LIFE SCIENCES

Programme Code: LIFE05

Programme Outcome:

- **Mastery of Modern Life Sciences** Demonstrate a comprehensive and unified understanding of fundamental and contemporary life sciences, bridging diverse undergraduate backgrounds through advanced coursework in molecular, cellular, and systems biology.
- **Advanced Technical & Computational Proficiency** Acquire hands-on expertise in diverse biotechniques, data science, and structural bioinformatics through intensive modular laboratories to address complex biological questions.
- **Specialized Research Synthesis** Apply specialized knowledge in domains such as cancer biology, infectious as well as non-infectious diseases, biophysics & biochemistry or ecology to design and execute semester-long research projects that culminate in a formal Master's dissertation.
- Students must demonstrate a clear "Gap Analysis" in their chosen field, identifying what is unknown and proposing a statistically sound experimental design to address it in the PhD program.
- **Research Methodology & Ethical Conduct** Implement rigorous research methodologies and adhere to global standards of publication ethics while navigating the transition from structured learning to independent doctoral inquiry.
- **Independent Discovery & High-Impact Publication** Execute a challenging, time-bound PhD thesis project that generates original scientific knowledge and results in primary research publications within high-impact international journals.

- Inculcate collaborative research culture among the students and work in interdisciplinary areas of science where Life Sciences knowledge is required

DETAILED COURSE STRUCTURE

SEMESTER-I				
Sr.No	**Course Code**	**Course Code**	**Hours**	**Credits**
1	BIO704	Introductory Biophysics	60	4
2	BIO705	Cellular Biochemistry	60	4
3	BIO737	Evolutionary Biology	60	4
4	BIO708	Physiology	60	4
5	BIO741	Laboratory-I	15 lab hours (30 hrs.)	2
SEMESTER-II				
6	BIO731	Perspectives in Molecular Biology	60	4
7	BIO702	Molecular Genetics	60	4
8	BIO703	Biology of the Cell	60	4
9	BIO707	Bioinformatics and computational Biology	60	4
10	BIO742	Laboratory-II	15 lab hours (30 hrs.)	2
SEMESTER-III				
11	BIO709	Bio-techniques	60	4
12	BIO***	Elective-I	60	4
13	BIO***	Elective-II	60	4
14	BIO***	Elective-III	60	4
15	BIO841	Laboratory-III	15	2
SEMESTER-IV				
16	BIO706	Concepts in Immunology	60	4
17	BIO710	Quantitative and Systems Biology	60	4
18	BIO***	Elective-IV	60	4
19	BIO***	Elective-V	60	4
20	BIO842	Laboratory-IV	15 lab hours (30 hrs.)	2
				72
SEMESTER-V				
21	BIO898	Research Project-1		16
SEMESTER-VI				
22	BIO800	Research Methodology and Research Publication Ethics	60	4
23	BIO899	Research Project-2		20

LIST OF ELECTIVES

Sr.No	**Course Code**	**Course Title**	**Hours**	**Credits**
1	BIO711	ADVANCED MICROBIOLOGY	60	4
2	BIO712	ENZYMOLOGY	60	4
3	BIO713	ADVANCED NEUROBIOLOGY	60	4
4	BIO714	CHEMICAL BIOLOGY	60	4
5	BIO715	VIROLOGY	60	4
6	BIO716	PRINCIPLES OF DRUG DESIGN	60	4
7	BIO717	DEVELOPEMENTAL BIOLOGY	60	4
8	BIO718	GENETIC ENGINEERING	60	4
9	BIO719	INFECTIOUS DISEASE BIOLOGY	60	4

10	BIO720	CANCER BIOLOGY	60	4
11	BIO721	IMMUNE REGULATION AND INFECTION	60	4
12	BIO722	MACROMOLECULAR CRYSTALLOGRAPHY	60	4
13	BIO723	STRUCTURAL BIOLOGY	60	4
14	BIO724	ION CHANNELS	60	4
15	BIO725	CONCEPTS IN MECHANOBIOLOGY	60	4
16	BIO726	ENDOCRINOLOGY	60	4
17	BIO727	PLANT DEVELOPEMENTAL BIOLOGY	60	4
18	BIO728	TRANSLATIONAL CONTROL IN BIOLOGY	60	4
19	BIO729	MACROEVOLUTIONARY PRINCIPLES AND PATTERNS	60	4
20	BIO730	MODEL ORGANISMS IN BIOMEDICAL RESEARCH	60	4

COORDINATORS

Chief Coordinators:

Dr. Abdur Rahaman, Convener, Post-Graduate Committee of the School, Biology
(E-mail: *arahaman@niser.ac.in*),
Dr. Asima Bhattacharya, Chairperson of the School of Biological Sciences (E-mail: *asima@niser.ac.in*)

Core course Coordinators:

