQ type QUIZ

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Introduction to Computational Biology: An Evolutionary Approach, By Haubold&Wiele, Springer International Edition.
ii. Introduction to Bioinformatics, A. Lesk. OUP- India. Essential Bioinformatics by Jin Xiong, Cambridge University Press.
iii. Statistical methods in Bioinformatics: An introduction by W. Ewens and G.R. Grant Springer-Verlag.
iv. Bioinformatics: Sequence and genome analysis, by David mount, 2nd edition. Cold Spring Harbor lab press.
v. Bioinformatics: A practical guide to the analysis of genes & proteins. Edited by Baxevanis&Outlette, John Wiley & sons, inc. publication.
vi. An Introduction to Protein Informatics by Karl-Heinz Zimmermann, Springer International Edition. Fundamental Concepts of Bioinformatics by Krane, Pearson Education.
vii. Discovering Genomics, Proteomics and Bioinformatics, 2nd ed. by Campbell Pearson Education.
viii. Structural bioinformatics: an algorithmic approach. F. J. Burkowski. Chapman & Hall/CRC, 2009.

ix. Structural Bioinformatics, 2nd Edition, Jenny Gu (Editor), Philip E. Bourne (Editor), Wiley-Blackwell.

Master of Science (Biophysics)

Semester I

BPCC106:Practicals - I

Marks: 200 **Duration: 240 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- verify the knowledge acquired in the theory classes through experiments.
- apply the theory learnt to the practical problems

COURSE OUTCOMES:

CO1: Should be able to independently handle scientific equipment used in experiments

CO2: Should be able to design adequate positive and negative controls relevant to the experiment.

CO3: Should be able to analyze data and explain the findings

CONTENTS:

1. Protein Sequence analysis
    a. Sequence search using tools such as BLAST.
    b. To make and analyse an alignment (CLUSTALW) and a phylogenetic tree (MEGA).
2. Protein Structure analysis
    a. To visualize protein structure using visualizing programs like DEEPVIEW, PyMOL
    b. Prediction of protein structure through homology modeling (SWISS-MODEL)
3. To study evolution of a protein family using structural databases like SCOP/CATH
4. To predict function of protein given it's structure (ProKnow, ProFunc)
5. Enzyme Kinetics (ex LDH - Lactate dehydrogenase)
6. Computer simulation of chemical/biological structures
7. Potentiometric/Conductometric titration
8. Viscosity andsurfacetension measurements

Master of Science (Biophysics)

Semester II

BPCC201: Molecular Biophysics

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- understand the chemical structure of various macromolecules involved in propagation of life.
- comprehend the influence of macromolecular three dimensional structure on their function.
- appreciate the relevance of physics e.g. thermodynamics, kinetics and cooperatively, to the function of biological macromolecules.

COURSE OUTCOMES:

CO1: Should be able to appreciate the effect of various forces in shaping the molecular conformation

CO2: Should be able to correlate the biomolecular structure to its specific functions

CO3: Should be able to comprehend the role of biomolecular conformation to function.

CO4: Should know the role and importance of rarer biomolecules

CO5: Should be able to appreciate the effect of cooperatively in protein/enzyme function

CO6: Should understand non-equilibrium biological process through thermodynamic principles (non-equilibrium)

CONTENTS:

UNIT 1:

Nature of Chemical bonds: Forces responsible for molecular conformation, e.g. Hydrogen bonds, ionic/electrostatic interactions, van der waals interaction, hydrophobic interaction, stereo-chemical factors.

[6]

UNIT 2:

Macromolecular Structure

a) Protein Structure: Amino acids, peptide bond, primary, secondary, tertiary and quaternary structure of proteins, motifs and folds, super-secondary structures.

b) Nucleic acid Structure: nucleosides and nucleotides, RNA structure, DNA structure and conformation, polymorphism of DNA, protein-DNA and Drug-DNA interaction

c)Other Biological Polymers: polysaccharides, associations formed among different macromolecular types, protein lipid interactions, nucleoproteins, membrane proteins.

[18]

UNIT 3:

Macromolecular Conformation

a) Defining Conformation: Parameters defining conformation of a macromolecular chain, strategies for calculating the probable conformational status of a macromolecule, Computer simulation of macromolecular conformation, membrane protein conformation.

[8]

b) Supercoiling of bio-macromolecules: Linking, twisting and writhing, topoisomerases, relevance of supercoiled DNA in biology.

[6]

UNIT 4:

Special Bio-Macromolecules: Metalloproteins, nucleoproteins, ribozymes, chaperons & prions.

[8]

UNIT 5:

Cooperativity in bio-macromolecular interactions: the phenomenon of cooperativity, DNA and protein melting, allosteric enzymes

[6]

UNIT 6:

Non-equilibrium Thermodynamics in Biology: Information and Entropy, Non-equilibrium Processes, Coupling of Fluxes, Coupling of Chemical Reactions, far-from-Equilibrium Molecular Processes.

[8]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should be able to appreciate the effect of various forces in shaping the molecular conformation	Lectures	MCQ type test.
2	Should be able to correlate the biomolecular structure to it's specific functions	Lectures	Short answer type test
3	Should be able to comprehend the role of biomolecular conformation to function.	Lectures + videos	MCQ type test.
4	Should know the role and importance of rarer biomolecules	Lectures + videos	Short presentation (Group activity) on function of the molecules from published reviews
5	Should be able to appreciate the effect of cooperatively in	Lectures	MCQ type QUIZ

	protein/enzyme function		
6	Should understand non-equilibrium biological process through thermodynamic principles (non-equilibrium)	Lectures	MCQ type QUIZ

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Biophysics - An Introduction by Rodney Cotterill (Wiley)
ii. Molecular Biophysics: Structures and Dynamics by Michel Daune (Oxford Univ. Press)
iii. The Biophysical Chemistry of Nucleic Acids & Proteins by Thomas E. Creighton (Helvetica Press)
iv. The Physical and Chemical Basis of Molecular Biology by Thomas E. Creighton (Helvetica Press)
v. Molecular Biophysics by MV Volkenstein (Academic press)
vi. Biophysics by W.HoppeW. Lohmann, H. Markl, H. Ziegler (Springer)

Master of Science (Biophysics)

Semester II

BPCC202: Physical Methods in Biology

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- understand the physical principles behind the various techniques available for interrogating biological macromolecules.
- know how to correctly interpret the results obtained from such studies.
- choose and apply the most relevant biophysical technique for characterizing the dynamic behavior of a macromolecule, especially proteins.

COURSE OUTCOMES:

CO1: Should be able to analyze and interpret data from various spectroscopic techniques

CO2: Should be able to understand the important aspects of the macromolecular structures

CO3: Should be able to understand how hydrodynamic methods can be used for differentiating biological macromolecules

CO4: Should be able to describe how various chromatographic methods can be used to separate various macromolecules

CO5: Should be able to correctly interpret the migration of macromolecules during electrophoresis.

CO6: Should be clear about the necessity to use radioactive methods and calculations involved

CO7: Should be able to comprehend the utility of different types of microscopy

CONTENTS:

UNIT 1:

Spectroscopy

a) UV & Visible absorption spectrophotometry: Lambert Beer's Law, molar extinction coefficient and its determination, instrumentation & applications

[8]

b) Fluorescence Spectroscopy: principles and applications, Polarization of light, Fluorescence studies of plane-polarized light.

