UNIVERSITY OF DELHI
MASTER OF SCIENCE (BIOPHYSICS)
(M.Sc. Biophysics)

(Proposed to be effective from Academic Year 2019-20)

PROGRAMME BROCHURE

Revised Syllabus as approved in the meeting of Faculty of Interdisciplinary & Applied Sciences on 03 July 2018

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2018 and Executive Council on YYYY, 2018
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</table>
I. About the Department

1. Historical Background of Department

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. Subhendu Ghosh joined the department as a Lecturer followed by Dr. Dinkar Sahal (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 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 & Dr. Das left the department in 2005 as a professor and left after a year. At present there are three faculty members, Dr. Subhendu Ghosh (Professor), Dr. Manisha Goel (Assistant Professor) & Dr. Manish Kumar (Assistant 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 is going to start M.Phil. Biophysics from the Academic Year 2018-19. The department offers research opportunities in the areas of structural biology, bioinformatics, membrane biology and neuro-biophysics (cognitive science) in general. The main research emphasis of the Department is in the area of theoretical biology and membrane biophysics, e.g. ion channels and neuro-biophysics. A special emphasis is given on learning, memory and computational neuroscience. 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. Other areas of active research are: enzymatic modulation of ion channels, e.g. phosphorylation, biological spectroscopy. 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 course on Biophysics is being offered. Keeping this in view Department of Biophysics proposes to introduce a post-graduate course highlighting various applications of physical sciences to biology. The proposed course is referred as M.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), Jamia Milia Islamia (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 of 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 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 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 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 same department. Students of other Department 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 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 of 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. M.Sc. Biophysics 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 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-semester. A student is required to complete 96 credits for the completion of course and the award of degree.

<table>
<thead>
<tr>
<th>Part – I</th>
<th>Semester</th>
<th>Part – II</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year</td>
<td>Semester I</td>
<td>Second Year</td>
<td>Semester III</td>
</tr>
<tr>
<td>Semester II</td>
<td>Semester IV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### 4. Course Credit Scheme

<table>
<thead>
<tr>
<th>Semester</th>
<th>Core Courses</th>
<th>Elective Course</th>
<th>Open Elective Course</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>4 T + 1P</td>
<td>16 L + 8P</td>
<td>0</td>
<td>86</td>
</tr>
<tr>
<td>II</td>
<td>3T + 1P</td>
<td>12 L + 8P</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>III</td>
<td>3T + 1P</td>
<td>12 L + 8 P</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>IV</td>
<td>1 T + 1 D</td>
<td>4 L + 18 P</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>96</td>
</tr>
</tbody>
</table>

- For each Core Course and Elective Course, there will be 4 lecture hours of teaching per week.
- Open Electives to the maximum total of 2 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
  D = Dissertation
5. Semester wise details of M.Sc. Biophysics Course

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits in each core course</th>
<th>Theory</th>
<th>Practical</th>
<th>Tutorial</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPCC101: Introductory Biology (for students with Physical Science background) OR BPCC102: Introductory Physics &amp; Chemistry (for students with Biological Science background)</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td></td>
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<tr>
<td>BPCC103: Mathematics and Statistics for Life Sciences</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>BPCC104: Concepts of Biochemistry</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MBCC301: Molecular Biology (from Department of Microbiology, University of Delhi South Campus)</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>BPCC105: Practical-I</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>8</td>
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</tr>
<tr>
<td><strong>Total credits in core courses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits in each elective course</th>
<th>Theory</th>
<th>Practical</th>
<th>Tutorial</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIL</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total credits in elective courses</strong></td>
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<td></td>
<td></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Open Electives</th>
<th>Credits in open elective</th>
<th>Theory</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIL</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Total credits in open elective</strong></td>
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<td></td>
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</table>

**Total credits in Semester 1: 24**
### Semester II

#### Number of core courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Theory</th>
<th>Practical</th>
<th>Tutorial</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPCC201: Molecular Biophysics</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>BPCC202: Physical Methods in Biology</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>GENCC204: RECOMBINANT DNA TECHNOLOGY (from Department of Genetics, University of Delhi South Campus)</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>BPCC203: Practical-II</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total credits in core course</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>

