BIOPHYSICS — M D

PREAMBLE

The MD (Biophysics) course serves to interface the various disciplines – biology, medicine, physical sciences and computer applications. The students undergo training in an environment of advanced research in various aspects biophysics. They receive a sound theoretical knowledge coupled with a demanding practical application. By the end of the course, the student is confident to discuss and dissect any aspect biophysical problem related to clinical sciences.

OBJECTIVES

The course aims to impart to the students

1. a sound theoretical perspective of biophysics
2. practical skill to use biophysical techniques
3. capability to evaluate any published work
4. capability to carry out independent research

SALIENT FEATURES

1. regular lectures by the faculty on the basics and current aspects of biophysics
2. group discussions to critically evaluate the work
3. seminars to review and update the developments in biophysics
4. thesis embodying advanced research
5. computer training and applications
6. use of bioinformatic tools

EXAMINATION

1. Theory examination

   Paper – I

   Paper – II

   Paper – III

Paper – IV

2. Practical Examination

   One experiment in any of the biophysical techniques taught - one day

3. *Viva voce* Examination

   Thesis presentation

   Bench *Viva voce*

   General *Viva voce*

The detailed curriculum to achieve the above objectives is detailed below. It contains four sections of theoretical course and one section of practical course. Besides these, the students require to complete a thesis in any of the research activities of the faculty. To help in acquiring theoretical knowledge, additional resources are indicated in appendix – 1.

I. ALLIED BIOPHYSICS

II. BIOPHYSICAL TECHNIQUES

III. CELLULAR AND MOLECULAR BIOPHYSICS

IV. APPLIED BIOPHYSICS

V. LABORATORY EXPERIMENTS

VI. THESIS

APPENDIX - 1

PAPER I

ALLIED BIOPHYSICS, MOLECULAR PHARMACOLOGY, BIOSTATISTICS, BIOMECHANICS AND MEDICAL INFORMATICS

MOLECULAR PHARMACOLOGY

Definition and determination of important pharmaco-kinetic, parameters, pharmacokinetic basis of individual difference in response to drugs, pharmacokinetic properties, pharmacophore identification, influence of structural modifications on pharmacokinetic properties. Mode of action of drugs, quantitative structure-activity relationship, present and future aids to drug-design.

Hormones and Drugs

Structure and conformation of drugs and receptors, drug-receptor binding forces, haemoglobin as a model receptor, steroid conformation, receptor binding and hormone action, structural aspects of drug-nucleic acid interactions.

BIOMECHANICS

Basic concepts of fluid dynamics, Bernoulli equation and its applications, streamline flow, Reynolds number, viscous flow, effects of gravity and external acceleration on circulation.

BIOSTATISTICS

Mean, Mode, Dispersion, SD, Correlation & Regression, T-Test, chi-square test, F-test and ANOVA (theory) how to enter data, edit/modify data, transform data, descriptive statistics i.e. how to calculate

mean, SD, range etc., Frequency distribution, Hypothesis tests for means and proportions, ANOVA, scatter plot, correlation matrix, Regression, probability dist.

MEDICAL INFORMATICS

Medical data collection, storage and analysis of hospital data using computers, computers in medical instrumentation and diagnosis.

PAPER II

BIOPHYSICAL TECHNIQUES AND COMPUTER PROGRAMMING

BIOPHYSICAL TECHNIQUES

Spectroscopic Techniques

Basic principles, instrumentation and applications of visible, ultraviolet, infra-red, optical rotatory dispersion, circular dichroism and Raman spectroscopies.Basic principles of nuclear magnetic resonance, nuclear Larmor precession in the applied magnetic field, precessing nucleus in an oscillating radio frequency field, spin-spin and spin-lattice relaxations, introduction to continuous wave and Fourier transform NMR, applications of NMR spectroscopy to biomolecules.

Principles and instrumentation of electron spin resonance, spin hamiltonian and its use to study biomolecules, spin probes and their uses, principles of Mossbauer spectroscopy, quadrupole splitting, isomer chemical shift and magnetic hyperfine splitting, applications of Mossbauer spectroscopy in medicine and biology.

Electron Microscopy

Basic principles, procedures and applications in biology and medicine.

X-Ray Diffraction Techniques

Methods of recording the X-ray diffraction patterns: rotation method, Weissenberg method, precession method, precession rotation method and diffractometer methods. Methods of protein structure analysis, crystallization of proteins, symmetry in molecules and crystals, Principle of X-ray diffraction, isomorphous replacement, molecular replacement method.

Separation Techniques

Basic principles and application of electrophoresis, centrifugation and chromatography.

Molecular Modelling

Basic principle of modeling, Modeling by energy minimization technique, Concept of rotation about bonds, Energy minimization basic technique for samll molecules. Ramachandran plot, Torsional space minimization. Energy minimization in Cartesian space. Molecular mechanics basic principle. Molecular dynamics basic principles.