Course	Coordinators	Contact
Introductory Biophysics	Dr. Saleem Mohammed	saleem@niser.ac.in
Cellular Biochemistry	Dr. Abdur Rahaman	arahaman@niser.ac.in
Evolutionary Biology	Dr. Aniruddha Datta Roy & Dr. Rittik Deb	datta.roy@niser.ac.in debrittik@niser.ac.in
Physiology	Dr. Asima Bhattacharyya & Dr. Kishore C. Panigrahi	asima@niser.ac.in panigrahi@niser.ac.in
Laboratory-I	Dr. Pankaj V. Alone, Dr. Abdur Rahaman, Dr. Debasmita P. Alone, Dr. Rudresh Acharya, Dr. Manjusha Dixit	pankaj@niser.ac.in arahaman@niser.ac.in debasmita@niser.ac.in rudresh.acharya@niser.ac.in manjusha@niser.ac.in
Perspectives in Molecular Biology	Dr. Pankaj V. Alone & Dr. Tridib Mahata	pankaj@niser.ac.in tridibmahata@niser.ac.in
Molecular Genetics	Dr. Manjusha Dixit & Dr. Debasmita Alone	manjusha@niser.ac.in debasmita@niser.ac.in
Biology of the Cell	Prof. Chandan Goswami	Chandan@niser.ac.in
Bioinformatics and computational Biology	Dr. Badireenath V. Konkimalla	badireenath@niser.ac.in
Laboratory-II	Dr. Harapriya Mohapatra & Dr. Swagata Ghatak & Prof. Chandan Goswami & Dr. Ramanujam Srinivasan & Dr. Praful S. Singru	hm@niser.ac.in swagata@niser.ac.in chandan@niser.ac.in rsrini@niser.ac.in pssingru@niser.ac.in
Bio-techniques	Dr. Rudresh Acharya & Prof. Palok Aich	rudresh.acharya@niser.ac.in palok@niser.ac.in
Laboratory-III	Dr. Subhasis Chattopadhyay, Dr. Kishore V. Panigrahi, Dr. Himabindu V. Kilambi, Dr. Asima Bhattacharya, Dr. Tirumala Kumar Chowdary	subho@niser.ac.in panigrahi@niser.ac.in hvk@niser.ac.in asima@niser.ac.in tkchowdary@niser.ac.in
Concepts in Immunology	Dr. Subhasis Chattopadhyay	subho@niser.ac.in
Quantitative and Systems Biology	Prof. Palok Aich	palok@niser.ac.in
Laboratory-IV	Dr. Aniruddha Datta Roy, Dr. Rittik Deb, Dr. Mohammed Saleem, Dr. Palok Aich, Dr. Badireenath V.Konkimalla	datta.roy@niser.ac.in debrittik@niser.ac.in saleem@niser.ac.in palok@niser.ac.in badireenath@niser.ac.in
Research Methodology and Research Publication Ethics	Dr. Abdur Rahaman & Dr. Himabindu Vasuki K.	arahaman@niser.ac.in hvk@niser.ac.in

Elective courses coordinators

Course	Coordinators	Contact
Advanced microbiology	Dr. Harapriya Mohapatra	hm@niser.ac.in
Enzymology	Dr. Tirumala Kumar Chowdary	tkchowdary@niser.ac.in
Advanced neurobiology	Dr. Praful S. Singru	pssinsgru@niser.ac.in
Chemical biology	Prof. Palok Aich	palok@niser.ac.in
Virology	Dr. Tirumala Kumar Chowdary	tkchowdary@niser.ac.in
Principles of drug design	Dr. Badireenath V. Konkimalla	badireenath@niser.ac.in
Developmental biology	Dr. Debasmita P. Alone & Dr. Swagata Ghatak	debasmita@niser.ac.in swagata@niser.ac.in
Genetic engineering	Dr. Manjusha Dixit	manjusha@niser.ac.in
Infectious disease biology	Dr. Harapriya Mohapatra	hm@niser.ac.in
Cancer biology	Dr. Asima Bhattacharya	asima@niser.ac.in
Immune regulation and infection	Dr. Subhasis Chattopadhyay	subho@niser.ac.in
Macromolecular crystallography	Dr. Rudresh Acharya	Rudresh.acharya@niser.ac.in
Structural biology	Dr. Rudresh Acharya	Rudresh.acharya@niser.ac.in
Ion channels	Prof. Chandan Goswami	chandan@niser.ac.in
Concepts in mechanobiology	Dr. Ramanujam Srinivasan	rsrini@niser.ac.in
Endocrinology	Dr. Praful S. Singru	pssingru@niser.ac.in
Plant developemental biology	Dr. Kishore C. Panigrahi & Dr. Himabindu Vasuki K.	panigrahi@niser.ac.in hvk@niser.ac.in
Translational control in biology	Dr. Pankaj V. Alone	pankaj@niser.ac.in
Macroevolutionary principles and patterns	Dr. Aniruddha Datta Roy	datta.roy@niser.ac.in
Model organisms in biomedical research	Dr. Debasmita P. Alone	debasmita@niser.ac.in

CORE COURSES

BIO-703: Biology of the Cell (60 Lecture Hrs)

Coordinators: Prof. Chandan Goswami
(Chandan@niser.ac.in)

Course Details:

- **Understanding the Cell**

- Various cell types as model systems
- Different sub-cellular structures and their function
- Ultra structure of subcellular organelles
- Others.

- **Microscopy as tools for understanding cellular structure function**

- Biological sample preparation. Difficulties and advancements
- Various fluorescence proteins and their applications
- Other fluorescence probe
- Auto fluorescence and its application
- Others.

- **Principle, uniqueness and application of different microscopes**

- Fluorescence microscope
- Phase contrast microscope,
- DIC microscope
- Confocal microscope, Spectral detection
- Total internal reflection fluorescence microscope (TIRF),
- Electron microscope,
- Atomic force microscope,
- Others
- .

- **Application of microscopes**

- Live cell imaging difficulties and advantages
- FLIM application
- FRET
- FRAP
- Photo-activation
- Metal imaging
- Others

- **Understanding cellular dynamics**

- Cell division
- Cytoskeletal reorganization, microtubule and actin cytoskeleton
- Vesicle trafficking and recycling, endocytosis and exocytosis
- Nuclear dynamics
- Efflux and influx of ions and others
- Others.