#### Number of elective courses

<table>
<thead>
<tr>
<th>Credits in each elective course</th>
<th>Theory</th>
<th>Practical</th>
<th>Tutorial</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPEC201: Photo-Biophysics, Radiation &amp; Environmental Biophysics</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>BPEC202: Programming and Data Analytics</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total credits in elective courses</strong></td>
<td></td>
<td></td>
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<td><strong>4</strong></td>
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</table>

#### Number of Open Electives

<table>
<thead>
<tr>
<th>Credits in each open elective</th>
<th>Theory</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIL</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total credits in open elective</strong></td>
<td></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

**Total credits in Semester II: 24**
<table>
<thead>
<tr>
<th>Course</th>
<th>Theory</th>
<th>Practical</th>
<th>Tutorial</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPCC301: Cellular Biophysics &amp; Bioenergetics</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>BPCC302: Computer Applications in Biology</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>BPCC303: Physiological Biophysics</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>BPCC304: Practical-III</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total credits in core course</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>20</strong></td>
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</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Theory</th>
<th>Practical</th>
<th>Tutorial</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPEC301: Methods in High-throughput Biology</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>BCCC302: Developmental Biology (from Department of Biochemistry, University of Delhi South Campus)</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total credits in elective courses</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Theory</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIL</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total credits in open elective</strong></td>
<td></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

**Total credits in Semester III: 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 B.Sc./B.E./B.Tech. 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 Phosphorylation; 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

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 end semester examination will be done by all teachers of 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)**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Mode of evaluation</th>
<th>Weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Attendance (Lectures including Interactive Periods and Tutorials)</td>
<td>5%</td>
</tr>
<tr>
<td>2.</td>
<td>Written assignments / tutorials / project reports/ Class Test(s) / Quiz(s)</td>
<td>25%</td>
</tr>
</tbody>
</table>
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:

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

UNIT 2:
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.

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.
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.

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.

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

(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.

UNIT 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

<table>
<thead>
<tr>
<th>Unit</th>
<th>Course Learning Outcomes</th>
<th>Teaching and Learning Activity</th>
<th>Assessment Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Should be able to appreciate the affect of evolution on generating genomic and phenotypic diversity</td>
<td>Discussion on the various theories of evolution proposed and observations supporting them</td>
<td>MCQ type test.</td>
</tr>
<tr>
<td>2</td>
<td>Should be able to understand the constituents and working of a cell as a whole</td>
<td>Lectures</td>
<td>Short answer type test</td>
</tr>
<tr>
<td>3</td>
<td>Should be able to enumerate the various cell organelles and their function</td>
<td>Lectures + videos</td>
<td>Short presentation on each cell organelle (group activity)</td>
</tr>
<tr>
<td>4</td>
<td>Should be able to describe various types of cell multiplications and divisions and differences between</td>
<td>Lectures + videos</td>
<td>Short presentation (Group activity) on types of cell divisions</td>
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<tr>
<td>5</td>
<td>They should be able to enumerate the differences in cellular organization of various life forms.</td>
<td>Lectures + Discussion</td>
<td>Short Presentation on various animal organ systems (individual activity)</td>
</tr>
<tr>
<td>6</td>
<td>They should understand how evolution can be studied on genetic basis.</td>
<td>Lectures + Discussion + Solving numerical aspects of genetics</td>
<td>MCQ type QUIZ including numerical</td>
</tr>
</tbody>
</table>

**SUGGESTED READINGS:**

Latest editions of following books are recommended:

1. Cell and Molecular Biology De By Robertis & De Robertis (Lippincott & Wilkins)
2. Molecular Biology of the Cell By Alberts B et al. (Garland)
3. Molecular Cell Biology By Lodish, H. et al. (Freeman)
5. Genetics-a Conceptual Approach Pierce B. A. (Freeman)
7. 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:

- 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:

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.

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.

