Centre for Interdisciplinary Research in Basic Sciences

Jamia Millia Islamia

Syllabus for Pre-PhD course

Semester I Module A

Compulsory courses (8 credits)

Fundamentals of Computing for Bioinformatics	(PPC 101)
Mathematics for Biologists	(PPC 102)
Fundamentals of Physics	(PPC 103)
Chemistry for Biologists	(PPC 104)

Semester I Module B

Compulsory courses (8 credits)

Fundamentals of Computing for Bioinformatics	(PPC 101)
Cell and Molecular Biology	(PPC 105)
Biochemistry and Biophysics	(PPC 106)
Biotechnology	(PPC 107)

Semester II

Optional courses (Any two, 4 credits)

Protein Structural Biology	(PPC 201)
Bioinformatics and Biomathematics	(PPC 202)
Nanotachnology and System Biology	(PPC 203)
Molecular Endrocrinology and Medicinal Chemistry	(PPC 204)
Molecular Virology	(PPC 205)

Compulsory courses (4 credits)

Seminars

Semester I (Module A)

(PPC 101) Fundamentals of Computing for Bioinformatics

Unit I **[06]**

Operating systems, Types of operating systems. Related operating system and their introduction. Introduction to various software packages. Machine learning techniques.

Unit II **[06]**

Concepts in computing and computer programming, Basic model of computing, Programming languages, compilation, linking, testing, debugging and documentation. Introduction to object -oriented programming.

Unit III **[06]**

Database system concepts and architecture, classification of DBMS, database languages. Data Mining and Knowledge discovery, Data Mining on Biological data.

Unit IV **[06]**

Introduction to genomics and proteomics, Human genome project, Techniques and methods**:** sequence file formats (FASTA, Gene Bank), structure file formats Bioinformatics tools, Getting started with PERL

Recommended books:

1) Operating Systems by Galvin, Addison Wessely , 2000
2) C++: How to program by Deitel & Deitel, Pearson Edition, 2002.
3) Fundamentals of Database Systems by Elmasari and Navathe, Prentice Hall (India) , 2001

4) Data Mining Concepts and Techniques- Jiawei Han, Micheline Kamber, Morgan Kaufmann publisher, 2001

5) Bioinformatics: An introduction, Jeremy J. Ramsden, Springer

6) Machine Learning and Soft Computing, Keeman V. , Pearson

7) Data mining in Bioinformatics, Wang J.T.et.al. , Springer

8) Basics of Perl, NIIT

(PPC 102) Mathematics for Biologists

Unit 1:Matrices and Determinant [6L]

Types of matrices, determinant and rank of a matrix, basic properties of determinant, minors and cofactors, expansion formula for determinant, adjoint and inverse of a matrix, system of non-homogenous and homogenous linear equations, Cramer's rule, geometrical interpretation of determinant as area or volume; Gaussian elimination and Gauss-Jordon elimination method.

Unit 2: Calculus (Differentiation and Integration [6L]

Differentiation: Derivative and its physical significance, basic rules of derivative (without derivation), maxima and minima, definition of exact and inexact derivatives, Leibniz theorem.

Integration: Basic rules for integration, geometric meaning of integration, definite and indefinite integrals, Riemann sums and definite integrals, substitution in definite integrals, Improper integrals, application in biology and chemistry.

Unit 3: Differential Equations [6L]

Order and degree of differential equations, ordinary differential equations of first degree and order (variable separable method), exact, linear and non linear differential equations, Bernoulli differential equations, second order differential equations, application of differential equations in chemistry and biology.

Unit 4: Numerical Methods [6L]

Solutions to non-linear algebraic equations by the method of iteration and Newton-Raphson method, numerical integration by trapezoidal rule and Simpson's rule,

numerical solutions of ordinary differential equations by pilchard's method of successive approximation, Euler's method and Rangu-Kutta method. Solving set of linear equations, Monte Carlo technique.