- **Super resolution**

- STED,
- PALM,
- STROM,
- Others.

Course Outcomes:

- Understanding the basic principles governing cell structure and functions, bio-chemcial, biophysical, genetical basis of cell and its response
- Key concepts in maintenance of cell structure
- Evolution of cell organelles, importance in health and disease.
- Importance of ion channels in health and disease, pharmacology and applications
- Advanced knowledge of details of microscopy Bridging the gap between theory and research methodology.

Reference Books:

1. Molecular Biology of the Cell: Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter: Garland Science

BIO-704: Introductory Biophysics (60 Lecture Hrs)

Coordinators: Dr. Saleem Mohammed
(saleem@niser.ac.in)

Course Details:

- **Introduction:**

- Matter, origin of life and elemental properties for life; Dogma of molecular biology, chemical bonding and laws of thermodynamics.

- **Forces driving the structure and conformation of nucleic acids**

- Properties & ionization equilibria of nucleosides and nucleotides; Composition, primary, secondary, tertiary and quaternary structure of nucleic acid; Geometries and steric hindrance in nucleic acid structure; Base pairing and stacking; Discovery of DNA double helix, X-Ray diffraction and analysis of Photo 51

- **Forces driving the structure and conformations of Proteins**

- Properties & ionization equilibria of amino acids; Composition, primary, secondary, tertiary and quaternary structure of proteins; Geometries of polypeptide chain, Ramachandran or steric contour diagrams; Estimates of potential energy (nonbonded interactions, dipolar interactions etc); Hydrogen bonding, hydrophobic interactions, ionic interaction, disulfide bonds; Discussion on the work of Linus Pauling on structure of
- Levinthal's Paradox, the energy landscape theory, folding equilibrium and lifetime of proteins; 2D Lattice model, conformation analysis, protein folding funnel, entropy, free energy, reaction coordinates.

- **Stability of macromolecule structure and interactions**

- Boltzmann distribution/partition function, free energy, laws of mass action, equilibrium constant

- **Biological membrane remodelling**

- Physicochemical parameters of membranes (dielectric constant, potential, tension, rigidity, curvature); Shape of lipids, spontaneous curvature, membrane geometry, shapes of organelles; Free energy of membrane deformation; Vesicles in cellular transport, biological forces driving membrane fission (eg., clathrin-coated vesicles, dynamin and ESCRT mediated fission) and fusion; Mechanosensitive ion channels and membrane elasticity

- **Cellular Energy**

- Membranes as batteries and ATP; How to make and use ATP; Structure of F1 F0 ATPase, discovery of stepping rotation of F1-ATPase, efficiency of biological engine

- **Diffusion in Cellular Systems**:

- Bulk properties, photobleaching, Brownian motion, random walk, probability of path

- Diffusive vs ballistic motion, diffusion of contents in cytoplasm (i.e, mRNA, protein)
- Stokes-Einstein Equation, Reynolds number, diffusion constant

- Size of cell and scale of diffusion (eg., neurotransmitter at synapse, Oxygen etc)
- Life at low Reynold's number, drag force (bacterial motion)

- **Ion Channels**

- Selective membrane permeability, ionic current and gating current, Nernst equation; Structure and function of K+ channel, magnitude of voltage, conformational changes in the gate, implications for nerve impulse propagation; Structure of pore domain, selectivity filter, comparison between K+ and Na+ channel, Na+ K+ Transporter (ATPase

- **Biophysical approach to biological problems**

- Light-matter interaction, optical resolution, diffraction limit, image formation (Rayleigh criteria, point spread function); Fluorescence based approaches to visualize and quantify biological processes - fluorescence, stokes shift, epifluorescence, confocal, spinning disk, super resolution microscopy and fluorescence lifetime measurements (principle and examples of applications); Optical tweezers for biological force measurements (principle and examples of measured forces); Micropipette aspiration (principle and examples of applications); Atomic force microscopy/spectroscopy (principle and examples of applications)

- **Biology by numbers:**

- Estimates in biology; sizing up cells, energy budget, chromosome packing, sizing up membranes, diffusion of proteins and few select other examples

Course Outcomes:

- students are expected to develop quantitative and physical understanding of molecular and cellular aspects of biology.
- Understand fundamental concepts and tools of physics and their application to the study of biological molecules, living systems and life processes.
- Develop competence in identifying fundamental problems, critical thinking, observation and interpretation of biological phenomena using framework of concepts at the interface of biology and physics.

Reference Books:

1. Molecular Biology of the Cell: Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter, New York and London: Garla nd Science

BIO-705: Cellular Biochemistry (60 Lecture Hrs)

Coordinators: Dr. Abdur Rahaman (arahaman@niser.ac.in)

Course Details:

- **Protein secretion**
- **Protein folding: In vivo - In vitro**
- **Conditional enzyme kinetics**
- **Post translational modification**
- **Protein degradation**

Course Outcomes:

- Understanding the mechanism of protein folding
- In depth knowledge about Post translational modifications of proteins
- Mechanisms and implications of protein turn over in cells

Reference Books:

1. Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson and Michael M. Cox

2. "Fundamentals of Biochemistry" by Voet and Voet

3. "Biochemistry" by JM Berg, JL Tymoozko, L Stryer

BIO-706: Concepts in Immunology (60 Lecture Hrs)

Coordinators: Dr. Subhasis Chattopadhy (subho@niser.ac.in)

Course Details:

- **Overview of the Immune system**
- **Cells and organs of the immune system**
- **Innate immunity**
- **Adaptive immunity**
- **MHC, Antigen processing & presentation**
- **Cell mediated Immunity: T cell response and its diversity.**
- **Humoral Immunity: B cell response and its diversity.**
- **Cytokines and Chemokines**
- **Self-Non- self immune response**
- **Brief outline of altered Immune response and disease pathology**

Course Outcomes:

• Understating the basics of the immune system and the immunological processes during infection, tumor progression, inflammation and immunogenic responses of various cases of altered host physiological functions and phenotypes

Reference Books:

1. Kuby IMMUNOLGY 6th Edition by Richard A. Goldsby, Barbara Anne Osborne, Janis Kuby. Publisher: W.H. Freeman

BIO-707: Bioinformatics and Computational Biology (60 Lecture Hrs)

Coordinators: Dr. Badireenath V Konkimalla
(badireenath@niser.ac.in)

Course Details:

- **Introduction to Bioinformatics:**

- Introduction; History and importance; Field and scope.

- **Databases and Database searching:**

- Demo: NCBI, SWISS-PROT, PDB.

- **Locating Coding regions and Gene prediction**

- 6-frame translation; parameters governing prokaryotic and eukaryotic translation; Concept, neural networks and its importance in gene prediction as example

- **Alignments:**

- Significance and importance, types, classification
- Dot-plot matrix.

- **Substitution Matrices:**

- Significance, types, derivation of BLOSUM and PAM
- Application of Substitution Matrices

- **Algorithms behind pairwise sequence alignments:**

- Dynamic programming, Smith-Watermann, Needleman-Wunsch, Heuristic algorithms BLAST, FASTA; Applications, statistical parameters governing BLAST results

- **Multiple sequence alignments**

- Importance; progressive sequence alignment; ClustalW; statistical parameters governing clustalW; Applications

- Phylogenetic tree construction and different approaches

- Neighbour-Joining (star decomposition method), BootstrappingIntroduction, importance, classification and parts of tree,
- predicting number of root and unrooted trees, orthologs and paralogs, transitions and transversions, susbstitutions matrices,
- different methods to construct phylogenetic tree,
- Neighbour-Joining (star decomposition method), Bootstrapping.

- **Pattern matching/position specific scoring matrices:**

- Importance of patterns, motifs, deriving PSSM, sequence logo

- **Structural Bioinformatics:**

- Introduction to structural bioinformatics and protein structure, Ramachandrean plot
- Secondary structure prediction and methods
- Hydropathy plot, helical wheel, signal peptide prediction, transmembrane prediction,
- Concepts related to Drug design : Lipinski Rule of 5 and Molecular dockinglts

- **Systems Biology**

- Introduction, need for computers in system biology
- High-throughput and omic approaches, difference and application
- Graph theory
- Gene Ontology

Course Outcomes:

- Application of bioinformatics knowledge in understanding relationships at sequence, structure and network-level.
- Demonstration of popularly used bioinformatics tools for research work
- Help understand the patterns of life and rhythms.

Reference Books:

1. Introduction to bioinformatics – Arthur M. Lesk
2. Bioinformatics – David Mount
3. Essential bioinformatics – Jin Xiong

BIO-708: physiology (60 Lecture Hrs)

Coordinators: Dr. Asima Bhattacharyya,
Dr. Kishore C. Panigrahi
(asima@niser.ac.in & panigrahi@niser.ac.in)

Course Details:

- **Fundamentals of physiology:**

- Adaptation
- Acclimatization, acclimation
- Conformity and regulation.

- **Overview of animal body plan**

- Relationships between phyla
- Body plan, symmetry and cavities

- **Homeostasis**

- Milieu internae, feedback and control systems
- Feedforward systems
- Nonpysiological homeostasis.

- **Biomembranes & transport across membrane**

- Membrane composition, models
- Transmembrane movement of ions, diffusion, osmosis

- **Growth regulation in plant systems: Auxins, Cytokinins, Ethylene**
- **Phytochrome, Photomorphogenesis**
- **Cryptochromes, Phototrophins and UV light responses**
- **Control of flowering time**

Course Outcomes:

- Learning molecular, chemical and physical principles of animal body plan.
- Understanding structure-function relationships and how various physiological systems work.
- Understanding of the growth and flowering physiology of a plant.

Reference Books:

1. Animal Physiology", Hill R, Wise G A & Anderson M Sinauer.
2. Principles of Animal Physiology", Moyes, Schulte
3. Eckert Animal Physiology Mechanisms and Adaptations", Randall, Burggren, French
4. Plant Physiology" by Taiz & Zeiger Sinaue,
5. Plant Physiology" by Salisbury and Ross

BIO-709: Bio – Techniques (60 Lecture Hrs)

Coordinators: Dr. Rudresh Acharya,
Prof. Palok Aich
(rudresh.acharya@niser.ac.in & palok@niser.ac.in)

Course Details:

- **Techniques use in DNA characterization: construction of genomic & cDNA library; Agarose gel electrophoresis; Northern blotting; Southern blotting.**
- **Techniques use in DNA manipulations: PCR and its application; Restriction digestion; Ligation; Site directed mutagenesis.**
- **Statistics: Precision of Measurement, Confidence Limits, Statistical Models**
- **Estimating Sample Size, Simulation for Sample Size and power calculation**
- **Enzymes used in genetic engineering experiments: DNA polymerases; Ligase; Reverse transcriptase; Restriction endonucleases and other enzymes.**
- **Techniques use in protein characterization: SDS-Gel electrophoresis; Western blotting; IEF-2D gel electrophoresis; FRET; Co-Immunoprecipitation; CHIP; Protein-ligand interactions and affinity studies by Surface Plasmon resonance; Density gradient separation.**
- **Spectrophotometry (UV-Vis, CD, Fluorescence).**
- **Principles of Centrifugation.**
- **Uses of radioactive isotopes and autoradiography.**
- **Biophysical techniques: X-ray crystallography; NMR; ORD.**
- **Principals of chromatography: Ion exchange; Gel filtration; Affinity; Reverse flow; HPLC**