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

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

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

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<tbody>
<tr>
<td>1</td>
<td>Should be able to solve the statics &amp; dynamics of rigid bodies.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving</td>
</tr>
<tr>
<td>2</td>
<td>Should understand storage &amp; flow of energy and their applications.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving</td>
</tr>
<tr>
<td>3</td>
<td>Should be able to apply laws of electricity &amp; magnetism.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving +Short presentation (group activity)</td>
</tr>
<tr>
<td>4</td>
<td>Should be able to apply laws of optics.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving +Short presentation (group activity)</td>
</tr>
</tbody>
</table>
Department of Biophysics, University of Delhi

<table>
<thead>
<tr>
<th>5</th>
<th>Should understand physical basis of chemical bonding, ion conduction and the chemistry of organic molecules &amp; apply those to biology.</th>
<th>Lectures+Numerical Problem Solving</th>
<th>Short answer type test +Numerical Problem Solving +Short presentation (group activity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Should be able to apply principles of ion conduction.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving +Short presentation (group activity)</td>
</tr>
</tbody>
</table>

**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


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.

UNIT 2:
Vectors: Vector algebra and vector calculus; dot & cross products; concept of gradient, divergence, curl and laplacian opertaors.

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

UNIT 3:
Application of Derivatives and Dynamical System: Stability and derivatives, the logistic dynamical system, optimization, approximating functions, Newton's method.

Department of Biophysics, University of Delhi

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

UNIT 4:


UNIT 5:

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

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<tbody>
<tr>
<td>1</td>
<td>Students will be able to refresh simple mathematics knowledge, which they have learned at the school level.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving</td>
</tr>
<tr>
<td>2</td>
<td>Students will be able to solve problems related to vector &amp; linear equations.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving</td>
</tr>
<tr>
<td>3</td>
<td>Students will be able to apply advanced calculus to dynamical systems including biological systems.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving+Short presentation (group activity)</td>
</tr>
<tr>
<td>4</td>
<td>Students will be able to apply knowledge of probability &amp; statistical methods.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving+Short presentation (group activity)</td>
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</table>
Students will be able to correlate mathematical & computational methods and apply to natural (biological) problems like time series, network analyses

<table>
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<th>Lectures+Numerical Problem Solving</th>
<th>Short answer type test +Numerical Problem Solving+Short presentation (group activity)</th>
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</table>

**SUGGESTED READING:**

Latest editions of following books are recommended:


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:
- 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.

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.

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.

UNIT 4:
Metabolic Pathways: Glucose and glycogen metabolism, Citric acid cycle, photosynthesis, lipid metabolic pathways, amino acid metabolism, nucleotide metabolism

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.

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

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

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 Donald Voet, Charl, Judith G. Voet – (Wiley)
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. Student 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.

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.

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.
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.

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.

Unit VI:

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

**SUGGESTED READINGS:**
Master of Science (Biophysics)

Semester I

BPCC105: Practical-I

Marks: 100

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:
: 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. Enzyme Kinetics (ex LDH - Lactate dehydrogenase)
2. Plasmid DNA isolation
3. Restriction digestion of plasmid DNA
4. Agarose gel electrophoresis
5. Bacterial Growth curve
6. Computer simulation of chemical/biological structures
7. Potentiometric/Conductometric titration
8. Viscosity & Surface Tension measurements
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:

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

CO2: Should be able to correlate the biomolecular structure to it's 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 thermodynamical 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.

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.

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.

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

UNIT 4:
Special Bio-Macromolecules: Metalloproteins, nucleoproteins, ribozymes, chaperons & prions.

UNIT 5:
Cooperativity in bio-macromolecular interactions: the phenomenon of cooperativity, DNA and protein melting, allosteric enzymes, other examples of cooperativity in biology.

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.

