Department of Biophysics

University of Delhi South Campus

Proposal

M.Phil Biophysics

The Department of Biophysics proposes to begin a course **Master of Philosophy (M.Phil) in Biophysics**. As per the revised Ph.D ordinance, the M.Phil/Ph.D program is supposed to have a common entrance test and course work. Further, students who successfully complete the course work for M.Phil can appear directly for interviews for selection to Ph.D. The student is also exempted from doing a course work during Ph.D. The proposed M.Phil (Biophysics) curriculum has kept the above mentioned facts in view. The faculty members believe that this will enable the department to carry out specialized teaching and allow vertical movement of the students. In future this could also enable the faculty to design an integrated M.Phil/Ph.D program.

The Course committee may kindly recommend the following:

1. That a program in M. Phil Biophysics be initiated in the department
2. M.Phil in Biophysics will run as per the ordinances and guidelines of the University.
3. The intake of the students will depend upon the available vacancies for a given academic year, which will be advertised. The eligibility criteria will be governed by the M.Phil ordinance in force at the time.
4. The admission to M.Phil will be through an entrance test followed by an interview held in common for that of the Ph.D program in Biophysics.
5. The students will be required to complete a course work consisting of 3 papers (of which Research Methodology is mandatory) amounting to 300 marks & 12 credits (100 marks each x 3 = 300 marks; 4 credits x 3 = 12 credits) in addition to the dissertation of 300 marks (12 credits) including viva.
6. Currently, the department will offer the following papers (details are given separately)):
    i. Paper I (BPHY001): Information Processing and the Brain
    ii. Paper II (BPHY002): Physical Methods in Biology
    iii. Paper III (BPHY003): Computer Applications in Biology
    iv. Paper IV (BPHY004): Omics Biology
    v. Paper V (BPHY005): Research Methodology
7. In addition to the above mentioned papers, students may opt for pre-PhD course papers being offered by other departments of **Faculty of Inter-disciplinery & Applied Sciences**, University of Delhi South Campus, if and where available.

अध्यक्ष / HEAD
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BPHY001: Information Processing and the Brain
(4 Credits)

Preamble: In recent years there has been a lot of exchange of knowledge among neurobiology, computer science/ informatics, physics, mathematics, psychology/ behavioral science and other disciplines. This has not only enriched Brain Science, but also took it beyond the typical boundaries of biology. Keeping in view these developments in Brain research the present course has been designed in order to keep the students up to date about the interfaces of the above-mentioned disciplines. This is a course which comes under the category of Cognitive Neuroscience, a true interdisciplinary in nature.

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.

[16 classes]

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

[10 classes]

3. **Computability:** Origin of the concept of computability; Turing machines; Logic circuits; principles of functioning of a computer.

[4 classes]

4. **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 classes]

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

[10 classes]

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

[10 classes]

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

[2 classes]

8. Open discussions on the interface of artificial neural net and the brain.

[2 classes]

Suggested Books

1. Scott, A. (2002) Neuroscience: A Mathematical Primer, Springer
2. Churchland, P.S. & Sejnowski, T.J. (1999). The Computational Brain, MIT Press.
3. Nelson, P. C. (2004). Biological Physics, W.H. Freeman & Co., Chapter 12.
4. Gazzaniga, M.S. et al. (2002). Cognitive Neuroscience: The Biology of the Mind, W.W. Norton & Co.
5. Rosenzweig et.al. (2005). Biological Psychology, Sinauer Associates, Inc.
6. Kendel, (2002). Principles of Neural Science.
7. Lytton, W.W. (2002). From Computers to Brain, Springer.
8. Haken, H. (2002). Brain Dynamics, Springer.
9. Kluwe, R.H. et al. (2003). Birkhauser.
10. Landau, L.J. & Taylor, J.G. (1998) Concepts for Neural Networks, Springer.

Evaluation:

1. 50% on written test (End Semester Examination).
2. 25% on term papers/ periodic evaluation.
3. 25% on Seminar presentation/ discussions.