Recommended books:

1. Luedeman J.K and Lukawecki S. M., Elementary Linear Algebra, West Publishing Company (1986).
2. James S., Calculus, 2nd edition, Brooks/ Cole Publishing Company (1991).
3. Arfken G.B and Weber H.J Mathematical methods for Physicist –...
4. Rainville E.D. and Bedient P.E., Elementary Differential equations, Sixth Edition, Macmillan, New York, (1981).

(PPC 103) Fundamentals of Physics

Unit I: Mathematical Physics [6L]

Generalized co-ordinates, Lyapunov exponent and sensitive dependence on initial conditions, discrete time dynamics and maps. Fourier transformation, convolution. Basic postulates of statistical mechanics (Helmhotz's and Gibb's free energy, enthalpy and entropy), density of states, Photoelectric effect, de-Broglie relation, wave function and probabilistic interpretation, Particle in a box , simple harmonic oscillator (one dimensional).

Unit II: Electrodynamics [6L]

.

Electric field and potential, Columb's law, flux, dielectrics, polarization (right handed and left handed circularly polarized light), displacement vector, dielectric constant.

Unit III: Crystallography [6L]

Basis and Lattices, crystal structure, primitive cells, ionic, covalent, cooperative, electronic bonding, Hydrogen bonding, X-ray diffraction, optical microscopy (including confocal microscopy), electron microscopy (Scanning electron Microscopy, Transmission Electron Microscopy).

Unit IV: Spectroscopy: [6L]

Frank-Hertz experiment, UV-visible spectroscopy, Infra-Red (IR) (rotational and vibrational) spectroscopy, Fourier transform-infra-red (FT-IR) spectroscopy,

Photoluminescence (Fluorescence and Phosphorescence), laser spectroscopy, dynamic light scattering spectroscopy, Circular Dichroism, Raman and micro Raman spectroscopy, NMR, ESR, mass spectroscopy.

Recommended books:

1. University Physics, Sears, Zemansky, Young.

2. Introduction to Spectroscopy for Biologist -S.B. Brown

3. Spectroscopy for the Biological Sciences – G.G. Hammes

4. Fundamentals of molecular spectroscopy – Banwell.

5. Atomic and molecular spectroscopy – Saverg.

6. Concepts of modern Physics – A. Baiser.

(PPC 104) Chemistry for Biologists

Unit-I Thermodynamics [6 L]

Joule-Thomson effect, carnot cycle, calculation of entropy changes of an ideal gas with change in pressure, volume and temperature, application of clapeyron-clausius equation, experimental verification of third law.

Unit-II Solutions [6 L]

Fractional distillation of binary liquid solutions, azeotropic mixtures, distillation of immiscible liquids, solubility of partially miscible liquids.

Unit-III: Chemical kinetics [6 L]

Methods of determining order of a reaction, order and molecularity of a reaction, effects of temperature on reaction rates, effects of catalyst, theories of reaction rates.

Unit IV: Acid, Bases and Buffers [6 L]

Concepts of acids and bases (the ionization of water; definition of pH, pH-scale, Arrhenius concept; strength of acids and bases). The exact treatment of the ionization of monoprotic acid in water; Relation between initial acid concentration, pKa and pH, Henderson-Hasselbalch equation, dependence of ionization on pH solution, uses of the H-H equation, titration of strong and weak acids with strong base. Exact treatment of the ionization of diprotic acid. Exact treatment of Bronsted lowery type monobase. Salt hydrolysis. Buffer mixtures (buffering range, buffering capacity). pH indicators, Biological relevance of pH: buffering in living organism, effect of pH on protoplasmic components.

Semester I (Module B)

(PPC 101) Fundamentals of Computing for Bioinformatics

Unit I **[06]**

Operating systems, Types of operating systems. Related operating system and their introduction. Introduction to various software packages. Machine learning techniques.

Unit II **[06]**

Concepts in computing and computer programming, Basic model of computing, Programming languages, compilation, linking, testing, debugging and documentation. Introduction to object -oriented programming.