TEACHING PLAN:
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Facilitating the achievement of Course Learning Outcomes

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<tr>
<td>1</td>
<td>Should be able to appreciate the effect of various forces in shaping the molecular conformation</td>
<td>Lectures</td>
<td>MCQ type test.</td>
</tr>
<tr>
<td>2</td>
<td>Should be able to correlate the biomolecular structure to its specific functions</td>
<td>Lectures</td>
<td>Short answer type test</td>
</tr>
<tr>
<td>3</td>
<td>Should be able to comprehend the role of biomolecular conformation to function.</td>
<td>Lectures + videos</td>
<td>MCQ type test.</td>
</tr>
<tr>
<td>4</td>
<td>Should know the role and importance of rarer biomolecules</td>
<td>Lectures + videos</td>
<td>Short presentation (Group activity) on function of the molecules from published reviews</td>
</tr>
<tr>
<td>5</td>
<td>Should be able to appreciate the effect of cooperatively in protein/enzyme function</td>
<td>Lectures</td>
<td>MCQ type QUIZ</td>
</tr>
<tr>
<td>6</td>
<td>Should understand non-</td>
<td>Lectures</td>
<td>MCQ type QUIZ</td>
</tr>
</tbody>
</table>
equilibrium biological process through thermodynamical principles (non-equilibrium)

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 M.V. Volkenstein (Academic press)
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 most relevant biophysical technique for characterizing the dynamic behavior of a macromolecule, especially proteins.

COURSE OUTCOMES:
: 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.

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

**UNIT 3:**
**Hydrodynamic Methods:** Viscosity, Sedimentation equilibrium and Velocity Centrifugation, Density Gradient method, applications to bio-macromolecules and bio-materials.

**UNIT 4:**
**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.

**UNIT 5:**
**Electrophoresis:** Behavior of bio-macromolecules in electric fields, Types of electrophoresis, PAGE, Agarose Gel Electrophoresis, 2D Electrophoresis, Dialectrophoresis.

**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.

**UNIT 7:**
**Microscopy:** Optical Microscope, Fluorescent Microscope, Confocal Microscope, Electron Microscope, Applications of each microscopic method.

**Emerging topics in Biophysical methods**

**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

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<tr>
<td>1</td>
<td>Should be able to analyze and interpret data from various</td>
<td>Lectures + Videos</td>
<td>Critical Interpretation of spectroscopic data</td>
</tr>
</tbody>
</table>
### Suggested Readings:

Latest editions of following books are recommended:

1. Fundamentals of Molecular Spectroscopy by Colin Banwell (McGraw Hill)
4. Handbook of Fluorescence Spectroscopy and Imaging: From Single Molecules to Ensembles by Prof. Dr. Markus Sauer, Prof. Dr. Johan Hofkens, Dr. JörgEnderlein,
5. Biomolecular NMR Spectroscopy, by Jeremy N. S. Evans, (OUP Oxford)

xi. Optical methods in Biology by Slayter E.M. (John Wiley)


xiv. Biological Spectroscopy by Iain D. Campbell, Raymond A. Dwek
Master of Science (Biophysics)

Semester II

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:
: 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**

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:

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

Applications of recombinant DNA technology in biology and medicine

Gene editing technologies

Suggested readings:

2. *Gene Cloning and Manipulation* Howe C Cambridge University 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:

: Should understand the principles of interaction of light with organic molecules and their significance in 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, Chemi-luminescence.

UNIT 2.


UNIT 3.

Radiation in Environment:
(i) Ionizing & Non-Ionizing Radiations and their origins; Dose Measurement;
(iii) Electromagnetic Radiations and classification.

UNIT 4.

Radiation Biophysics:
Department of Biophysics, University of Delhi

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

UNIT 5.
**Environmental Biophysics**: Introduction to Ecosystem: Physical Environment, Geological Environment and Biosphere.

**Ecosystem Analysis**: Population Dynamics, Prey-Predator Models

**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.

**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

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<td>Should understand the principles of interaction of light with organic molecules and their significance in environment.</td>
<td>Lectures+Discussions+ Video/Films</td>
<td>Quiz+ Short answer type test + Short presentations</td>
</tr>
<tr>
<td>2</td>
<td>Should understand the biophysical principles of interaction of light with living systems and their significance in biosphere sustenance.</td>
<td>Lectures+Discussions+ Video/Films</td>
<td>Quiz+Short answer type test + Short presentations</td>
</tr>
<tr>
<td>3</td>
<td>Should know various kinds of radiations in the environment and their sources.</td>
<td>Lectures+Discussions+ Video/Films</td>
<td>Quiz+Short answer type test + Short presentations</td>
</tr>
<tr>
<td>4</td>
<td>Should know the effects of various radiations on living systems and how to prevent ill effects of radiation.</td>
<td>Lectures+Discussions+ Video/Films</td>
<td>Quiz+Short answer type test + Short presentations</td>
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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**