BPHY002: Physical Methods in Biology
(4 Credits)

Pereamble: In almost all the researches in experimental biology methods based on the principles of Physics are used. While using equipments (optical and others) it is necessary for the students to understand the principles in order to achieve correct analysis of the experimental data and to design new and suitable experiments. The present course is designed keeping in view the above-mentioned points.

Details of the Course:

1. **Spectroscopy:**
   i. Historical background of development of optics; Corpuscular theory of light; Wave theory of light; Electromagnetic theory of light; Planck's concept and modern theory of light; Electronic structures of atoms & molecules; Theory of chemical bonding.
   [2 classes]
   ii. Scattering of Light.
   [2 classes]
   iii. UV & Visible absorption spectrophotometry; Lambert Beer's Law; molar extinction coefficient and its determination; instrumentation & applications.
   [6 classes]
   iv. Fluorescence Spectroscopy: principles and applications; Polarization of light; Fluorescence studies of plane-polarized light.
   [6 classes]
   v. Optical Rotatory Dispersion (ORD); Circular Dichroism (CD).
   [8 classes]
   vi. Fundamentals of X-ray Crystallography: instrumentation and biological applications.
   [8 classes]
   vii. Principles of magnetic resonance; Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR) and biological applications; Relaxation studies.
   [8 classes]
2. **Hydrodynamic Methods:** Viscosity; Sedimentation equilibrium and Velocity Centrifugation; Density Gradient method; Applications to bio-macromolecules and bio-materials.
   [4 classes]
3. **Chromatography:** Partition and Absorption Chromatography; Paper and thin layer chromatography, gel filtration; Ion-exchange and affinity chromatography; GLC, HPLC and FPLC; Emerging trends in chromatography.
   [6 classes]
4. **Electrophoresis:** Behavior of bio-macromolecules in electric fields; Types of electrophoresis; PAGE; Agarose Gel Electrophoresis; 2D Electrophoresis; Dialectrophoresis.

[4 classes]

5. **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.

[2 classes]

6. **Emerging topics in Biophysical methods,**
   - (i) **Electron Microscopy** [2 classes]
   - (ii) **Confocal Microscopy** [2 classes]
   - (iii) **Mass Spectroscopy** [2 classes]
   - (iv) **Any other new topic** [2 classes]

Suggested Books

1. **Physical Biochemistry.** David Freifelder, (1984), W.H. Freeman & Co.
2. **Biological Spectroscopy. L.D.** Cambell & R. Dwek (1984), Benjamin-Cumming Pub. Co.
3. **Biophysical Chemistry.** C. Cantor & P. Schimmel (1980), W.H. Freeman & Co.

Evaluation:

1. 50% on written test (End Semester Examination)
2. 25% on term papers/ periodic evaluation.
3. 25% on Seminar presentation/ discussions.

BPHY003: Computer Applications in Biology

(4 Credits)

Section 1: Sequence analysis

a. **Biological Databases:** Introduction, biological databases – primary, secondary and structural, Protein and Gene Information Resources. Specialized genomic resources.

[4 classes]

b. **Sequence formats:** Different formats of molecular biology data.

[4 classes]

c. **Sequence alignment:** Methods and algorithms of pairwise and multiple sequence alignment. Database similarity searching, global and local alignment, alignment scoring matrices.

[4 classes]

d. **Notion of homology:** Concept of orthology, paralogy and homology in gene and protein sequences.

[4 classes]

e. **Molecular Phylogenetics:** Methods and tools for phylogenetic analysis, creation evaluation and interpretation of evolutionary trees, advantages and disadvantages of phenetic and cladistic approaches, motif detection, protein families.

[8 classes]

f. **Genomics and Gene Annotation:** Organization of the prokaryotic and eukaryotic genomes; Genome databases; Annotation of genome, automated in-silico methods of finding gene and relevant features.

[8 classes]

Section 2: Structural Bioinformatics

a. **Protein structure:** Amino acid properties, Levels of Protein structure, General properties and characteristics.