Unit III **[06]**

Database system concepts and architecture, classification of DBMS, database languages. Data Mining and Knowledge discovery, Data Mining on Biological data.

Unit IV **[06]**

Introduction to genomics and proteomics, Human genome project, Techniques and methods**:** sequence file formats (FASTA, Gene Bank), structure file formats Bioinformatics tools, Getting started with PERL

Recommended books:

9) Operating Systems by Galvin, Addison Wessely , 2000

10) C++: How to program by Deitel & Deitel, Pearson Edition, 2002.

11) Fundamentals of Database Systems by Elmasari and Navathe, Prentice Hall (India) , 2001

12) Data Mining Concepts and Techniques- Jiawei Han, Micheline Kamber, Morgan Kaufmann publisher, 2001

13) Bioinformatics: An introduction, Jeremy J. Ramsden, Springer

14) Machine Learning and Soft Computing, Keeman V. , Pearson

15) Data mining in Bioinformatics, Wang J.T.et.al. , Springer

16) Basics of Perl, NIIT

(PPC 105) Cell and Molecular Biology

Unit I: Cell Biology: [6 L]

Cellular structures and functions: plasma membrane, nucleus, chromatin and chromosome, mitochondria, chloroplast, golgi complex, endoplasmic reticulum, lysosomes, peroxisomes. Cell cycle and cell division. Cellular cytoskeleton.

Unit II: DNA Replication and RNA Transcription: [6 L]

Structures of DNA, RNA, DNA replication in prokaryotes. RNA transcription in prokaryotes. Post transcriptional modifications in RNA.

Unit III: Gene Expression and Regulation: [6 L]

Genetic code and degeneracy. Components and mechanism of translation. Post translational modifications of proteins. Overview of gene expression and regulation.

Unit IV: Applications of Molecular Biology: [6 L]

Cell-cell communication: overview of signal transduction. Gene Therapy, Gene silencing. Apoptosis, Cancer biology: oncogenes, proto-oncogenes. Stem cell biology.

Recommended books:

1. Robertis De 1987; Cell and Molecular Biology (8th edition); Lea and Febiger.
2. W. H. Freeman and Michael M. Cox (Fourth edition); Lehninger Principles of Biochemistry; Freeman and Company, New York.
3. B. D. Singh; Genetics (1st edition 2003); Kalyani publishers.

4. B. D. Singh; Biotechnology.

5. T. A. Brown; Gene Cloning and DNA analysis: An Introduction (Fifth edition); Blackwell Publishing.

6. P. C. Winter, G. I. Hickey, H. L. Fletcher. Instant Notes in Genetics (Second edition), Viva Books Pvt. Ltd.

(PPC 106) Biochemistry and Biophysics

Unit I: Amino Acids, Peptides and Proteins:

Twenty standard amino acids: conformation and configuration, acids-base behavior (pka and its determinations), zwitterions, isoelectric point. Peptide bond. Levels of structure in proteins, secondary, tertiary and quaternary structures. **[6L]**

Unit II: Carbohydrates, Lipids and Metabolism:

Sugars, Anomers and epimers. Classification. Sugar derivatives. Principle of energetics, glycolysis, tricarboxylic acid cycle. Oxidative phosphorylation. Lipids: Biological functions; classification into fatty acids, structure. **[6L]**

Unit III: Dynamics of Biological systems: System parameters and state functions, force and motion (Lagarangian eqn of motion should come here), thermodynamic basis of biochemical reaction, aqueous and ionic equilibrium of living cells, electrochemical equilibrium: The Nerst equation, Donnan equilibrium, analysis of fluxes, flux uncharged substances, fluxes of electrolytes. **[6L]**

Unit IV: Electrochemical cells: Diffusion potential, ions in cells and organelle, ion transport in biological molecules, network of cellular transporters; the cell as accumulator of electrochemical energy, action potential, electric field in cells and organisms, electric/electronic structure of living organism, electric field in extra cellular space, electrical properties of tissue and cell suspensions, single cells in external electric fields, manipulation of cells by electric fields. **[6L]**