Course Outcomes:

- Students are expected to learn the basic principle behind the biophysical, and biochemical experiments. Troubleshoot the experiments, interpretation of results, plotting of graphs, design the experiments

Reference Books:

1. "Immunology Laboratory Manual" by Myers and Richard L
2. "Genetic Engineering" by Reece
3. "The tools of Biochemistry" by Terrance G. Cooper
4. "Biophysical Chemistry" by Alan Cooper
5. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology

BIO-710: Quantitative and System Biology (60 Lecture Hrs)

Coordinators: Prof. Palok Aich
(palok@niser.ac.in)

Course Details:

- **Recent Trends in Biology and Health Research:**

- Adaptation
- Acclimatization, acclimation
- Conformity and regulation Modern tools of health research
- Existing and emerging health and biological problems.

- **Modern Biotechnology**

- Recombinant technology and genetic engineering
- Application of biotechnology

- **Integrative and Systems Biology**

- Comparative understanding of systems and integrative biology
- Concepts and high-throughput techniques of systems Biology
- Application of and advances in systems biology.

- **Quantitative and Non-linear Biology**

- Mathematical modelling and applications in Biology
- Lotka-Volterra Model
- B-Z reaction, population genetics

- **Recent Trends in Biology and Health Research:**

- Simple and effect statistics
- Correlation and distribution.

- **Univariate Analysis**

- Parametric and non-parametric analysis
- t-test, ANOVA, MANOVA

- **Multivariate Analysis**

- Classification and grouping
- Clustering, PCA, LDA, DCA.

- **Sample size and power of calculation**

Course Outcomes:

- Introducing the concepts of mathematics in biology

- Understanding the quantitative aspects of biology
- How is statistics and mathematics required and applied in the field of biology
- Understanding how mathematical models of biology are developed
- Didactic methodology of teaching is used to make the students think more analytically and get oriented to develop problem solving skills in the domain of quantitative biology
-
- Understanding quantitative biology to do new and more insightful biology.

Reference Books:

1. Class notes, handouts
2. Systems Biology: A Textbook, Edda Klipp (Author), Wolfram Liebermeister (Author), Christoph Wierling (Author), Axel Kowald (Author), Hans Lehrach (Author), Ralf Herwig
3. Systems Biology: Properties of Reconstructed Networks by Bernhard O. Palsson, University of California, San Diego; ISBN: 9780521859035; DOI: 10.2277/0521859034
4. Statistics at the Bench: A Step-by-Step Handbook or Biologists by Martina Bremer
5. Nonlinear dynamics and chaos:with applications to physics, biology, chemistry, and engineering; Steven Henry Strogatz

BIO-731: Perspectives in Molecular Biology (60 Lecture Hrs)

Coordinators: Dr. Pankaj V. Alone,
Dr. Tridib Mahata
(pankaj@niser.ac.in & tridibmahata@niser.ac.in)

Course Details:

- **Signaling pathways and regulation:**

- Translation initiation, translation control in metabolic
- Genetic disorders and development

- **Importance of cis regulatory elements**

- mRNA, CAP, 5'-UTR, 3'-UTR Poly A tail
- IRES structure and function
- trans-acting factors in protein expression, examples of Iron homeostasis

- **Statistics: Precision of Measurement, Confidence Limits, Statistical Models General amino acid control mechanism, translation in developmental decision, GAIT mediated translational silencing, translation silencing by microRNA.**

- **Yeast mating type switch: Mating type locus, experimental evidence for cis regulatory elements, experimental evidence for transacting factors in mating type switch, donor preference, recombinant enhancers.**

- **Long term evolution experiment: Evolution of Cit+ function, potentitation of Cit+ function, actualization of Cit+ function, refinement of Cit+ function and molecular mechanism.**

- **Molecular mechanism of PRK action and host-virus evolution. Role of dimerization domain, kinase domain activation independent of dimerization domain, substrate recognition motif, evolutionary pressure on PRK and pox virus pseudosubstrate.**

- **How do new protein arise: Minimal sequence code for switching protein structure-function, domain rearrangement give rise to new function, horizontal gene transfer between the genome, intergenic region as a potential site for new gene, gene duplication and refinement of its function**

Course Outcomes:
Understand the recent advancements in molecular biology, structure-function analysis and regulation. Reading research articles, designing experiment and data analysis.