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<tr>
<th>5</th>
<th>SUGGESTED READINGS:</th>
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<tr>
<td>Latest editions of following books are recommended:</td>
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<tr>
<td>i. Nuclear Physics, Theory and Experiment by Roy R.R &amp; Nigam B.P. (Wiley)</td>
<td></td>
</tr>
<tr>
<td>ii. Introductory Nuclear Physics by Halliday D, (John Wiley)</td>
<td></td>
</tr>
<tr>
<td>iii. Biological Effects of Radiation by Coggle J.E.. (Taylor &amp; Francis).</td>
<td></td>
</tr>
<tr>
<td>iv. Molecular Theory of Radiation Biology by Chadwick K.H. &amp; Leenbouts H.P. (Springer Verlag)</td>
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</tr>
<tr>
<td>v. Introduction to Radiological Physics and Radiation Dosimetry by Atlik F.H. (John Wiley)</td>
<td></td>
</tr>
<tr>
<td>vi. An Introduction to Environmental Biophysics by Campbell, Gaylon S., Norman, John M. (Springer)</td>
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</tr>
</tbody>
</table>
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.

UNIT 2:

UNIT 3:

UNIT 4:

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.

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

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<td>Implement a simple program by writing the code, testing the code and debugging the program.</td>
<td>Demonstration</td>
<td>Problem solving</td>
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<tr>
<td>2</td>
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<td>3</td>
<td>Use R-studio to write R scripts</td>
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<tr>
<td>4</td>
<td>Apply selected probability distributions to solve problems</td>
<td>Demonstration</td>
<td>Problem solving</td>
</tr>
<tr>
<td>5</td>
<td>Apply and evaluate different learning algorithms and model selection.</td>
<td>Demonstration</td>
<td>Problem solving</td>
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SUGGESTED READINGS:

Latest editions of following books are recommended:

ii. https://leanpub.com/rprogramming
iii. http://dss.princeton.edu/training
Master of Science (Biophysics)
Semester II
BPCC203: Practical-II

Marks: 100                                    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:
2. Estimation of protein concentration using spectroscopic methods.
5. Studying interaction of dyes with DNA through fluorescence spectroscopy.
7. Studying dynamics of chlorophylls I & II through absorption spectroscopy.
8. Effect of light on Vitamin A (retinol) through spectroscopic methods.
9. Protein purification (affinity chromatography) and SDS-PAGE
Master of Science (Biophysics)

Semester III

BPCC1301: 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


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.

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 & Modeling.

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

UNIT 4.  
**Biophysics of Apoptosis:** Relevance of Programmed Cell Death, Necrosis & Apoptosis, Mechanisms of Apoptosis, Role of beta Amyloid, Caspases and Mitochondrial proteins.  

**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.  

UNIT 5.  
**Energy production in the cell:** oxidation-reduction reactions, coupled reactions and group transfer.  

**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 CO₂; Structure and Properties of Mitochondria, Cytochrome c, Chemiosmotic Coupling, Electron Transport and Oxidative Phosphorylation, Photosynthetic Stages and Light-Absorbing Pigments, Molecular Analysis of Photosystems  

**TEACHING PLAN:**  
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Facilitating the achievement of Course Learning Outcomes  

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<td>2</td>
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<td>Should understand the principles of healthy development of an embryo and its protection.</td>
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<td>4</td>
<td>Should understand the biophysical principles of programmed cell death &amp; their</td>
<td>Lectures+Discussions+ Video/ Films</td>
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Department of Biophysics, University of Delhi

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<td>5</td>
<td>Should be able to apply thermodynamics in cellular &amp; biochemical processes.</td>
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SUGGESTED READINGS:

Latest editions of following books are recommended:

i. New Era of Bioenergetics by Yasuo Mukohata, (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 Mårten Wikström (Editor) (RSC Publishing)
viii. Chemical Biophysics by Daniel A Beard (Cambridge University Press, 2008)
Master of Science (Biophysics)
Semester III
BPCC302: 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.

