SYLLABUS FOR COURSES OFFERED IN PH.D. COURSE WORK

(Applicable from January 2016 onwards)

Department of Biophysics,
University of Delhi South Campus,
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DEPARTMENT OF BIOPHYSICS
FACULTY OF INTERDISCIPLINARY AND APPLIED SCIENCES
UNIVERSITY OF DELHI SOUTH CAMPUS

Syllabus for Ph.D Course Work

The department offers the following five papers for Ph.D course work.

PAPER I (BPHY001): Physical Methods in Biology
PAPER II (BPHY002): Information Processing and the Brain
PAPER III (BPHY003): Computer Applications in Biology
PAPER IV (BPHY004): Omics Biology
PAPER V (BPHY005): Research Methodology

PAPER I is designed to introduce the students to the principles of various instrumental techniques (optical and others) in order to achieve correct analysis of the experimental data and to design suitable experiments.
PAPER II is designed in order to keep the students up to date about the interfaces and exchange of knowledge among neurobiology, computer science/ informatics, physics, mathematics, psychology/ behavioral science and other related disciplines which come under the category of Cognitive Neuroscience.
PAPER III deals with the basics of the interdisciplinary field, popularly known as 'Bioinformatics', which harnesses computer science, mathematics, physics, and biology. This paper will introduce different biological databases and analysis tools used for this purpose.
PAPER IV will provide an overview of the important concepts of different topics of high throughput techniques, their advantages and disadvantages and also the interpretation and analysis of result.
PAPER V is design to impart an overview of research intent and design, methodology and technique, format and presentation, data management and analysis, commonly used statistical methods, ethical, IPR and other relevant issues to the students so that they can carry out research in more systematic, efficient and effective manner.

These courses are also open to students from other departments. The students of the department are also free to choose papers for Ph.D courses offered by other departments. A student has to pass three papers in one year (two semesters), including one compulsory paper on "Research Methodology" to successfully complete the Ph.D course work.

Evaluation: The total marks for all papers are 100 and a student has to score at least 50 to pass the course. The distribution of marks for different evaluation methods is shown:

	Total Marks (100)			
Paper Number	Semester	End Semester exam	Term paper submission	Presentation & Discussion of term Paper
BPHY001	I (July-Dec)	50	25	25
BPHY002	II (Jan-May)	50	25	25
BPHY003	Both (I & II)	100	NIL	NIL
BPHY004	Both (I & II)	100	NIL	NIL
BPHY005	Both (I & II)	50	25	25

Department of Biophysics, UDSC

Course Title: Physical Methods in Biology

Teacher: Dr. Subhendu Ghosh

Preamble:

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.

Syllabus:

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.

   [4 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.

   [6 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.

[4 classes]

6. **Emerging topics in Biophysical methods.**

[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.
2. 25% on term papers/ periodic evaluation.
3. 25% on Seminar presentation/ discussions.

Department of Biophysics, UDSC

Course Title: Information Processing and the Brain

Teacher: Dr. Subhendu Ghosh

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.

Syllabus:

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.
2. 25% on term papers/ periodic evaluation.
3. 25% on Seminar presentation/ discussions.

Department of Biophysics, UDSC

Course Title: Computer Applications in Biology

Teachers: Drs. Manisha Goel & Manish Kumar

Preamble:

Modern biological data generation and interpretation can't be done without use of computational tools. Further the large amount of data from the genome projects has necessitated establishment of computer databases that feature rapid assimilation, usable formats and algorithm software programs for efficient management and interpretation of biological data. This has given rise to an interdisciplinary field, popularly known as 'Bioinformatics', which harnesses computer science, mathematics, physics, and biology. This paper will introduce different biological databases and analysis tools used for this purpose.

Syllabus:

Section 1: Sequence analysis

1. **Biological Databases:** Introduction; Types of databases in terms of biological information content; Protein and gene information resources. Specialized genomic resources.

[4 classes]

2. **Sequence Formats:** Different formats of molecular biology data.

[4 classes]

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

[4 classes]

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

[4 classes]

5. **Molecular Phylogenetics:** Methods and tools for phylogenetic analysis; Creation evaluation and interpretation of evolutionary trees; Advantages and disadvantages of phenetic and cladistic approaches.

[8 classes]

6. **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.

[8 classes]

Section 2: Structural Bioinformatics

1. **Protein Structure:** Amino acid properties; Levels of Protein structure; General properties and characteristics.

[2 classes]

2. **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]

3. **Protein Structure Databases:** Understanding structures from Protein Data Bank (PDB); Accessing and mining other protein structure classification databases such as SCOP, CATH.

[4 classes]

4. **Molecular Visualization:** Tools for viewing and interpreting macromolecular structures.

[2 classes]

5. **Protein Secondary Structure Prediction:** *Ab-initio* and homology based methods.

[2 classes]

6. **Protein Structure Comparison:** Various algorithms and programs for superimposition of structures; RMSD calculations, multiple structure alignment methods such as DALI and VAST.

[4 classes]

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

[4 classes]

8. **Advanced Methods of Protein Structure Prediction:** Threading and *ab-initio* protein structure prediction.

[4 classes]

9. **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.

[6 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:

1. 100% on written test.

Department of Biophysics, UDSC

Course Title: Omics Biology

Teachers: Drs. Manisha Goel & Manish Kumar

Department: Biophysics, UDSC

Preamble:

In the last decade, a revolution has taken place in the way in which biological research has been pursued. These developments have enabled us to cast the hypothesis in a system wide approach and do the experiments in a high-throughput manner to accept or reject the hypothesis. Most high-throughput methods result in generation of large amount of data (the so called 'Big Data'). The large amount of data is not only difficult to handle but also more difficult to analyze. Keeping these developments in view, the course curriculum for 'OMICS Biology' has been prepared. The new course curriculum shall provide ample opportunity to the students to expose themselves to the latest happenings in the biological research. The course will provide an overview of the important concepts of different topics of high throughput techniques, their advantages and disadvantages and also the interpretation and analysis of result.

Syllabus:

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:** Prediction, analysis and comparison of 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 and 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 Dov Stekel, 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 lewitter. Current Protocols in Molecular Biology. Unit Number: UNIT 19.8 DOI: 10.1002/0471142727. mb 1908s87.
5. Additional reading materials will be provided with each class.

Evaluation:

1. 100% on written test.

Department of Biophysics, UDSC

Course Title: Research Methodology

Teachers: Drs. Manisha Goel & Manish Kumar

Preamble:

The main purpose of this course is to introduce students to quantitative and qualitative methods for conducting meaningful inquiry and research. They will gain an overview of research intent and design, methodology and technique, format and presentation, data management and analysis, commonly used statistical methods, ethical, IPR and other relevant issues. These topics will develop each student's ability to become more effective, efficient and aware about the way they should conduct their research activities.

Syllabus:

1. **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]

2. **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]

3. **Ethical Research:** Current understanding of ethics; International code and guidelines; Historical perspectives.

   [2 classes]

4. **Plagiarism:** Concept and importance of understanding plagiarism; What is and what is not plagiarism? Methods and ways to detect and avoid plagiarism; Available tools and software to detect plagiarism.

   [6 classes]

5. **Intellectual Property Right:** Concepts and types of intellectual property; Who needs intellectual property protection? Objectives and 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]

6. **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); Tests of significance.

   [16 classes]

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

   [5 classes]

8. **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 bibliography management in research papers and thesis.

   [6 classes]