[6]

c) Other common spectroscopic techniques: Principles, use and interpretation of Optical Rotatory Dispersion (ORD), Circular Dichroism (CD).

[4]

UNIT 2:

Macromolecular Structure Determination

a) Introduction to X-ray Crystallography: basis of crystallography theory, symmetry, instrumentation and biological applications, macromolecular diffraction and methods of phase determination.

[6]

b) Principles of magnetic resonance spectroscopy: Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR) and biological applications, Relaxation studies.

[6]

UNIT 3:

Hydrodynamic Methods: Viscosity, Sedimentation equilibrium and Velocity Centrifugation, Density Gradient method, applications to bio-macromolecules and bio-materials.

[6]

UNIT4:

Chromatography: Partition and Adsorption Chromatography, paper and thin layer chromatography, gel filtration, ion-exchange and affinity chromatography. GLC, HPLC and FPLC. Emerging trends in chromatography.

[6]

UNIT 5:

Electrophoresis: Behavior of bio-macromolecules in electric fields, Types of electrophoresis, PAGE, Agarose Gel Electrophoresis, 2D Electrophoresis, Dielectrophoresis.

[4]

UNIT 6:

Radioactive methods: Radioactive isotopes, nature of radioactive decay, sample preparation and counting, G.M. and Scintillation counters, Precautions in radio isotope handling, Autoradiography and its biological applications.

[4]

UNIT 7:

Microscopy: Optical Microscope, Fluorescent Microscope, Confocal Microscope, Electron Microscope, Applications of each microscopic method.

[6]

Emerging topics in Biophysical methods

[4]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**

1	Should be able to analyze and interpret data from various spectroscopic techniques	Lectures + Videos	Critical Interpretation of spectroscopic data published in research papers
2	Should be able to understand the important aspects of the macromolecular structures	Lectures + Videos	Short presentation of the structural aspects of a given macromolecular model e.g. from PDB (individual activity)
3	Should be able to understand how hydrodynamic methods can be used for differentiating biological macromolecules	Lectures	Short MCQ type test
4	Should be able to describe how various chromatographic methods can be used to separate various macromolecules	Lectures + Videos	Design a purification protocol for a given target protein (group activity)
5.	Should be able to correctly interpret the migration of macromolecules during electrophoresis.	Lectures	Critical interpretation of electrophoretic data published in research papers (group activity)
6	Should be clear about the necessity to use radioactive methods and calculations involved	Lectures	MCQ type test
7.	Should be able to comprehend the utility of different types of microscopy	Lectures	Critical interpretation of microscopy data published in research papers (group activity)

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Fundamentals of Molecular Spectroscopy by Colin Banwell (McGraw Hill
ii. Principles of Fluorescence Spectroscopy by Lakowicz, Joseph R. (Springer)
iii. Molecular Fluorescence: Principles and Applications by Bernard Valeur, Mario NunoBerberan-Santos (Wiley)
iv. Handbook of Fluorescence Spectroscopy and Imaging: From Single Molecules to Ensembles by Prof. Dr. Markus Sauer, Prof. Dr. Johan Hofkens, Dr. JörgEnderlein,
v. Biomolecular NMR Spectroscopy, by Jeremy N. S. Evans, (OUP Oxford)
vi. NMR – Conformation of Biological Molecules by Govil G. &Hosur R. V. (Springer- Verlag).
vii. Modern Optical Spectroscopy: With Exercises and Examples from Biophysics and Biochemistry by William W. Parson (Springer)

viii. Electrospray and MALDI Mass Spectrometry: Fundamentals, Instrumentation, Practicalities, and Biological Applications, by Richard B. Cole (Editor), Wiley-Blackwell; 2nd Edition
ix. Physical biochemistry by Friefelder D. (W.H. Freeman & Co).
x. Biomolecular crystallography: Principles, practice and application to structural biology by Bernhard Rupp (Garland Science).
xi. Optical methods in Biology by Slayter E.M. (John Wiley)
xii. Protein crystallography by Blundell T. L. and Johnson L.N. (Academic Press).
xiii. NMR of proteins and nucleic Acids by Wuthrich K. (Wiley Interscience Publications).
xiv. Biological Spectroscopy by Iain D. Campbell, Raymond A. Dwek

Master of Science (Biophysics)

Semester I

GENCC204: RECOMBINANT DNA TECHNOLOGY

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

Recombinant DNA technology is a set of molecular techniques for location, isolation, alteration and study of DNA segments or genes. Commonly called genetic engineering it encompasses ways to analyze, alter and recombine virtually any DNA sequences. Parting away from the classical gene-phenotype relationship, this technology provides information through direct reading of the nucleotide and/or protein sequences. This paper provides the details of the various techniques and tools used as well as their application in the generation of commercial products of myriad usage (Biotechnology). Looking at the vast implications, topics on Bioethics and Biosafety, implicit in such a technology will also be covered.

COURSE LEARNING OUTCOMES:

CO1: To understand methods to analyze DNA/RNA/proteins be contemporary genetic engineering techniques

CO2: Students would have learnt the basics of gene cloning, construction of various libraries and gene identification.

CO3: To understand the gene expression analysis by PCR -, Hybridization-, and Sequencing- based techniques.

CO4: Familiarize them with the various techniques to engineer and express recombinant proteins, for studying the dynamics of protein- protein and protein-DNA interaction and proteome analysis

CO5: To appreciate the importance and application of recombinant DNA technology in biology.

CONTENTS:

Unit I

Methods of DNA, RNA and protein analysis:

[8]

Electrophoretic techniques – agarose and polyacrylamide gel electrophoresis, native-, SDS-, and 2-D PAGE; Blotting techniques - Southern, northern, and western blots; Preparation of probes; RFLP analysis, DNA fingerprinting and its application

Unit II

Gene cloning and identification

[18]

Basics of cloning: Restriction and DNA modifying enzymes; Isolation and purification of nucleic acids; cloning methods; Cloning vectors – plasmids, phages, lambda vectors, phagemids, cosmids, fosmids, PAC, BAC and YAC; Selection and screening of clones

Construction of DNA libraries

Genomic and cDNA libraries; Screening of genomic and expression libraries

Gene identification

Subtractive hybridization, chromosome walking and jumping

Genome sequencing

DNA sequencing by Maxam and Gilbert method, Sanger's method, whole genome shotgun sequencing, next generation sequencing; Genome annotation: an overview

Unit III

Expression Analysis [14]

Analysis of gene expression- Northern blotting, RT-PCR, EST analysis, Promoter analysis; Mapping transcriptional start sites, Transcriptome analysis – cDNA- and oligo arrays; Serial Analysis of Gene Expression (SAGE); Polymerase Chain Reaction (PCR)- Concept of PCR, various kinds of PCR, Real Time PCR, Ligation Chain Reaction; Applications of PCR

Unit IV :

[16]