[2 classes]

b. **Structure determination methods:** ***i) X-ray crystallography:*** crystallography as microscopy, Principles and techniques of macromolecular crystallization, data collection, structure solution and refinement methods, Validation of structures ***ii) NMR:*** Principles of nuclear spin and magnetic resonance, biological applications.

[4 classes]

c. **Protein structure databases:** Understanding structures from Protein Data Bank (PDB).

Accessing and mining other protein structure classification databases such as SCOP, CATH.

[4 classes]

d. **Molecular visualization:** tools for viewing and interpreting macromolecular structures.

[2 classes]

e. **Protein secondary structure prediction:** Ab-initio and homology based methods.

[2 classes]

f. **Protein structure comparison:** Various algorithms and programs for superimposition of structures, RMSD calculations, multiple structure alignment methods such as DALI and VAST.

[4 classes]

g. **Basics of Molecular Modeling:** Basic principles of tertiary structure prediction, Homology modeling.

[4 classes]

h. **Advanced methods of protein structure prediction:** Threading and *ab-initio* protein structure prediction.

[4 classes]

i. **Inferring Function from protein Structure:** using evolutionary information, gene neighbourhood, phylogenetic profiles, gene fusion, catalytic templates, prediction and analysis of binding cavities for function prediction. [3 classes]

j. **Molecular Interaction Networks:** introduction to networks for pathways, reaction kinetics, kinetic modeling and flux balance

[3 classes]

Suggested Readings:

1. Introduction to Computational Biology: An Evolutionary Approach, By Haubold&Wiele, Springer International Edition.
2. Introduction to Bioinformatics, A. Lesk. OUP- India. Essential Bioinformatics by Jin Xiong, Cambridge University Press.
3. Statistical methods in Bioinformatics: An introduction by W. Ewens and G.R. Grant Springer-Verlag.
4. Bioinformatics: Sequence and genome analysis, by David mount, 2nd edition. Cold Spring Harbor lab press.
5. Bioinformatics: A practical guide to the analysis of genes & proteins. Edited by Baxevanis&Outlette, John Wiley & sons, inc. publication.
6. An Introduction to Protein Informatics by Karl-Heinz Zimmermann, Springer International Edition. Fundamental Concepts of Bioinformatics by Krane, Pearson Education.
7. Discovering Genomics, Proteomics and Bioinformatics, 2nd ed. by Campbell

Pearson Education.

8. Structural bioinformatics: an algorithmic approach. F. J. Burkowski. Chapman & Hall/CRC, 2009.
9. Structural Bioinformatics, 2nd Edition, Jenny Gu (Editor), Philip E. Bourne (Editor), Wiley-Blackwell.

Evaluation:

100% on written test (End Semester Examination).

BPHY004:Omics Biology

(4 Credits)

Section 1:

1. **Proteomics:** application of mass spectroscopy for identification of proteins, conformational variants of proteins, structural and functional implications of post-translation modifications, intrinsic protein disorder, protein motion and simulation, current developments and recent progress.

[8 classes]

2. **Structural Genomics:** aims and need, high throughput methods of structure determination, inferring function from structure,methods to detect positive selection in genes, structure-function implications of type-I and type-II functional divergence signals in proteins,protein engineering,current developments.

[8 classes]

3. **Macromolecular Interactions:** predicting, analyzing and comparing interaction of proteins with DNA, small ligands and other proteins. Methods and applications of docking approaches,current developments.

[8 classes]

4. **High throughput lead screening:** Different approaches to drug designing, high throughput vs. rational drug designing, target identification & validation, analyzing the active site of a target, scoring & lead optimization. Objective and concept of QSAR,current developments.

[8 classes]

Section 2:

1. **High Throughput Genomic Sequencing:** 1000 Genome Projects, ENCODE, NGS vs conventional sequencing,Different file formats, basic concepts of computing sequencing data in terms of algorithm and data structure? Metagenomics of Microbial Communities,current developments.