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.

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.

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.

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.g. DeepView, PyMol.

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.

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.

**TEACHING PLAN:**

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Facilitating the achievement of Course Learning Outcomes

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<tr>
<td>1</td>
<td>Should be able to know different molecular biology databases and formats in which data is stored.</td>
<td>Comparison of details available in different biological data resources.</td>
<td>Short presentation on differences among different databases</td>
</tr>
<tr>
<td>2</td>
<td>Should be able to understand the concept of different forms of sequence alignment methods and selection of appropriate alignment method</td>
<td>Making alignment of two sequences</td>
<td>MCQ type</td>
</tr>
<tr>
<td>3</td>
<td>Knowledge of the mechanisms of molecular evolution. Will be able to draw phylogenetic inference and will</td>
<td>Lectures + videos</td>
<td>Short presentation on each cell organelle (group activity)</td>
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be able to reconstruct phylogenetic
trees based on several molecular
markers, applying the State-of-the-
Art bioinformatics tools

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 interest from
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:


ii. Introduction to Bioinformatics, A. Lesk. OUP- India. Essential Bioinformatics by Jin Xiong, Cambridge University Press.


vii. Discovering Genomics, Proteomics and Bioinformatics, 2nd ed. by Campbell Pearson Education.


ix.  Structural Bioinformatics, 2nd Edition, Jenny Gu (Editor), Philip E. Bourne (Editor), Wiley-Blackwell.
Master of Science (Biophysics)
Semester III
BPCC303: 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 functioning of 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 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.

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.

UNIT 3.
Biophysics of Muscle Function: Ultra-structural, chemical and physiological basis of skeletal muscle contraction; Molecular mechanisms in muscle contraction.

UNIT 4.
Biophysics of Heart: Structure, origin, conduction and regulation of heart beat; Cardiac cycle; Electrocardiogram; Disorders of the heart; Atherosclerosis, arrhythmias.
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.

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.

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.

**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

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<td>Quiz + Short answer type test+ Short presentations</td>
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<td>2</td>
<td>Should be able to understand blood related disorders and recommend precautions.</td>
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<td>3</td>
<td>Should understand functioning of healthy muscles and diagnose muscle disorders.</td>
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<td>Should understand functioning of heart and recommend its healthy maintenance.</td>
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<td>5</td>
<td>Should be able to give recommendations for respiratory problems.</td>
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<tr>
<td>6</td>
<td>Should understand the biophysical principles of the functioning of kidney and its maintenance.</td>
<td>Lectures + Discussions + Video/ Films</td>
<td>Quiz + Short answer type test+ Short presentations</td>
</tr>
<tr>
<td>7</td>
<td>Should understand the role of various hormones in animal &amp; human bodies.</td>
<td>Lectures + Discussions+ Video/ Films</td>
<td>Quiz + Short answer type test+ Short presentations</td>
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</table>

**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)

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 & 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:


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.

UNIT 3:

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

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.

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.

UNIT 7:

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.

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

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<tr>
<th>Unit</th>
<th>Course Learning Outcomes</th>
<th>Teaching and Learning Activity</th>
<th>Assessment Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Understanding of quantification &amp; identification of proteins, their post-translational modifications and interactions from mass spectrometry data.</td>
<td>Lectures + Discussion</td>
<td>MCQ type QUIZ</td>
</tr>
<tr>
<td>2</td>
<td>Should understand different methods of bio-molecular structure determination, reason behind different functions in a protein family.</td>
<td>Lectures + Discussion</td>
<td>MCQ type QUIZ</td>
</tr>
<tr>
<td>3</td>
<td>Understanding of bio-molecular</td>
<td>Lectures + videos</td>
<td>MCQ type QUIZ</td>
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interactions and their role in modulation of biological processes.