Protein expression, engineering and interactions

Expression of recombinant proteins- Expression and tagging of recombinant proteins in E. coli, Other expression systems; Protein engineering- Insertion and deletion mutagenesis, site-directed mutagenesis; Proteome analysis - MALDI, protein arrays and their applications; Analysis of protein-DNA and Protein-protein interactions- Gel retardation assay, DNA footprinting, Yeast one- two- and three-hybrids assay; ChIP on chip assay; Split and reverse hybrids, Co-immuno precipitations; Phage display

Unit V [4]

Applications of recombinant DNA technology in biology and medicine

Gene editing technologies

Suggested readings:

.	Gene Cloning and DNA Analysis: An Introduction	Brown TA	Blackwell Publications
.	Gene Cloning and Manipulation	Howe C	Cambridge University Press
3.	Principles of Gene Manipulation and Genomics	Primrose SB &Twyman RM	Blackwell Publications
4.	Principles of Gene Manipulation	Primrose SB Twyman RM & Old RW	Wiley Blackwell
5	Molecular Cloning: A Laboratory Manual (3-	Sambrook J *et*	CSHL Press

.	Volume Set)	*al.*	
6.	Calculations for Molecular Biology and Biotechnology	Stephenson FH	Academic Press

Master of Science (Biophysics)

Semester II

BPEC201: Photo-Biophysics, Radiation & Environmental Biophysics

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- appreciate the role of light in the physiology of living organisms.
- understand the various kinds of radiations and their effect on living systems
- know the hazards posed by such radiations and the required precautions.

COURSE OUTCOMES:

CO1: Should understand the principles of interaction of light with organic molecules and their significance in the environment.

CO2: Should understand the biophysical principles of interaction of light with living systems and their significance in biosphere sustenance.

CO3: Should know various kinds of radiations in the environment and their sources.

CO4: Should know the effects of various radiations on living systems and how to prevent ill effects of radiation.

CO5: To understand the correlation of different environmental/ ecological parameters with living systems and their protection & sustenance.

CONTENTS:

UNIT I.

Photochemistry: Interaction of photons with chemical compounds, photosensitive chemicals, photo induced electronic transitions in organic molecules, quantum yield, photo induced chemical reactions in air (troposphere, stratosphere, other spheres, examples, reaction mechanisms and applications, Chemiluminescence.

[6]

UNIT 2.

Photosynthesis: The phenomenon and types, Chlorophyll molecules, Chloroplasts, Photochemical Systems, Electron Transport Processes, Vision, Molecular Mechanism of Photoreception, Bioluminescence, Bacteriorhodopsin.

[6]

UNIT 3.

Radiation in Environment:

(i) Ionizing & Non-Ionizing Radiations and their origins; Dose Measurement;

(ii) Nuclear Radiation: Nuclear structure & stability, Radio-Isotopes, Radioactive decay kinetics.

(iii) Electromagnetic Radiations and classification.

[14]

UNIT 4.

Radiation Biophysics:

(a) X-Ray: Effects on Bio-macromolecules.

(b) Gamma Radiation: Molecular Effects of Gamma Radiation, Radiation Chemistry of Water, Free Radicals, Effects on Biomolecules & Molecular Structures: Radiation Effects on Proteins, Radiation Effects on Nucleic Acids, Radiation Effects on Membranes. Effects on Cells and Organelles

(c) Ultraviolet Radiation: Effects on Bio-macromolecules & Molecular Structures, UV Radiation Effects on Proteins, Nucleic Acids, Cells and Organelles.

(d) **Alpha & Beta Radiations:** Effects on Cells and Organelles, human body.

(e) Radiation Hazards & Protection: Radiation Effects and Genetics. Methods to combat ionizing, non-ionizing and particle radiations, use of radiations in cancer & other diseases.

[20]

UNIT 5.

Environmental Biophysics: Introduction toEcosystem: Physical Environment, Geological Environment and Biosphere.

[4]

Ecosystem Analysis: Population Dynamics, Prey-Predator Models

[6]

Environmental Stress: Depletion of Oxygen Pressure with altitude, Pollutants and Ozone layer depletion, Toxicity and its effect on Bio-macromolecular Structure and Function, Physiological effects of environmental stress.

[4]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should understand the principles of interaction of light with organic molecules and their significance in the environment.	Lectures+Discussions+ Video/ Films	Quiz+ Short answer type test + Short presentations
2	Should understand the biophysical principles of interaction of light with living systems and their significance in biosphere sustenance.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test + Short presentations

3	Should know various kinds of radiations in the environment and their sources.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test + Short presentations
4	Should know the effects of various radiations on living systems and how to prevent ill effects of radiation.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test + Short presentations
5	To understand the correlation of different environmental /ecological parameters with living systems and their protection & sustenance.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test + Short presentations

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Nuclear Physics, Theory and Experiment by Roy R.R& Nigam B.P. (Wiley)
ii. Introductory Nuclear Physics by Halliday D, (John Wiley)
iii. Biological Effects of Radiation by Coggle J.E.. (Taylor & Francis).
iv. Molecular Theory of Radiation Biology by Chadwick K.H. &Leenbouts H.P. (Springer Verlag)
v. Introduction to Radiological Physics and Radiation Dosimetry by Atlik F.H. (John Wiley)
vi. An Introduction to Environmental Biophysics by Campbell, Gaylon S., Norman, John M. (Springer)

Master of Science (Biophysics)

Semester II

BPEC202: Programming and Data Analytics

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- analyze different types of high-throughput datasets
- construct analysis modules in statistical programming packages
- use different artificial intelligence and machine learning tools.

COURSE OUTCOMES:

CO1: Implement a simple program by writing the code, testing the code and debugging the program.

CO2: Apply R for inference from data

CO3: Use R-studio to write R scripts

CO4: Apply selected probability distributions to solve problems

CO5: Apply and evaluate different learning algorithms and model selection.

CONTENTS:

UNIT 1:

Basics of Programming: Introduction to Perl/C/Python, Flowcharting, Decision table, Algorithms, Structured programming concepts, Concept of data-structure, if-else loops and decision, Use and definition of sub-routines.

[16]

UNIT 2:

Introduction to R Language and Environment of Statistical Computing and Graphics: Introduction to R,Getting Started - R Console, Data types and Structures, Exploring and Visualizing Data, Programming Structures, Functions, and Data Relationships.

[8]

UNIT 3:

Introduction to R-studio: R-studio screen, Workspace tab,History tab, Defining and Setting Working directory, Making script in R-studio, Installing and saving packages, Plotting different type of graphs.

[6]

UNIT 4:

Probability Distribution: Random Variables and Probability Distributions, Inferential Statistics –Motivation and Single sample tests.

[8]

UNIT 5:

Machine Learning: Introduction to Machine Learning, Supervised Learning, Unsupervised Learning, Ordinary Least Squares Regression, Model Assessment and Selection, Support Vector Machines, Artificial Neural Networks, Ensemble Methods and Random Forests, Deep Learning, Association Rule Mining, Clustering Analysis of Data and Big Data, Association Rule Mining, Big Data, Clustering Analysis.