COMPUTER PROGRAMMING

Basic principles of Digital Computers, flow chart, constants & variables, Arithmetic operations and expressions, statements, Arithmetic assignment statements, labeling and unconditional GOTO, computed and assigned GOTO statements, IF statements, simple I/O, DO statements, arrays, standard functions, programming style, writing simple programs.

PAPER III

CELLULAR AND MOLECULAR BIOPHYSICS

CELLULAR BIOPHYSICS

Organization and structure of prokaryotes and eukaryotes, plasma membrane, organelles, nucleus and cytoplasm, functions of membranes, organization and replications of, transcription, translation and regulation of gene expression in malignancy, differentiation, cell cycle.

MOLECULAR BIOLOGY

Central Dogma, Genetic code, gene and operon, Structure of DNA and RNA, extrachromal elements, plasmids, selectable markers, gel electrophoresis, polymerase chain reaction (PCR), cloning PCR products, expression vectors, DNA sequence analysis, cDNA libraries, genomic libraries, applications of molecular biology methods, using internet resources in molecular biology.

MOLECULAR BIOPHYSICS

Nature of Chemical Bonds

Introduction to chemical bonds, relation between bond type and structure of molecules, small molecular groups in biology, their structure and binding properties.

Protein Structure and Function

Nature and function of globular proteins, basic principle of protein structure, amino acids, peptide structure, secondary structure of polypeptides and proteins, tertiary structures of haemoglobin, myoglobin, trypsinogen, trypsin, collagen and membrane proteins, interactions of proteins with small molecules and ions.

Nucleic Acids

Watson-Crick structure of DNA, polymorphism of DNA, helix coil transition and DNA and melting point, DNA super coiling and nucleosome structure, protein-DNA recognition, crystallographic study of oligonucleotides, structure of t-RNA.

Lipids

Structure of lipids, phase changes in lipids, their role in pathogenesis of atherosclerosis, gall stone formation, structure of membranes, membrane receptors, transport across membranes.

Contractile proteins

Role of contractile proteins in cell function and muscle contraction.

PAPER IV

APPLIED BIOPHYSICS:IMAGING TECHNIQUES, RADIATION BIOPHYSICS, NUCLEAR MEDICINE, BIOELECTRICITY

IMAGING TECHNIQUES

Ultrasound, nuclear magnetic resonance and positron emission tomography, computerized axial tomography, whole body scanner, dose calibrators, gamma scientillation camera, digital imaging techniques, acquisition, analysis and processing of data from Gamma camera, enhancement, tomographic reconstructioon, display and recording of the image.

RADIATION BIOPHYSICS

Production and types of radiations, radiation measurement units, interaction of radiation with matter, detection of radiation by ionization chamber, G.M. counter, proportional counter, liquid scientillation counter, radiation protection, molecular effects of radiation on membranes, cytoplasmic organelles, macromolecules, factors modifying effects of radiation, repairs of radiation induced damage.

WEAK FIELD EFFECTS

Effects of electromagnetic field, microwaves and gravitational fields on living systems

RADIOPHARMACEUTICALS

Production of radio-nuclides by reactors, cyclotrons and particle accelerators, use of radio nuclide generators, elements of radio-chemistry.

DIAGNOSTIC USES OF RADIONUCLIDES

In vivo imaging and functional studies of brain, thyroid, heart, biliary, liver, kidney , spleen, tumors, bones and abscesses.

Use of imaging devices and external detectors for organ imaging; time dependent and differential functional studies, use of physiological gating techniques for functional studies, methodology and quality control of competitive binding and radio immunoassay, procedures for the measurement of peptide hormones, drugs and other biological substances, basic principles of radionuclide therapy in thyrotoxicosis, carcinoma of thyroid.

BIO-ELECTRIC POTENTIALS

Principle and interpretations of electro-encephalogram, electro-cardiogram, and electro-retinogram.

PAPER V

LABORATORY EXPERIMENTS

1. Determination of unit cell constants using Weissenberg method.
2. Single crystal X-ray diffraction patterns from protein crystals using precession method.
3. Writing of small computer program for calculating mean and standard deviations.
4. PCR Experiment
5. Determination of Molecular Weight by SDS
6. DNA Electrophoresis.
7. Isolation of plasmid DNA.
8. Simulate ten base pairs of DNA in B-form with given sequence and determine the specified distances and angles.
9. To simulate alpha helix/beta sheet of protein with given sequences and determine specified angles and distances.
10. To plot phi-psi map for a given tripetide.
11. To fit a set of data points in a straight line.

PAPER VI

THESIS

The students are required to submit a thesis by research to the Institute six months before the final examination. External examiners will evaluate the thesis. An approval of the thesis is essential for the candidate to take the final examination.

APPENDIX – 1

Internet usage for data retrieval from various databases

Internet for various software usage

Internet usage for data retrieval in research, molecular biophysics, molecular structure, pharmacology journals: structural studies in all journals, in particular PNAS (USA), Nature, JMB, Biochemistry, JBC, EMBO, Science, Acta Crystallogr. D.