Reference Books:
1. "Molecular Cell Biology" 6th Edition By Lodish
2. "Gene X" By Lewin
3. "Translational Control in Biology and Medicine" By Michael B. Mathews, Nahum Sonenberg, John W.B. Hershey. CSH press
4. "Prokaryotic Gene Expression (Frontiers in Molecular Biology)" Oxford University Press, USA; First edition (July 29, 1999)
5. Class notes and research articles

BIO-737: Evolutionary Biology (60 Lecture Hrs)

Coordinators: Dr. Aniruddha Datta Roy,
Dr. Rittik Deb
(datta.roy@niser.ac.in & debrittik@niser.ac.in)

Course Details:

- Introduction to Evolutionary Biology
- Classification, Phylogeny & the tree of life
- Patterns of evolution
- Evolution & fossil record
- History of life on earth
- Geography of evolution
- Evolution of biodiversity
- Genetic variation
- Phenotypic variation
- Genetic drift
- Natural selection and adaptation
- Genetic theory of natural selection
- Evolution of phenotypic traits
- Conflict and cooperation
- Species and speciation
- Reproductive success
- Co-evolution- interactions amongst species
- Evolution of genes and genomics
- Evolution and development
- Macroevolution
- Evolution & society
- Human evolution

Course Outcomes:

Students are expected to develop:

- Understanding how life originated on the planet
- Understanding the formation of species and underlying genetic diversity
- Understanding biology from an organismal point of view and why some species evolve slowly while others evolve rapidly
- Understanding systematic relationships between organisms using phylogenetic tools

Reference Books:

1. "Evolution" by D. J. Futuyma

BIO-711: Advanced Microbiology (60 Lecture Hrs)

Coordinators: Dr. Harapriya Mohapatra (hm@niser.ac.in)

Course Details:

- Molecular microbial genetics
- Molecular medical microbiology: microbial pathogenesis & infectious diseases, study of selected pathogenic organisms with emphasis on recent insights into their mechanism of pathogenesis
- Environmental microbiology
- Microbial interactions: Quorum sensing, Biofilm

Course Outcomes:

- Understanding of bacterial responses to various stimuli
- Gain insights into bacterial biofilm formation and quorum sensing mechanisms

Reference Books:

1. Brock's Biology of Microorganisms by Madigan et al.;
2. Fundamental bacterial genetics by Trun & Trumphy;
3. Molecular medical microbiology by Sussman M;
4. Microbiology: diversity, disease and the environment Salyers, AA;
5. Colonization of mucosal surfaces by Nataro JP;
6. Medical microbiology by Murray PR;
7. Environmental microbiology by Maier RM;
8. Environmental microbiology by Varnam, AH;
9. Annual review of microbiology by Gottesman, Susan,
10. Marine microbiology: ecology and applications by Munn, CB

BIO-712: Enzymology (60 Lecture Hrs)

Coordinators: Dr. Tirumala Kumar Chowdary (tkchowdary@niser.ac.in)

Course Details:

- **General properties of enzymes**
- **Enzyme nomenclature**
- **Activation energy and reaction coordinates**
- **Denaturation of Enzyme**
- **Enzyme purification**
- **Enzyme kinetics: Michaelis Menten Equation, Line-Weaver Burk plot**
- **Enzyme catalytic mechanism: Acid-Base catalysis, covalent catalysis, Metal ion catalysis**
- **Enzymes in food technology**
- **Immobilization of enzyme, biosensor, Bioreactor**
- **Structure and function of specific enzymes: Lysozyme, serine protease**
- **Enzyme inhibition: Competitive inhibition, non-competitive inhibition, uncompetitive inhibition**
- **Allosteric regulation of enzyme activity: Carbonic anhydrase, Chymotrypsin, ATCase**
- **Allosteric enzyme inhibition**

Course Outcomes:

- Build comprehension on nature and functioning of enzymes.
- Make students understand kinetics of enzyme mediated reactions and enzyme inhibition kinetics
- Develop basic understanding on enzyme engineering

Reference Books:

1. "Fundamentals of Biochemistry" by Voet and Voet
2. "Biochemistry" by JM Berg, JL Tymoozko, L Stryer

BIO-713: Advanced Neurobiology (60 Lecture Hrs)

Coordinators: Dr. Praful S. Singru
(pssinsgru@niser.ac.in)

Course Details:

- Autonomic nervous system and regulation of body functions
- Somatic sensory system and Neurobiology of pain
- Regulation of sleep and wakefulness
- Reproductive brain, sex difference and age-related changes in the brain and neural circuitry
- Neurodegenerative disorders
- Neural basis of learning and memory
- Basal ganglia and the neural control of movement
- Blood supply to the brain and cerebrovascular attack, ventricular system in the brain
- Neuro-immune interaction and nonthyroidal illness syndrome

Course Outcomes:

- Develop understanding about the central nervous system-controlled process and their mechanism of regulation.
- In-depth understanding of the neural circuits and behavior.
- Understand and analyze the recent updates in the field and significance

Reference Books:

1. Zigmond, M.J., Bloom, F.E., Landis, S.C., Roberts, J.L., Squire L.R. (2008) Fundamental Neuroscience. Academic Press.

2. Kandel, E., Schwartz, J., Jessell, T. (2000) Principles of Neural Science. McGraw Hill.

3. Guyton, A. and Hall,J. (2006) Text book of medical physiology. Elsevier

BIO-714: Chemical Biology (60 Lecture Hrs)

Coordinators: Prof. Palok Aich
(palok@niser.ac.in)

Course Details:

- **Introduction:**

- Structure
- Chemistry and the Synthesis of Life
- Central Dogma
- What is Chemical Biology?

- **Proteins and protein folding**

- Describe different strategies for the production and isolation of proteins
- Experimentally determine the physicochemical and functional properties of proteins including laws of photochemistry
- Analyse and interpret protein sequences and structures, and use such information to predict protein function
- Protein folding--an overview

- **Peptide sequencing**

- Peptide sequencing, principles, and biological databases
- Pairwise, motifs, and domains
- Mass spectrometric analysis.

- **Peptide synthesis**

- peptide design, synthesis, and execution execution

- **Protein synthesis:**

- genetic code, amino acids, polypeptides
- nucleotide sequence and mutations.