[22]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Implement a simple program by writing the code, testing the code and debugging the program.	Demonstration	Problem solving
2	Apply R for inference from data	Demonstration	Problem solving
3	Use R-studio to write R scripts	Demonstration	Problem solving
4	Apply selected probability distributions to solve problems	Demonstration	Problem solving
5	Apply and evaluate different learning algorithms and model selection.	Demonstration	Problem solving

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. R Programming for Data Science, by Roger D. Peng,lulu.com, ISBN-10: 1365056821

ii. https://leanpub.com/rprogramming

iii. http://dss.princeton.edu/training

iv. Using R for Introductory Statistics, by John Verzani, Chapman & Hall/CRC, Second Edition 2014,ISBN 1466590734

v. Advanced R, by Hadley Wickham, ISBN 9781466586963.

vi. R for Everyone: Advanced Analytics and Graphics Paperback – 2014Pearson Education India; 1 edition (2014)ISBN-10: 9332539243

Master of Science (Biophysics)

Semester II

BPCC203: Practicals - II

Marks: 200 **Duration: 240 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- Verify the knowledge acquired in the theory classes through experiments.
- Apply the theory learnt to the practical problems

COURSE OUTCOMES:

CO1: Should be able to independently handle scientific equipment used in experiments

CO2: Should be able to design adequate positive and negative controls relevant to the experiment.

CO3: Should be able to analyze data and explain the findings

CONTENTS:

1. Crystallization of lysozyme.
2. Estimation of protein concentration using spectroscopic methods.
3. Studying UV absorption spectra of DNA and protein, and effect of heat denaturation.
4. Studying secondary/tertiary structure of proteins through CD spectroscopy.
5. Studying interaction of dyes with DNA through fluorescence spectroscopy.
6. Characterization of live cells using microscope.
7. Studying dynamics of chlorophyllsI& II through absorption spectroscopy.
8. Effect of light on Vitamins A (retinol) through spectroscopic methods.
9. Protein purification (affinity chromatography) and SDS-PAGE

Master of Science (Biophysics)

Semester III

BPCC301: Cellular Biophysics and Bioenergetics

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- enumerate the various pathways controlling the cell viability and function
- understand the physical principles involved in cell function maintenance.
- understand the integration of principles of energetics to cellular systems.

COURSE OUTCOMES:

CO1: Should understand the structural organization &function of living cells.

CO2: Should understand the biophysical principles of cellular mechanism of sending messages.

CO3: Should understand the principles of healthy development of an embryo and its protection.

CO4: Should understand the biophysical principles of programmed cell death & their relevance in cancer.

CO5: Should be able to apply thermodynamics in cellular & biochemical processes.

CONTENTS:

UNIT 1.

The Dynamic Cell: Architecture and Life Cycle of Cells, Cells into Tissues

[6]

Cell Organization: Microscopy and Cell Architecture, Organelles of the Eukaryotic Cell.

[6]

Regulation of Eukaryotic Cell Cycle: Overview of the Cell Cycle and its Control, Biophysical Principles of Molecular Mechanisms for Regulating Mitotic Events, Cell-Cycle Control in Mammalian Cells, Checkpoints in Cell-Cycle Regulation.

[6]

UNIT 2.

Biophysics of Cell Signaling: Strategies of chemical signaling, Signaling mediated by intracellular receptors, Extracellular Signaling, Cell-Surface Receptors, G Protein–Coupled Receptors and Their Effectors, Phosphoinositol cycle, Role of Kinases, e.g. MAP Kinase Pathways, Second Messengers, Ca oscillations, Interaction and Regulation of Signaling Pathways, Molecular Mechanisms of Vesicular Traffic, From Plasma Membrane to Nucleus, bacterial and plant two-component signaling systems, Bacterial Chemotaxis and Modeling.

[6]

Biophysics of Excitable Cells: Electrical Activities of Cardiac and Neuronal cells, Glial cells.

[4]

UNIT 3.

Cell Differentiation and Developmental Biophysics: Cellular differentiation; localization of cytoplasmic determinants in egg; Molecular mechanism of cell differentiation: Role of morphogens, protein kinase C, cytoskeleton, extracellular matrix, etc.

[5]

UNIT 4.

Biophysics of Apoptosis: Relevance of Programmed Cell Death, Necrosis & Apoptosis, Mechanisms of Apoptosis, Role of beta Amyloid, Caspases and Mitochondrial proteins.

[6]

Cancer: Tumor Cells and the Onset of Cancer, Proto-Oncogenes and Tumor-Suppressor Genes, Oncogenic Mutations Affecting Cell Proliferation, Mutations Causing Loss of Cell-Cycle Control, Mutations Affecting Genome Stability.

[7]

UNIT 5.

Energy production in the cell: oxidation-reduction reactions, coupled reactions and group transfer.

[4]

Bio-Energetics: Gibb's Free Energy, Gibb's Law of Chemical Reactions; Entropy and enthalpy driven reactions, Biological Oxidation: Aerobic Oxidation and Photosynthesis, Oxidation of Glucose and Fatty Acids to CO_2; Structure and Properties of Mitochondria, Cytochrome c, Chemiosmotic Coupling, Electron Transport and Oxidative Phosphorylation, Photosynthetic Stages and Light-Absorbing Pigments, Molecular Analysis of Photosystems

[10]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should understand the structural organization &function of living cells	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ Short presentations
2	Should understand the biophysical principles of cellular mechanism of sending messages.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ Short presentations
3	Should understand the	Lectures+Discussions+	Quiz+Short answer type

	principles of healthy development of an embryo and its protection.	Video/ Films	test+ Short presentations
4	Should understand the biophysical principles of programmed cell death & their relevance in cancer.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ Short presentations
5	Should be able to apply thermodynamics in cellular & biochemical processes.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ Short presentations

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. New Era of Bioenergetics by YasuoMukohata, (Academic Press)
ii. Principles of Bioenergetics by Vladimir P. Skulachev, Alexander V. Bogachev, Felix O. Kasparinsky, (Springer Science & Business Media).
iii. Bioenergetics by David G. Nicholls, Stuart J. Ferguson (Academic Press)
iv. Computational cell biology by C.P. Fall (Springer, NY).
v. Essential Cell Biology by Bruce Alberts et al. (Garland Science)
vi. Advanced Bioenergetics and Biodynamics by M.Amin (Capital Publishing)
vii. Biophysical and Structural Aspects of Bioenergetics by MårtenWikström (Editor) (RSC Publishing)
viii. Chemical Biophysics by Daniel A Beard (Cambridge University Press, 2008)

3.

Master of Science (Biophysics)

Semester III

BPCC302: Physiological Biophysics

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- enumerate the various processes & mechanisms controlling the physiological viability and function
- understand the physical principles involved in physiological function of various organs and their sustenance.
- understand the integration of principles of physiological functioning & sustenance at the whole body level.

COURSE OUTCOMES

CO1: Should be able to design nutrition.
CO2: Should be able to understand blood related disorders and recommend precautions.
CO3: Should understand functioning of healthy muscles and diagnose muscle disorders.
CO4: Should understand the functioning of the heart and recommend its healthy maintenance.
CO5: Should be able to give recommendations for respiratory problems.
CO6: Should understand the biophysical principles of the functioning of the kidney and its maintenance.
CO7: Should understand the role of various hormones in animal & human bodies.

CONTENTS:

UNIT 1.

Digestion and Nutrition: Composition, function and regulation of salivary, gastric, pancreatic, bile and intestinal juices.