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<tr>
<th></th>
<th>Demonstrate knowledge of drug discovery, design and development</th>
<th>Lectures + videos</th>
<th>MCQ type QUIZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Knowledge of commonly used technologies and bioinformatics principles for high-throughput genomics analysis</td>
<td>Lectures + Discussion</td>
<td>MCQ type QUIZ</td>
</tr>
<tr>
<td>6</td>
<td>Should evaluate and apply the appropriate experimental design in a given metabolomics research question (including sample processing, choice of methods and analytical strategies)</td>
<td>Discussion</td>
<td>MCQ type QUIZ</td>
</tr>
<tr>
<td>7</td>
<td>Know important biological databases and relevant statistics/bioinformatics software tools to analyze microarray and NGS transcriptomics data</td>
<td>Discussion + hands-on</td>
<td>MCQ type QUIZ</td>
</tr>
<tr>
<td>8</td>
<td>Understand the general principles, assumptions and basic techniques used in genetic association studies (including quality control checks and association between genotype and phenotype)</td>
<td>Lectures + Discussion</td>
<td>MCQ type QUIZ</td>
</tr>
</tbody>
</table>

**SUGGESTED READINGS:**

Latest editions of following books are recommended:

- 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 Dov Stekel, (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, Harald Barsnes, Geir Egil Eide and Lennart Martens (John Wiley &Sons)
Master of Science (Biophysics)

Semester III

BCCC302: Developmental Biology

Marks: 100 (4 Credits)  Duration: 60 Hrs (15 Weeks)

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 embryo, 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


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 associated 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**


**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.

**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

<table>
<thead>
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<tr>
<td>I.</td>
<td>Students will learn about basic concepts of developmental processes, how cell fate is determined and link between development evolution.</td>
<td>Chalk and board and power point presentations, regular question-answer activities. Consultation of text books and reviews.</td>
<td>Assessment through interactive discussion in the class, periodic question-answer sessions during teaching.</td>
</tr>
<tr>
<td>II.</td>
<td>Role of various signaling pathways will be learnt, early events of fertilization, implantation, germ layer formation and patterning of vertebrate body plan.</td>
<td>Chalk and board and power point presentations, regular question-answer activities. Consultation of relevant research articles and watching movies.</td>
<td>Oral questions will be asked, students will be given to solve analytical problems relating to class teachings. Students will be asked to read original research papers and discuss the experimental approach and findings.</td>
</tr>
<tr>
<td>III.</td>
<td>Students will learn the</td>
<td>Chalk and board and Power Writing assignments</td>
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<tbody>
<tr>
<td></td>
<td>molecular events of embryogenesis: Nieuwkoop center, Spemann organizer theory and mesodermal induction.</td>
<td>point presentations, regular question-answer activities, consultation of relevant research articles and reviews.</td>
<td>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.</td>
</tr>
<tr>
<td>IV</td>
<td>Students will learn about utility of various model organisms to follow development processes and hence diseases.</td>
<td>Chalk and board and Power point presentations, regular question-answer activities, consultation of relevant research articles and reviews.</td>
<td>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.</td>
</tr>
<tr>
<td>V</td>
<td>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.</td>
<td>Chalk and board and Power point presentations, regular interaction activities, discussion of case studies.</td>
<td>Students will be asked to segregate different type of stem cells based on the markers, they will be asked design experiments to test stemness properties of cells in animal models.</td>
</tr>
<tr>
<td>VI</td>
<td>Students will learn about developmental disorders, IVF, therapeutic cloning and regenerative medicine.</td>
<td>Chalk and board and Power point presentations, student interaction discussion of case studies.</td>
<td>Students will be evaluated through class discussion, assignments and tests.</td>
</tr>
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</table>
Master of Science (Biophysics)
Semester III
BPCC304: Practical-III

Marks: 100 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:
- 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. 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. 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:
:
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 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.

UNIT 2.
**Nervous System**: Introduction to Nervous system; Neurons; Glial cells; Sensory Receptors and perception; Chemical and Electrical synapses.

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.

UNIT 4.
**Models of Neurons & Action Potential**: Artificial neurons; FHN and other models; Physiological neuronal network versus artificial neural network.
UNIT 5.
**Neural Basis of Cognition and Behavior:** Principles of learning & memory; Cellular mechanism of learning & memory and comparison with machine learning; Animal behavior.