- **Natural product synthesis**

- introduction, NRPS & PKS

- **Nucleic acids and DNA synthesis**

- Oligonucleotide synthesis
- Bioconjugate synthesis.

- **Molecular Evolution & Chemical Genetics**

- classical genetic and chemical genetic procedures, genotype-based and phenotype based genetic methods
- explain and contrast how gene expression is controlled by both proteins and small molecules,

including regulatory RNA molecules
- biology and chemistry of RNA

- **Protein-protein interactions & proteomics**

- introduction, databases
- principles, methodologies and applications of proteomics and synthetic biology.

Course Outcomes:

- Introducing the concept of chemical biology
- Application of chemistry to advance the study of biological systems
- Understanding biology to do new chemistry?
- How is chemical biology used to advance science and human health?
- Understanding chemical structures of bio-molecules
- Comparative understanding of biosynthesis and laboratory synthesis
- Understanding energetics of biochemical pathways and processes
- Be competent in reading and interpreting primary literature in the areas of chemical biology.

Reference Books:

1. Blackburn, G.M. & Gait, M.J. Nucleic Acids in Chemistry and Biology. Oxford (1996)
2. Branden, C. & Tooze, J. Introduction to Protein Structure.
3. Garland (1999) Creighton, T.E. Proteins: Structures and Molecular Properties.
4. Freeman (1993) Fersht, A. Structure and Mechanism in Protein Science. Freeman (1999)
5. Miller and Tanner (2008). Essentials of Chemical Biology, Wiley

BIO-715: Virology (60 Lecture Hrs)

Coordinators: Dr. Tirumala Kumar Chowdary (tkchowdary@niser.ac.in)

Course Details:

- Scope and outline of the course, history and introduction to virology
- Virus structure and classification: viral genome, capsid and envelope; different classification schemes and ICTV database
- Techniques in virology
- Viral biology: entry to egress
- Virus-host interactions: cell receptors for viral entry, host proteins for replication, translation and processing of viral
- Host cell response to virus infection
- Pathogenesis of viral infection and epidemiology
- Cell transformation by viruses
- Vaccines and antiviral drugs
- Use of viruses in gene delivery, molecular biology & as oncolytic agents
- Plant viruses and important plant pathogens of relevance to India
- Bacteriophages and insect viruses
- Specific virus families of importance:

- Orthomyxoviridae (Influenza virus)
- Paramyxoviridae (Measles, Mumps, New Castle disease viruses and Respiratory syncytial virus)
- Togaviridae/Alphavirus genus (Chikungunya virus)
- Flaviviridae (Dengue, Japanese encephalitis, Tickborne encephalitis, West Nile and Hepatitis C viruses)
- Coronaviridae (SARS virus)
- Retroviridae (HIV)
- Papillomaviridae (Human Papilloma viruses)
- Reoviridae (Rotavirus)
- Picornoviridae (common cold and Polio viruses)
- Herpesviridae (Herpes Simplex, Chickenpox, Kaposi's sarcoma and EpsteinBarr viruses)
- Emerging viruses: SARS, Chikungunya, Dengue, Hendra and Nipah viruses and Crimean Congo hemorrhagic fever virus

Course Outcomes:

- At completion of the course, student is expected to
- comprehend structural organization, and different biological processes of viruses
- Develop basic knowledge of biology and pathological manifestation of few important human

and animal viral pathogens

- Develop comprehension of tools and approaches to study viral biology.

Reference Books:

1. Basic Virology, 3rd edition by Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini. Year: 2007; Publisher: Wiley-Blackwell. ISBN: 978-1-4051-4715-6
2. Principles of virology, 3rd edition (vol.1) by S. Jane Flint, Lynn W. Enquist, Vincent R. Racaniello and Anna Marie Skalka. Year: 2008; Publisher:ASM press.ISBN: 978-1-55581-443-4
3. Virology: Molecular Biology and Pathogenesis by Leonard Norkin. Year: 2010; Publisher: ASM press. ISBN: 978-1-55581-453-3
4. Fields Virology, 5th edition. Edited by David. M. Knipe and Peter M. Howley. Year: 2007; Publisher: Lippincott Williams & Wilkins. ISBN/ISSN: 9780781760607

BIO-716: Principles of Drug design (60 Lecture Hrs)

Coordinators: Dr. Badireenath V. Konkimalla (badireenath@niser.ac.in)

Course Details:

- Introduction to the Drug Discovery
- Source of Drugs
- Drug Development
- Development of prodrugs
- Lead Identification and optimization
- Pharmacology of drug action
- Identification of target for drug discovery
- Approaches towards drug design
- Drug interactions
- Computer-aided drug design
- High throughput technologies in drug discovery

Course Outcomes:

- As an interdisciplinary course, the students will be introduced to the different concepts of drug discovery and development.

Reference Books:

1. Principles of Drug Action: The Basis of Pharmacology. William B. Pratt, Palmer Taylor.

2. High-Throughput Screening in Drug Discovery (Methods and Principles in Medicinal Chemistry). Jörg Hüser, Raimund Mannhold, Hugo Kubinyi, Gerd Folkers.