Recommended books:

1. Proteins Structures and Molecular Properties by T. E. Creighton, W.H. freeman and Company, New York

2. Lehringer, 2000, Principles of Biochemistry, CBS Publishers.

3. Zubay, 1995, Biochemistry, Brown publishers.

4. Voet and Voet, 2000Biochemistry, John Wiley.

5. L. Stryer, 2002, Biochemistry, W.H. Freeman.

6. Harper, 2003, Biochemistry, McGraw-Hill

7. Biophysics: Glaser, Ronald.

8. Methods of modern Biophysics: Noitting Bengt.

(PPC 107) Biotechnology

Unit I: Tools and Techniques in Molecular Biology Part I: [6L]

Enzymes used in recombinant DNA technology: DNA and RNA polymerases, ligases, methylases, endonucleases and exonucleases.

Unit II: Tools and Techniques in Molecular Biology Part II: [6L]

Nucleic acid isolation methods; Nucleic acid separation techniques: Agarose gel electrophoresis of DNA and RNA. Blottings: Southern, Northern and Western. Nucleic acid amplification protocols; DNA sequencing.

Unit III: Tools and Techniques in Molecular Biology Part III: [6L]

Sterilization and disinfection. Competent cell preparation and transformation protocols. Radioimmunoassay (RIA) and Enzyme Linked Immunosorbant Assay (ELISA).

Unit IV: Tools and Techniques in Molecular Biology Part IV: [6L]

Vectors: cloning, expression and shuttle vectors. Cloning strategies. Expression of cloned DNA. Cloning and expression in bacterial system.

Centre for Interdisciplinary Research in Basic Sciences

(Semester II)

(PPC 201) Protein Structure Biology

Unit I: Amino Acids **(6 L)**

Twenty standard amino acids: Notations, general formula, conformation and configuration and side chain configuration. Properties of amino acids: *Acids-Base behaviour* (pka values and its determination (potentiometric), ampholytes, zwitterion, (isoelectric point); Beer-Lambet law.

Unit II: Peptides & Protein conformation **(6 L)**

Definitions: Peptide bond, N- and C-terminal residues, peptide group. Peptide units: Bond lengths and angles, cis- and trans-conformations, Levels of structure in Proteins: primary structure, secondary structure, tertiary structure and quaternary structure. Amino acid composition and sequence determination. Dipeptide conformation: Ramachandran plot, allowed and prohibited contact distances and allowed conformations.

Unit III: Measurements of Protein Structure **(6 L)**

Optical techniques: Basic principles and applications of absorption and fluorescence spectroscopy, circular dichroism NMR Spectroscopy and X-ray Diffraction.

Unit IV: Protein Structure and Stability **(6 L)**

The native state: Definition and types of bonding in native proteins. The denatured state: Definition and modes of denaturation. Protein stability, Definition and theoretical estimation of stability of the native protein, and experimental determination of protein stability from chemical and thermal denaturation studeis (analysis of denaturation curves). The protein folding problem. Various models of protein folding. The molten

globule state. General properties of protein folding transition: Stability of folded state and cooperativity of folding. Kinetic aspect of folding: Experimental results of folding and refolding, transition states for folding, and modes of folding, *in vivo* protein folding.

(PPC 202) Bioinformatics and Biomathematics

Unit 1: Biological Databases and Programming Languages [6L]

Sequence and structural databases, organism databases, Entry and retrieval of data from public databases, Database searches for homologous sequences, Bio-programming.

Unit 2: Bioinformatics Tools [6L]

DNA and protein sequence analysis: BLAST, FASTA, scoring matrices, local and global alignment concepts and dynamic methodologies. Multiple sequence alignment. Phylogenetic analysis. Gene finding methods. Protein visualization tools.

Unit 3: Biostatistics [6L]

Measures of central tendency and dispersal; probability of distributions (Binomial, Poisson and Normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; X^2 test; Basic introduction to Muetrovariate statistics, etc.