[8]

UNIT 2.

Biophysics of the circulatory system: Composition and function of blood and lymph; Blood pressure, capillary pressure, regulation of blood pressure, role of ionic balance; Blood groups and Rh factors, blood coagulation, structure and function of haemoglobin; Sickle-cell anemia, thalassemia and other disorders; Biophysical perspective of the above.

[10]

UNIT 3.

Biophysics of Muscle Function: Ultra-structural, chemical and physiological basis of skeletal muscle contraction; Molecular mechanisms in muscle contraction.

[8]

UNIT 4.

Biophysics of Heart: Structure, origin, conduction and regulation of heart beat; Cardiac cycle; Electrocardiogram; Disorders of the heart; Atherosclerosis, arrhythmias.

[8]

UNIT 5.

Biophysics of Respiration: Mechanisms and control of breathing; Transport of oxygen and carbon-di-oxide; Oxygen dissociation curves of haemoglobin and myoglobin, Bohr effect; Chloride shift; Human respiratory disorders.

[10]

UNIT 6.

Structure and Function of the kidney: Physiology of urine formation; Role of kidney in the regulation of water, salt and acid-base balance, renal disorders, remedies; Biophysical perspective of the above.

[8]

UNIT 7.

Integration and Control: The endocrine system, hormones and other signaling molecules, hypothalamus, pituitary, parathyroid, adrenal, pancreas and gonads; Other endocrine elements (pancreatic islets etc.); Local chemical mediators, prostaglandins; Consequences of endocrine malfunction; Biophysical perspective of the above.

[8]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should be able to design nutrition.	Lectures + Discussions+ Video/ Films	Quiz + Short answer type test+ Short presentations
2	Should be able to understand blood related disorders and recommend precautions.	Lectures + Discussions+ Video/ Films	Quiz + Short answer type test+ Short presentations
3	Should understand functioning of healthy muscles and diagnose muscle disorders.	Lectures + Discussions+ Video/ Films	Quiz + Short answer type test+ Short presentations
4	Should understand the functioningof the heart and recommend its healthy maintenance.	Lectures + Discussions+ Video/ Films	Quiz + Short answer type test + Short presentations
5	Should be able to give recommendations for respiratory problems.	Lectures + Discussions + Video/ Films	Quiz + Short answer type test+ Short presentations
6	Should understand the	Lectures + Discussions +	Quiz + Short answer type

	biophysical principles of the functioning of the kidney and its maintenance.	Video/ Films	test+ Short presentations
7	Should understand the role of various hormones in animal & human bodies.	Lectures + Discussions+ Video/ Films	Quiz + Short answer type test+ Short presentations

SUGGESTED READING:

Latest editions of following books are recommended:

i. Biophysics: A Physiological Approach by Professor Patrick F. Dillon (Author)
ii. Physiology, Biophysics, and Biomedical Engineering by Andrew W Wood (Taylor & Francis)
iii. Textbook of Medical Physiology by Arthur C. Guyton (Elsevier Saunders)
iv. Cell Physiology Source Book: Essentials of Membrane Biophysics edited by Nicholas Sperelakis (Academic Press)

Master of Science (Biophysics)

Semester I

MBCC301: Molecular Biology

Marks: 100 **Duration: 64Hrs.**

COURSE OBJECTIVES:

The purpose of this course is to introduce the student to the advanced concepts in molecular biology. Students will gain an understanding of molecular mechanisms of DNA replication, DNA repair, transcription, translation, and gene regulation in prokaryotic and eukaryotic organisms. The student will study the techniques and experiments used to understand these mechanisms.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student:

CO1: is able to describe structure of DNA and RNA, organization of eukaryotic genome

CO2: is able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, DNA repair, transcription

CO3: is able to explain concepts in DNA repair mechanisms, and recombination as a molecular biology tool

CO4:is able to explain various levels of gene regulation in both prokaryotic and eukaryotic organisms

CO5: is able to describe post-transcriptional processes, RNA editing, RNAi and miRNA

CO6: is able to describe translation mechanism in prokaryotes and eukaryotes, regulation of translation, and post-translational processing

CO7: is able to describe post-translational processes

CONTENTS:

Unit I:

The nature of Genetic material: The structure of DNA and RNA; melting of DNA, super-helicity, organization of microbial genomes, organization of eukaryotic genomes, chromatin arrangement, nucleosome formation.

[8]

Unit II:

DNA replication: Arrangement of replicons in a genome, various modes of replication, continuous, discontinuous synthesis, various replication enzymes, replication fork and priming, leading and lagging strand, elongation, termination, specific features of replication in prokaryotes and eukaryotes, action of topoisomerases, telomere maintenance and chromatin assembly, single stranded DNA replication, relationship between DNA replication and cell cycle, and DNA copy number maintenance.

[10]

Unit III:

Recombination and Repair of DNA: DNA repair and recombination, DNA mismatch repair, Double Strand Break repair, recombination as a molecular biology tool, CRISPR-Cas systems for editing, regulating and targeting genomes.

[8]

Unit IV:

Transcription: Transcription machinery of prokaryotes, various transcription enzymes and cofactors, initiation, elongation and termination, sigma factors, transcription machinery of eukaryotes, various forms of RNA polymerase and cofactors, initiation, elongation and termination, promoters, enhancers, silencers, activators, effect of chromatin structure, regulation of transcription.

[10]

Unit V:

Post-transcriptional processes: RNA processing, splicing, capping and polyadenylation, rRNA and tRNA processing, RNA Editing; RNAi and miRNAs, Antisense RNA, Post-transcriptional gene regulation.

[10]

Unit VI:

Translation: The genetic code and protein structure, Mechanisms of translation in prokaryotes, Mechanisms oftranslation in eukaryotes, initiation complex, ribosomes and tRNA, factors, elongation and termination, *in-vitro*translation systems, polycistronic/ monocistronic synthesis, Regulation of translation, RNA instability, inhibitors oftranslation, stringent response in bacteria.

[12]

Unit VII:

Post-translational processes: Protein modification, folding, chaperones, transportation; The Signal Hypothesis, protein degradation.

[6]

SUGGESTED READINGS:

1. Gene IX by Benjamin Lewin. Jones and Bartlett Publishers. 2007.
2. Molecular Biology by R.F. Weaver, 4thedition. McGraw Hill, USA. 2007.
3. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. 6th edition. Benjamin Cummings. 2007.
4. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 5th edition. Garland Science, New York and London. 2007.
5. Biochemistry by J.M. Berg, J.L. Tymoczko, L. Stryer. 5th edition. W.H. Freeman and Company, USA. 2008.
6. Current Protocols in Molecular Biology edited by: F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl. John Wiley and Sons, Inc. 2007.

Master of Science (Biophysics)

Semester III

BPEC301:Methods in High-throughput Biology

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- select appropriate platform for system-level understanding of a cellular phenomena
- critically assess the results of a high-throughput experiment.
- understand the merits/demerits of a analysis tool of employed to analyze the results

COURSE OUTCOMES:

CO1: Understanding of quantification and identification of proteins, their post-translational modifications and interactions from mass spectrometry data.

CO2: Should understand different methods of bio-molecular structure determination, reason behind different functions in a protein family.