UNIT 6.
**Intrinsic or Non-Synaptic Plasticity:** The phenomenon and its importance; the role of various Ion Channels.

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.

**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

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<tbody>
<tr>
<td>1</td>
<td>Should achieve conceptual understanding of the structure &amp; function of biological membranes including ion channels, receptors &amp; other components.</td>
<td>Lectures+Discussions+ Video/ Films</td>
<td>Quiz+Short answer type test+ seminar presentations</td>
</tr>
<tr>
<td>2</td>
<td>Should understand the functioning of the nervous system.</td>
<td>Lectures+Discussions+ Video/ Films</td>
<td>Quiz+Short answer type test+ seminar presentations</td>
</tr>
<tr>
<td>3</td>
<td>Should understand electrical behavior of neurons &amp; other brain cells.</td>
<td>Lectures+Discussions+ Video/ Films</td>
<td>Quiz+Short answer type test+ seminar presentations</td>
</tr>
<tr>
<td>4</td>
<td>Should be able to make a comparison between the functioning of natural brain &amp; artificial (computer) brain.</td>
<td>Lectures+Discussions+ Video/ Films</td>
<td>Quiz+Short answer type test+ seminar presentations</td>
</tr>
<tr>
<td>5</td>
<td>Should understand physical basis of microscopic structure of matter and chemical interaction.</td>
<td>Lectures+Discussions+ Video/ Films</td>
<td>Quiz+Short answer type test+ seminar presentations</td>
</tr>
<tr>
<td>6</td>
<td>Should understand newer mechanisms of learning.</td>
<td>Lectures+Discussions+ Video/ Films</td>
<td>Quiz+Short answer type test+ Short presentations</td>
</tr>
<tr>
<td>7</td>
<td>Should be able to understand Turing’s principle of computation and their applications in computers &amp; brain.</td>
<td>Lectures+Discussions+ Video/ Films</td>
<td>Quiz+Short answer type test+ Short presentations</td>
</tr>
</tbody>
</table>
SUGGESTED READINGS:

Latest editions of following books are recommended:

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)
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: 50
Duration: 30 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 future of a complex biological system.
CO5: Should understand the physical principles of biological evolution.
CO6: Should be able to analyse biological network, e.g. cellular, biochemical, ecological.
CO7: Should be able to apply topology to biological problems.

CONTENTS:

UNIT 1.

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. [4]

UNIT 3.

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.

UNIT 5.
**Prebiotic Evolution:** Theories and Models, Eigen’s Hypercycle, Kimura’s idea, Non Linearity and Biological Evolution.

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.

UNIT 7.
**Elements of Topology:** Elementary Concepts and Theorems, Topology of DNA, Supercoiling, Knots, Twists etc, Catastrophe Theory and Applications to Morphogenesis.

**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

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<tbody>
<tr>
<td>1</td>
<td>Should be able to analyze nonlinear systems in biology.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving/ Short presentation (group activity)</td>
</tr>
<tr>
<td>2</td>
<td>Should be able to apply Information Theory to biology.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving/Short presentation (group activity)</td>
</tr>
<tr>
<td>3</td>
<td>Should be able to apply stochastic models in biology.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving/Short presentation (group activity)</td>
</tr>
<tr>
<td>4</td>
<td>Should be able to predict future of a complex biological system.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving/Short presentation (group activity)</td>
</tr>
<tr>
<td>5</td>
<td>Should understand the physical principles of biological evolution.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving/Short presentation (group activity)</td>
</tr>
<tr>
<td></td>
<td>Should be able to analyze biological network.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving /Short presentation (group activity)</td>
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<tr>
<td>7</td>
<td>Should be able to apply topology to biological problems.</td>
<td>Lectures+Numerical Problem Solving</td>
<td>Short answer type test +Numerical Problem Solving /Short presentation (group activity)</td>
</tr>
</tbody>
</table>

**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)
v. Applied numerical analysis by C.F. Gerald, Wheatley, Patrick O (Pearson Educations Inc)
vi. Computational Cell Biology by C.P. Fall, (Springer)
Master of Science (Biophysics)
Semester IV
BPCC402: Dissertation

Marks: 450 Duration: 540 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.