[8 classes]

2. **Metabolomics:** Introduction to spectroscopic analytical platforms (MS & NMR) commonly used in metabolic profiling. Metabolomics standards and databases e.g. KEGG, BioCyc, MetExplore and Cytoscape for metabolic pathway and network analysis,current developments.

[8 classes]

3. **Large Scale Gene Expression Analysis (Microarray, Transcriptomics):** Data preprocessing and normalization, Identification of differential genes (including methods suitable for NGS data analysis) Clustering, down-stream enrichment analyses,current developments.

[8 classes]

4. **Genome-wide Association Studies (GWAS):** Introduction and need of GWAS.Study design at marker, gender and subject levels. Progress and promises of GWAS,current developments.

[8 classes]

Suggested Readings:

1. Microarray Bioinformatics by DovStekel, published by Cambridge University Press.
2. Structural Bioinformatics, 2nd Edition, Jenny Gu (Editor), Philip E. Bourne (Editor), Wiley-Blackwell.
3. Salzberg SL. Nucleic Acids Res. 2001 Mar 1;29 (5): 1185-90. 8. Resources for Small Regulatory RNAs.
4. George W.Bell, Fran lewitterCurrent Protocols in Molecular Biology. Unit Number : UNIT 19.8 DOI: 10.1002/0471142727. mb 1908s87.

Evaluation:

100% on written test (End Semester Examination).

BPHY005: Research Methodology
(4 Credits)

Research Methodology: What is a research problem? Philosophy and meaning of research, identification and definition of research problem, Survey of available literature and bibliographical research, search and verification of facts, the analysis of evidence; truth & causation, sources of prejudice and bias. Formulation of Research problem

[2 classes]

Science in Indian context: History and evolution of Science in India, societal impressions of scientists and research in India, historic milestones in modern Indian science (case studies), current challenges.

[2 classes]

Ethical Research: Current understanding of ethics, international code and guidelines, historical perspectives.

[2 classes]

Plagiarism: Concept and importance of understanding plagiarism, what is and what is not plagiarism? Methods and ways to detect and avoidplagiarism, available tools and software to detect plagiarism.

[6 classes]

Intellectual Property Right: Concepts and types of intellectual property.Who needs intellectual property protection?Objectivesand differences among patent, copyright and trademark. Procedure for obtaining a patent, protection against infringement,Indian and global institutions involved in IPR,issues in patentability,Search engines for patent, IP for Bioinformatics, types of Bioinformatics Patents.

[6 classes]

Statistical Analysis of Data: Statistical analysis, measures of central tendency, measures of dispersion, measures of association/relationship, regression and correlation analysis, hypothesis testing (for proportion and means), test of significance.

[16 classes]

Basic Computer: Introduction and working knowledge of Windows,Linux,Unix,Mac.

[5 classes]

Use of ICT in Research: methods to search required information effectively,Reference Management Software like Zotero/Mendeley, tools for paper formatting like LaTeX/MS Office, tools for bibliographymanagement in research papers and thesis.

[6 classes]

Research writing: Prewriting considerations, preparation of Manuscripts, research paper writing, book reviews, difference between literature review for thesis and review articles, difference between summary and abstracts, writing research grant proposals, referencing and citation methods/styles, Structure, language and style in the thesis. Foot–notes, diagrams, bibliographies, index, quotation and translation,Reference management software.

[6 classes]

Research presentation: Making posters, delivering oral presentations, conference presentations vs. dissertation presentations.

[4 classes]

Publishing Research: Open source *vs* traditional journal publishing, understanding of impact factors and citation index.

[3 classes]

Good lab practices: recording data, lab safety, guidelines on safe use of reagents and chemicals, Bio-safety issues, handling and disposal of chemical, radioactive and biological hazardous material,Computer lab safety rules.

[6 classes]

Suggested Readings:

Study material will be provided with each topic.

Evaluation:

1. 50% on written test (End Semester Examination).
2. 50% on term papers/ Seminar presentation/ discussions.