CO3: Understanding of bio-molecular interactions and their role in modulation of biological processes.

CO4: Demonstrate knowledge of drug discovery, design and development.

CO5: Knowledge of commonly used technologies and bioinformatics principles for high-throughput genomics analysis.

CO6: Should evaluate and apply the appropriate experimental design in a given metabolomics research question (including sample processing, choice of methods and analytical strategies).

CO7: Know important biological databases and relevant statistics/ bioinformatics software tools to analyze microarray and NGS transcriptomics data.

CONTENTS:

UNIT 1:

Proteomics: Application of mass spectroscopy for protein quantification and identification; Finding post-translational events using proteomic tools, Structural and functional implications of post-translational modifications, Current developments and recent progress.

[8]

UNIT 2:

Structural Genomics: Aims and need,High throughput methods of structure determination;Inferring function from structure,Methods to detect positive selection in a gene and implications of functional divergence,Current developments.

[6]

UNIT 3:

Macromolecular Interactions: Prediction, analysis and comparison of different modes and types of macro-molecular interactions, Current developments.

[6]

UNIT 4:

High-throughput Drug Screening: Different methods of drug discovery; Different methods of target identification and validation;Quantitative structure-activity relationship and objectives and concept of QSAR;Ways of lead identification and optimization; *in-silico* prediction of ADMET properties for drug molecules; Current developments.

[5]

UNIT 5:

High Throughput Genomic Sequencing:Different methods of sequencing; Different file formats;Concepts of Metagenomics;Gene regulation and the ENCODE project;Need and use of personal genomics projects;Current developments.

[10]

UNIT 6:

Metabolomics: Introduction of different tools for metabolic profiling;Different tools used for metabolic data and database analysis e.g. KEGG, BioCyc, MetExplore and Cytoscape;Current developments.

[5]

UNIT 7:

Large Scale Gene Expression Analysis (Microarray, Transcriptomics): Data preprocessing and normalization,Significance testing and Gene filtering, Cluster Analysis and down-stream enrichment analysis,Identification of differential gene expression,Gene annotation and gene ontology analysis,Current developments.

[10]

UNIT 8:

Genome-wide Association Studies (GWAS): Introduction and need of GWAS;Study design at marker, gender and subject levels;various technologies for data generation, Progress and promises of GWAS;Current developments.

[10]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understanding of quantification and identification of proteins, their post-translational modifications and interactions from mass spectrometry data.	Lectures + Discussion	MCQ type QUIZ
2	Should understand different methods of bio-molecular structure	Lectures + Discussion	MCQ type QUIZ

	determination,reason behind different functions in a protein family.		
3	Understanding of bio-molecular interactions and their role in modulation of biological processes.	Lectures + videos	MCQ type QUIZ
4	Demonstrate knowledge of drug discovery, design and development	Lectures + videos	MCQ type QUIZ
5	Knowledge of commonly used technologies and bioinformatics principles for high-throughput genomics analysis	Lectures + Discussion	MCQ type QUIZ
6	Should evaluate and apply the appropriate experimental design in a given metabolomics research question (including sample processing, choice of methods and analytical strategies)	Discussion	MCQ type QUIZ
7	Know important biological databases and relevant statistics/ bioinformatics software tools to analyze microarray and NGS transcriptomics data	Discussion + hands-on	MCQ type QUIZ
8	Understand the general principles, assumptions and basic techniques used in genetic association studies(including quality control checks and association between genotype and phenotype)	Lectures + Discussion	MCQ type QUIZ

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Statistical methods in Bioinformatics: An introduction by W. Ewens and G.R. Grant Springer-Verlag
ii. An Introduction to Protein Informatics by Karl-Heinz Zimmermann, Springer International Edition. Fundamental Concepts of Bioinformatics by Krane, Pearson Education.
iii. Discovering Genomics, Proteomics and Bioinformatics, 2nd ed. by Campbell Pearson Education
iv. Structural Bioinformatics, 2nd Edition, Jenny Gu (Editor), Philip E. Bourne (Editor), Wiley-Blackwell
v. Microarray Bioinformatics by DovStekel, (Cambridge University Press)
vi. Current Protocols In Molecular Biology by George W.Bell, Fran lewitters
vii. Computational and Statistical Methods for Protein Quantification by Mass Spectrometry by Ingvar Eidhammer, HaraldBarsnes, GeirEgilEide and Lennart Martens (John Wiley &Sons)

viii. Statistical Analysis Principles for Omics Data. Methods in Molecular Biology by Dunkler D, Sánchez-Cabo F, Heinze G. Totowa, NJ (Humana Press)

Master of Science (Biophysics)

Semester III

BCCC302: Developmental Biology

Marks: 100 **Duration: 64 Hrs.**

COURSE OBJECTIVES:

The objective is to impart knowledge about the significant processes of development, various model organisms and their applications in research, modern implications of developmental biology in understanding and treatment of various human diseases.

Course Learning Outcomes:

- Students will acquire knowledge about basic concepts of developmental processes, fertilization,germ layer formation and patterning of body plan.
- Students will gain detailed insight into the molecular events of embryogenesis, various model systems and their applications in understanding human development and associated defects.
- Students will learn about Stem cells, their roles in development and significance in development of regenerative medicines, current applications and advancement in stem cell research.

CONTENTS:

Unit I: History and basic concepts of developmental processes, mechanisms of specifying cell fate, role of development in evolutionary change.

Unit II: Early events of fertilization, implantation, generation of multicellular embryos, formation of germ layers, patterning of vertebrate body plan. Morphogenesis: Cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation and cell migration.

Unit III: Molecular events of embryogenesis: Nieuwkoop center, Spemann-Magold organizer theory and mesodermal induction. Role of cell-cell communication in development; Concepts of induction and competence; Epithelial-mesenchymal interactions and developmental signals from extracellular matrix.Brief discussion on role of various signaling pathways during development.

Unit IV: Model systems

A. *C. elegans*: Study of cell lineage, cell fate determination, regulation of blastomere identity, anterior-posterior axis formation and organogenesis (vulva formation).
B. *Drosophila*: Polarity determination of embryo by maternal genes, pattern formation, formation of body segments, homeotic genes and their significance.
C. *Zebrafish*: Developmental stages, somite formation, mechanisms of pigment patterning in fish skin.

D. *Mouse:* Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.
E. *Arabidopsis*: Development and morphogenesis of plants, role of phytohormones, embryogenesis, flowering, shoot and root development.

Unit V: Role of stem cells in development: Definition, types and properties of stem cells, adult stem cells and embryonic stem cells, cancer stem cells, stem cell markers, applications of stem cells, advancement in research and ethical issues.

Unit VI: Medical implications of developmental biology: Developmental disorders, *in-vitro* fertilization, design of future medicines like gene therapy, therapeutic cloning and regeneration therapy.

