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

Master of Science (Biophysics)

Semester I

GENCC204: RECOMBINANT DNA TECHNOLOGY

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

COURSE OBJECTIVES:

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

COURSE LEARNING OUTCOMES:

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

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

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

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

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

CONTENTS:

Unit I

Methods of DNA, RNA and protein analysis:

[8]

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

Unit II

Gene cloning and identification

[18]

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

Construction of DNA libraries

Genomic and cDNA libraries; Screening of genomic and expression libraries

Gene identification

Subtractive hybridization, chromosome walking and jumping

Genome sequencing

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

Unit III

Expression Analysis [14]

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

Unit IV :

[16]

Protein expression, engineering and interactions

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

Unit V [4]

Applications of recombinant DNA technology in biology and medicine

Gene editing technologies

Suggested readings:

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

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

Master of Science (Biophysics)

Semester II

BPEC201: Photo-Biophysics, Radiation & Environmental Biophysics

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

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

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

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

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

CONTENTS:

UNIT I.

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

[6]

UNIT 2.

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

[6]

UNIT 3.

Radiation in Environment:

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

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

(iii) Electromagnetic Radiations and classification.

[14]

UNIT 4.

Radiation Biophysics:

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

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

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

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

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

[20]

UNIT 5.

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

[4]

Ecosystem Analysis: Population Dynamics, Prey-Predator Models

[6]

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

[4]

TEACHING PLAN:

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

Facilitating the achievement of Course Learning Outcomes

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

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

SUGGESTED READINGS:

Latest editions of following books are recommended:

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

Master of Science (Biophysics)

Semester II

BPEC202: Programming and Data Analytics

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

CO2: Apply R for inference from data

CO3: Use R-studio to write R scripts

CO4: Apply selected probability distributions to solve problems

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

CONTENTS:

UNIT 1:

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

[16]

UNIT 2:

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

[8]

UNIT 3:

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

[6]

UNIT 4:

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

[8]

UNIT 5:

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

[22]

TEACHING PLAN:

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

Facilitating the achievement of Course Learning Outcomes

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

SUGGESTED READINGS:

Latest editions of following books are recommended:

i. R Programming for Data Science, by Roger D. Peng,lulu.com, ISBN-10: 1365056821
ii. https://leanpub.com/rprogramming
iii. http://dss.princeton.edu/training
iv. Using R for Introductory Statistics, by John Verzani, Chapman & Hall/CRC, Second Edition 2014,ISBN 1466590734
v. Advanced R, by Hadley Wickham, ISBN 9781466586963.
vi. R for Everyone: Advanced Analytics and Graphics Paperback – 2014Pearson Education India; 1 edition (2014)ISBN-10: 9332539243

Master of Science (Biophysics)

Semester II

BPCC203: Practicals - II

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

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

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

CONTENTS:

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

Master of Science (Biophysics)

Semester III

BPCC301: Cellular Biophysics and Bioenergetics

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

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

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

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

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

CONTENTS:

UNIT 1.

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

[6]

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

[6]

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

[6]

UNIT 2.

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

[6]

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

[4]

UNIT 3.

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

[5]

UNIT 4.

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

[6]

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

[7]

UNIT 5.

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

[4]

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

[10]

TEACHING PLAN:

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

Facilitating the achievement of Course Learning Outcomes

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

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

SUGGESTED READINGS:

Latest editions of following books are recommended:

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

3.

Master of Science (Biophysics)

Semester III

BPCC302: Physiological Biophysics

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES

CO1: Should be able to design nutrition.

CO2: Should be able to understand blood related disorders and recommend precautions.

CO3: Should understand functioning of healthy muscles and diagnose muscle disorders.

CO4: Should understand the functioning of the heart and recommend its healthy maintenance.

CO5: Should be able to give recommendations for respiratory problems.

CO6: Should understand the biophysical principles of the functioning of the kidney and its maintenance.

CO7: Should understand the role of various hormones in animal & human bodies.

CONTENTS:

UNIT 1.

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

[8]

UNIT 2.

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

[10]

UNIT 3.

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

[8]

UNIT 4.

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

[8]

UNIT 5.

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

[10]

UNIT 6.

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

[8]

UNIT 7.

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

[8]

TEACHING PLAN:

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

Facilitating the achievement of Course Learning Outcomes

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

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

SUGGESTED READING:

Latest editions of following books are recommended:

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

Master of Science (Biophysics)

Semester I

MBCC301: Molecular Biology

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

COURSE OBJECTIVES:

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

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student:

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

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

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

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

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

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

CO7: is able to describe post-translational processes

CONTENTS:

Unit I:

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

[8]

Unit II:

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

[10]

Unit III:

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

[8]

Unit IV:

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

[10]

Unit V:

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

[10]

Unit VI:

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

[12]

Unit VII:

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

[6]

SUGGESTED READINGS:

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

Master of Science (Biophysics)

Semester III

BPEC301:Methods in High-throughput Biology

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

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

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

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

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

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

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

CONTENTS:

UNIT 1:

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

[8]

UNIT 2:

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

[6]

UNIT 3:

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

[6]

UNIT 4:

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

[5]

UNIT 5:

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

[10]

UNIT 6:

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

[5]

UNIT 7:

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

[10]

UNIT 8:

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

[10]

TEACHING PLAN:

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

Facilitating the achievement of Course Learning Outcomes

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

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

SUGGESTED READINGS:

Latest editions of following books are recommended:

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

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

Master of Science (Biophysics)

Semester III

BCCC302: Developmental Biology

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

COURSE OBJECTIVES:

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

Course Learning Outcomes:

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

CONTENTS:

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

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

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

Unit IV: Model systems

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

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

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

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

SUGGESTED READINGS

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

TEACHING PLAN:

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

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

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

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

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

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

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

Week 8: Introduction of model organisms and their applications.

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

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

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

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

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

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

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

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

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

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

Facilitating the achievement of Course Learning Outcomes

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

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

Master of Science (Biophysics)

Semester III

BPCC303: Practicals-III

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

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

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

CONTENTS:

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

Master of Science (Biophysics)

Semester IV

BPCC401: Membrane Biophysics and Neuro-Biophysics

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

CO2: Should understand the functioning of the nervous system.

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

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

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

CO6: Should understand newer mechanisms of learning.

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

CONTENTS:

UNIT 1.

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

[14]

UNIT 2.

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

[10]

UNIT 3.

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

[10]

UNIT 4.

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

[10]

UNIT 5.

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

[10]

UNIT 6.

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

[2]

UNIT 7.

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

[4]

TEACHING PLAN:

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

Facilitating the achievement of Course Learning Outcomes

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

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

SUGGESTED READINGS:

Latest editions of following books are recommended:

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

Master of Science (Biophysics)

Semester IV

BPOE401: Theoretical and Mathematical Biology

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

COURSE OBJECTIVES:

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

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

COURSE OUTCOMES:

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

CONTENTS:

UNIT 1.

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

[14]

UNIT 2.

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

[8]

UNIT 3.

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

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

[10]

UNIT 4.

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

[8]

UNIT 5.

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

[6]

UNIT 6.

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

[8]

UNIT 7.

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

[6]

TEACHING PLAN:

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

Facilitating the achievement of Course Learning Outcomes

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

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

SUGGESTED READINGS:

Latest editions of following books are recommended:

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

Master of Science (Biophysics)

Semester IV

BPCC402: Dissertation

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

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

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

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