Unit 4: Biomathematics [6L]

Introduction of Bio mathematics, Linear and Non linear First order Discrete Time Model; The Biology of Insect Population Dynamics; A Model for insect Population dynamics with Competition, Differential Equation Models, Modeling with Predator Functional response, Ecosystem modeling, Basic Model for Macro parasitic Diseases.

Recommended books:

1. Nicholas F. Briton, Essential Mathematical Biology, Springer-Verlag London

(2003)

2. P.N. Arora & P.K.Malhan, Biostatistics, Himalaya Publishing House (2006)

(PPC 203) Nanotechnology and System Biology

Unit I: Introduction to Systems biology: Systems biology as reversed engineering process, Systems engineering and molecular biology, Systems approach in molecular, cellular and developmental biology, Biological network, Hubs, Network motif, random network, scale free network, Erdos-Renyi (ER) network, Small world network, Barabasi-Albert (BA) model. **[6L]**

Unit II: Systems microbiology: Deterministic and stochastic pictures of cellular processes, Molecular interaction, Chemical master equation, Langevin equation, Gillespie's algorithm. Dynamical response as a switch, Genetic switch, Lambda phase as genetic switch, Stability and multistability analysis, Genetic oscillator, Construction and modeling of genetic networks. **[6L]**

Unit III: Nanotechnology: Definition, fabrication processes, nano-biotechnology, nanopatterning techniques, self-assembly (including DNA, RNA) and bio/chemi cal methods, characterization techniques, Biocompatibility, fabrication techniques of nano-biostructures, Application of nano-science to biology, Biomedical applications. **[6L]**

Unit IV: Scanning probe microscopy (SPM) for Nanotechnology and Biology: Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Scanning tunneling microscopy, Atomic force microscopy, SNOM, Phase contrast, Focal and Con-focal microscope, Thermal Microscope **[6L]**

Recommended books:

1. Introduction to systems biology: Uri Alon
2. Computational Cell Biology: Edited by: C.P. Fall, E.S. Marland, J.M. Wagner and J.J. Tyson.
3. Nanotechnology: Understanding small systems : Rogers.
4. Fundamentals of molecular spectroscopy: Banwell.

(PPC 204) Molecular Endocrinology and Medicinal Chemistry

Unit I: Male reproductive system and molecular basis of hormone action (6 L)

Gonadotropins and sex-steroids; hypothalamo-pituitary axis in males; Physiology of testis; Spermatogenesis.

Unit II: Female reproductive system and molecular basis of hormone action (6 L)

Biology of gonadotropin releasing hormone (GnRH) and sex steroid. Biology of oocyte; Mechanisms of ovulation. Molecular events associated with fertilization.

Unit III: Drug Design I (6 L)

Development of new drugs, concept of lead compound and lead modification, structure activity relationship (SAR).

Unit IV: Drug Design II (6 L)

Theories of drug activity, Quantitative structure activity relationship, Free Wilson analysis, Hansch analysis. LD-50, ED-50.

(PPC 205) Molecular Virology

Unit I: Introduction to Virology: **[6L]**

Virus structure and morphology: RNA viruses, DNA viruses. Immune response to viral infections. Emerging viruses.

Unit II: General virology: **[6L]**

Antiviral strategies: Antiviral drugs, interferon, vaccines, modern approaches of viral control. Animal cell culture and Virus propagation.

Unit III: Respiratory viruses: **[6L]**

Respiratory viruses: Respiratory syncytial virus, influenza viruses, Para influenza viruses etc. RSV Biology: virion, proteins, replicative cycle, genotypes, vaccine development.

Unit IV: Hepatitis Viruses: **[6L]**

Introduction to hepatitis associated viruses; Clinical aspects of hepatitis B associated viral hepatitis; Structure and Replication of Hepatitis B Virus (HBV); Antiviral therapy and antiviral resistance in chronic hepatitis B. **[6L]**