SUGGESTED READINGS

1. S. F. Gilbert. 2008. Developmental Biology (9^{th} Edition), Sinauer Associates, Inc., MA, USA.
2. D.L. Riddle, T. Blumenthal, B.J. Meyer, J.R. Priess. 1997. *C. elegans* II. Cold Spring Harbor Laboratory Press, New York, USA.
3. Worm Book: The Online Review of *C. elegans* Biology. 2005. The *C. elegans* Research Community, Pasadena, USA. (www.wormbook.org)
4. L. Wolpert, R. Beddington, T. Jessell. 2010. Principles of Development (4^{th} Edition), Oxford University Press, New York, USA.
5. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira. 2003. Molecular Cell Biology, W.H. Freeman, New York, USA.
6. A. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouseembryo: a laboratory manual, Cold spring Harbor Press, New York, USA.

TEACHING PLAN:

Week 1: Introductory classes: General introduction about the history and basic concepts of developmental processes, mechanisms of specifying cell fate, role of development in evolutionary change.

Week 2: Early events of fertilization, implantation, generation of multicellular embryo, formation of germ layers.

Week 3: Patterning of vertebrate body plan. Morphogenesis: Cell adhesion, cleavages, mid-blastula transition and formation of blastula.

Week 4: Gastrulation, different cellular movements, neural tube formation and cell migration.

Week 5: Molecular events of embryogenesis: Nieuwkoop center, Spemann-Magold organizer theory and discussion of experimental evidences.

Week 6: Mesodermal induction: different signaling mechanisms.Role of cell-cell communication in development; Concepts of induction and competence.

Week 7: Epithelial-mesenchymal interactions and developmental signals from extracellular matrix.Role of various signaling pathways during development.Revision of the covered units, mid-term test.

Week 8: Introduction of model organisms and their applications.

C. elegans: Study of cell lineage, cell fate determination, regulation of blastomere identity, anterior-posterior axis formation and organogenesis (vulva formation).

Week 9:*Drosophila*: Polarity determination of embryo by maternal genes, pattern formation, formation of body segments, homeotic genes and their significance.

Week 10:*Zebrafish*: Developmental stages, somite formation, mechanisms of pigment patterning in fish skin.

Week 11:*Mouse:* Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.

Week 12:*Arabidopsis*: Development and morphogenesis of plants, role of phytohormones, embryogenesis, flowering, shoot and root development.

Week 13: Role of stem cells in development: Definition, types and properties of stem cells, adult stem cells and embryonic stem cells, cancer stem cells.

Week 14:stem cell markers, applications of stem cells, advancement in research and ethical issues.

Week 15: Medical implications of developmental biology: Developmental disorders, *in-vitro* fertilization.

Week 16: Design of future medicines like gene therapy, therapeutic cloning and regeneration therapy. Course revision, presentation of the concepts learned in the class, class test, discussion of the results;solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about basic concepts of developmental processes, how cell fate is determined and link between development evolution.	Chalk and board and power point presentations, regular question-answer activities. Consultation of text books and reviews	Assessment through interactive discussion in the class, periodic question-answer sessions during teaching
II.	Role of various signaling pathways will be learnt, early events of fertilization,	Chalk and board and power point presentations, regular question-answer activities,	Oral questions will be asked, students will be given to solve

	implantation, germ layer formation and patterning of vertebrate body plan.	consultation of relevant research articles and watching movies.	analyticalproblems relating to class teachings.Students will be asked to read original research papers and discuss the experimental approach and findings.
III.	Students will learn the molecular events of embryogenesis: Nieuwkoop center, Spemann organizer theory and mesodermal induction.	Chalk and board and Power point presentations, regular question-answer activities, consultation of relevant research articles and reviews.	Writing assignments given to students, schematics of various molecular events will be shown with missing links, students will fill in the names of the missing molecules. Students will be asked to present results of relevant research papers.
IV	Students will learn about utility of various model organisms to follow development processes and hence diseases.	Chalk and board and Power point presentations, regular question-answer activities, consultation of relevant research articles and reviews.	Pictures of various mutants will be shown for students to identify the developmental defects, oral questions, quiz and puzzles will be used for day to day evaluation during class.
V	Properties and significance of stem cells and their role in development will be learnt, they different types and their research applications including current status in India.	Chalk and board and Power point presentations, regular interaction activities, discussion of case studies.	Students will be asked to segregate different type of stem of cells based on the markers, they will be asked design experiments to test stemness properties of cells in animal models.
VI	Students will learn about developmental disorders, IVF, therapeutic cloning and regenerative medicine.	Chalk and board and Power point presentations, student interaction discussion of case studies.	Students will be evaluated through class discussion, assignments and tests.

Master of Science (Biophysics)

Semester III

BPCC303: Practicals-III

Marks: 200 **Duration: 240 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- verify the knowledge acquired in the theory classes through experiments.
- apply the theory learnt to the practical problems

COURSE OUTCOMES:

CO1: Should be able to independently handle scientific equipment/software used in experiments

CO2: Should be able to design adequate positive and negative controls relevant to the experiment.

CO3: Should be able to analyze data and explain the findings

CONTENTS:

1. Plasmid DNA isolation
2. Restriction digestion of plasmid DNA
3. Agarose gel electrophoresis
4. Bacterial Growth curve
5. Preparations of liposomes, proteo-liposomes and dye diffusion
6. EEG & ECG of human subjects
7. Bilayer Electrophysiology (BLM) of ion-channels

Master of Science (Biophysics)

Semester IV

BPCC401: Membrane Biophysics and Neuro-Biophysics

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- enumerate the structure, function & dynamics of cellular & organelle membranes.
- understand the physical principles involved in functioning of the cell & organelle membranes, ion channels, receptors & cell signaling.
- understand the biophysical basis of functioning of neurons & other brain cells, their electrical behavior & communication mechanism.
- understand the biophysics of perception, cognition & memory formation and the related neuronal disorders.

COURSE OUTCOMES:

CO1: Should achieve conceptual understanding of the structure & function of biological membranes including ion channels, receptors & other components.

CO2: Should understand the functioning of the nervous system.

CO3: Should understand electrical behavior of neurons & other brain cells.

CO4: Should be able to make a comparison between the functioning of the natural brain & artificial (computer) brain.

CO5: Should understand the biophysical principle of learning & memory.

CO6: Should understand newer mechanisms of learning.

CO7: Should be able to understand Turing's principle of computation and their applications in computers & brain.

CONTENTS:

UNIT 1.

Electrical behavior of the biological membrane: Model membranes; Biological membranes and Dynamics; Membrane Capacitance; Transport across cell and organelle membranes; Ion Channels; Experimental methods to study Ion Channels.

[14]

UNIT 2.

Nervous System: Introduction to Nervous system; Neurons; Glial cells; Sensory Receptors and perception; Chemical and Electrical synapses.

[10]

UNIT 3.

Synaptic Transmission: Physicochemical principles; Resting potential; Action Potential; Membrane theory of action potential; Hodgkin Huxley's (HH) model; Mathematical solutions of H-H equations.

[10]

UNIT 4.

Models of Neurons & Action Potential: Artificial neurons; FHN and other models; Physiological neuronal network versus artificial neural network.

[10]

UNIT 5.

Neural Basis of Cognition and Behavior: Principles of learning & memory; Cellular mechanism of learning & memory and comparison with machine learning; Animal behavior.

[10]

UNIT 6.

Intrinsic or Non-Synaptic Plasticity: The phenomenon and its importance; the role of various Ion Channels.

[2]

UNIT 7.

Computability: Origin of the concept of computability; Turing machines; Logic circuits; principles of functioning of a computer. Discussion on the interface of artificial neural net and the brain.

[4]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should achieve conceptual understanding of the structure & function of biological membranes including ion channels, receptors & other components.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ seminar presentations
2	Should understandthe functioning of the nervous system.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ seminar presentations
3	Should understand electrical behavior of neurons & other brain cells.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ seminar presentations
4	Should be able to make a comparison between the functioning of natural brain & artificial (computer) brain.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ seminar presentations
5	Should understand physical basis of microscopic structure of matter and chemical interaction.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ seminar presentations
6	Should understand newer mechanisms of learning.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ Short presentations

7	Should be able to understand Turing’s principle of computation and their applications in computers & brain.	Lectures+Discussions+ Video/ Films	Quiz+Short answer type test+ Short presentations

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Neuroscience: A Mathematical Primer by Scott, A. (Springer)
ii. The Computational Brain by Churchland, P.S. &Sejnowski, T.J. (MIT Press).
iii. Biological Physics by Nelson, P. C. (W.H. Freeman & Co).
iv. Cognitive Neuroscience: The Biology of the Mind by Gazzaniga, M.S. et al. (W.W. Norton & Co)
v. Biological Psychology by Rosenzweig et.al. (Sinauer Associates, Inc)
vi. Principles of Neural Science by Eric R Kandel et al, (McGraw Hill).
vii. From Computers to Brain by Lytton, W.W. (Springer).
viii. Brain Dynamics by Haken, H. (Springer).
ix. Concepts for Neural Networks by Landau, L.J. & Taylor, J.G. (Springer)
x. Membrane Biophysics by Mohammad Ashrafuzzaman, Jack A. Tuszynski, (Springer Science & Business Media)
xi. Structure and dynamics of membranous interfaces by Kaushik Nag (Wiley)
xii. Mechanics of the Cell by David Boal (Cambridge University Press)
xiii. Particles at Fluid Interfaces and Membranes by P. Kralchevsky, K. Nagayama (Elsevier)
xiv. The Structure of Biological Membranes by Philip L. Yeagle, (CRC Press).
xv. Methods in Membrane Lipids by Alex DoPico (Humana Press)

Master of Science (Biophysics)

Semester IV

BPOE401: Theoretical and Mathematical Biology

Marks: 100 **Duration: 60 Hrs.**

COURSE OBJECTIVES:

At the end of the course, the student should be able to

- enumerate applications of different branches of Mathematics to Biology.
- understand the complexity of biological systems and the appropriate mathematical tools to analyze those.
- understand the collective behavior of biological systems from molecular level to ecosystem.

COURSE OUTCOMES:

CO1: Should be able to analyse nonlinear systems in biology.
CO2: Should be able to apply Information Theory to biology.
CO3: Should be able to apply stochastic models in biology.
CO4: Should be able to predict the future of a complex biological system.
CO5: Should understand the physical principles of biological evolution.
CO6: Should be able to analyse biological networks, e.g. cellular, biochemical, ecological.
CO7: Should be able to apply topology to biological problems.

CONTENTS:

UNIT 1.

Non Linear Systems Analysis: Definition of Non-linearity, Non-linear differential equations, examples, critical points, Stability &Liyapunov's Theorem, Near Equilibrium Solutions, Behaviour in the Phase plane, Feed Back Process and Oscillations, B-Z equations, LotkaVolterra and other Models with examples.

[14]

UNIT 2.

Information Theory and its Application in Biology: Basic concept of information and the related theorems, information theory and protein structure, coding of genetic information, information and sensory perception.

[8]

UNIT 3.

Statistical Mechanics and its application in Biology: Basic Foundation, Canonical & Grand Canonical Ensembles, Biomolecular System as an analogue of many body system. Quantitative analysis of a co-operative process.Ising Model and DNA melting, drug-DNA interaction and other cooperative process, Lipid phase Transitions, Collective Process in Cell Membranes and application of statistical Mechanics.

Stochastic Processes in Biology: Examples of Stochastic Behaviour, Stochastic Models, Markovian Processes in Biology, Stochastic Resonance.

[10]

UNIT 4.

Time Series Analysis: The Background and Necessity, Correlation Coefficient, Fourier Analysis, Wavelet Analysis, Application in the analysis of Electrophysiological recordings e.g. EEG, ECG, Fractals and Evolution of a System, Examples from Biological Systems, Difficulties and Limitation of Analysis.

[8]

UNIT 5.

Prebiotic Evolution: Theories and Models, Eigen's Hypercycle, Kimura's idea, Non Linearity and Biological Evolution.

[6]

UNIT 6.

Networks: Neural Network, Artificial Neural Networks, Metabolic Networks, Brain as a Complex network, Theories and Analytical Methods, Cellular Automata and its application in microbial and lower Organismic Population.

[8]

UNIT 7.

Elements of Topology: Elementary Concepts and Theorems, Topology of DNA, Supercoiling, Knots, Twists etc, Catastrophe Theory and Applications to Morphogenesis.

[6]

TEACHING PLAN:

The teaching will be done as per the above-mentioned sequence of units and corresponding number of classes.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Should be able to analyze nonlinear systems in biology.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving/ Short presentation (group activity)
2	Should be able to apply Information Theory to biology.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving /Short presentation (group activity)
3	Should be able to apply stochastic models in biology.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving /Short presentation (group activity)
4	Should be able to predict future	Lectures+NumericalProble	Short answer type test

	of a complex biological system.	m Solving	+Numerical Problem Solving /Short presentation (group activity)
5	Should understandthe physical principles of biological evolution.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving /Short presentation (group activity)
6	Should be able to analyze biological network.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving /Short presentation (group activity)
7	Should be able to apply topology to biological problems.	Lectures+Numerical Problem Solving	Short answer type test +Numerical Problem Solving /Short presentation (group activity)

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. Introduction to modeling biological cellular control systems by W. Liu (Springer)
ii. Applied numerical methods with MATLAB for engineers and scientists by S.C. Chapra, (McGraw-Hill)
iii. Mathematical modeling in Systems Biology: an introduction by B.P. Ingalls (MIT Press)
iv. Stochastic approaches for Systems Biology by M. Ullah, (Springer).
v. Applied numerical analysis by C.F. Gerald, Wheatley, Patrick O (Pearson Educations Inc)
vi. Computational Cell Biology by C.P. Fall, (Springer)
vii. Understanding molecular simulations by DaanFrenkel, BerendSmit (Academic Press)

Master of Science (Biophysics)

Semester IV

BPCC402: Dissertation

Marks: 400 **Duration: 480 Hrs.**

COURSE OBJECTIVES:

To provide conceptual and hands-on practical knowledge to the student in the current research areas in the field of biophysics.

COURSE OUTCOMES:

At the end of the dissertation, the student should be able to

- Should be able to understand the lacunae and complexity in the present level of understanding of biophysical principles governing biology.
- Should be able to frame relevant research problems and hypothesis to address these lacunae and complexity
- Independently design logical set of experiments to investigate the hypothesis
- Analyze the data to make meaningful results.
- Explain the findings in a scientific manner.