3. Drug Design: Structure- and Ligand-Based Approaches. Kenneth M. Merz, Dagmar Ringe, Charles H. Reynolds.

4. Burger′s Medicinal Chemistry, Drug Discovery, and Development: 8 Volume Set.

5. Biopharmaeutics and pharmacokinetics – A treatise. Brahmankar DM and Jaiswal SB

BIO-717: Developmental Biology (Lecture Hrs)

Coordinators: Dr. Debasmita P. Alone & Dr. Swagata Ghatak
(debasmita@niser.ac.in & swagata@niser.ac.in)

Course Details:

- **Key concepts and techniques:**

- Principles and excitements of Developmental biology Developmental events and differential gene expression; Developmental Genetics - approaches & techniques ;Cell fate determination in C. elegans

- **Early embryonic development**

- Gametogenesis; Fertilization; Cleavage; Gastrulation

- **Axial patterning**

- Axis formation in Amphibian; Anterior posterior patterning in Amphibians; Anterior posterior patterning in Drosophila; Homeotic gene regulation; Early mammalian development; Left right patterning.

- **Later embryonic development**

- Patterning in Central nervous system; Ectoderm; Mesoderm; Endoderm

- **Post embryonic development:**

- Sex determination in Drosophila, mammals and other species; Regeneration; Aging & Senescence.

- **Implications of Developmental Biology**

- Medical implications; Cancer as a developmental disease; Environmental regulation and development; Developmental mechanisms and evolutionary change.

Course Outcomes:

- Understanding the principles governing development of an organism from conception to birth.
- Key concepts in maintenance of growth of an organism and aging.
- Implications in Evolution, Health and disease.
-

Reference Books:

1. "Developmental biology" by Scott Gilbert

2. "Principles of Development" by Lewis Wolpert

BIO-718: Genetic Engineering (60 Lecture Hrs)

Coordinators: Dr. Manjusha Dixit
(manjusha@niser.ac.in)

Course Details:

1. Growth and maintenance of bacterial cultures, bacteriophages plasmids
2. Growth and maintenance of animal cells and viruses
3. Mutation, mutagenesis and mutant screening
4. Enzymes used in genetic engineering experiments, DNA, polymerases, ligase, reverse transcriptase, restriction endonucleases and other enzymes
5. Oligonucleotides synthesis & purification
6. Antisense DNA/RNA in genetic engineering
7. Radiolabelling of nucleic acids
8. Transformation & transfection
9. Construction of genomic & cDNA library
10. 1Genomic DNA & cDNA cloning
11. Analysis of DNA of cloned genes
12. Analysis of protein sequencing products & cloned genes
13. Nucleic acid & protein sequencing technology
14. Protein nucleic interaction and the methods to study those
15. Polymerase Chain Reactions, types of PCRs and analysis of PCR, products; Application of PCRs.
16. Site directed mutagenesis
17. Recombination, site specific recombination
18. Transgenic plants
19. Transgenic animals
20. Other transgenic life forms
21. Ethics and economics of GM crops and GM organisms

Course Outcomes:

- Understanding the basic principles of Recombinant DNA technology
- Knowledge of various tools and techniques used in genetic engineering
- Applications in the generation of transgenic models.

Reference Books:

1. “Genetic Engineering” by Reec

BIO-719: Infectious Disease Biology (60 Lecture Hrs)

Coordinators: Dr. Harapriya Mohapatra (hm@niser.ac.in)

Course Details:

- **Introductory lectures to IDB –**

- What is infection, what is disease, Microbes Causing Infectious Diseases- bacteria, viruses, fungi, protozoa, helminthes, prions. Present scenario of IDs worldwide. (General lectures based on journals)

- **Host pathogen interactions**

- Host-pathogen relationship, Toxins, Disease establishment, Disease transmission- zoonotic, nosocomial, epidemiology, Molecular Aspects of Host-Pathogen Interactions, Effect of nutrition on infectious diseases, Viruses and cancer

- **Host defense & Immunopathology**

- Host defense & Immunopathology.

- **Evolutionary Biology of Infectious Diseases**

- Emerging, Reemerging and Deliberately introduce infectious diseases, Factors that Contribute to the Emergence of a New Pathogens- role of evolution, ecology, genetics- HGT or LGT, clustered, regularly interspaced, short palindromic repeats (CRISPER), some EIDs and REIDs- malaria, Tb,influenza (SWINE flu), SARS, chikunguniya, HIV, west nile virus, marburg virus, bioterrorism, anthrax, CJD.

- B**acterial infections:**

- This willfocus on the major bacterial infections. The infections can be considered in groups related to the body systems infected.

- **Viral infections**

- Molecular biology of the different types of virus, the different strategies that are involved in their replication and the ways in which they cause disease. Consideration is given to the prevention, treatment and control of virus infections.

- **Parasitic infections:**

- Biology of parasites and the ways that they can cause disease. The organisms responsible for the major parasitic diseases will provide the main focus for instruction as they have also been the main focus for research.

- **Molecular Epidemiology and control of infectious diseases**

- Topics include analytic methods, study design, outbreak investigations, surveillance, vaccine development and evaluations, screening, modeling, and infectious causes of cancer or chronic diseases. Background on important infectious diseases will be presented.

Course Outcomes:

- Develop understanding infection process, infection epidemiology, host-pathogen interactions and evolution of pathogens.

Reference Books:

1. Alcamo's fundamentals of Microbiology by Jeffrey C. Pommerville,
2. General Microbiology by Roger E Stanier et al.,
3. Brock Biology of Microorganisms by Michael T Madigan
4. General Microbiology by Roger Y Stanier et al.
5. Microbiology 5th ed, Michael Z Pelczar Jr

BIO-720: Cancer Biology (60 Lecture Hrs)

Coordinators: Dr. Asima Bhattacharya (asima@niser.ac.in)

Course Details:

- **Cancer origin and terminology –**

- Molecular and cellular origin of cancer
- Clonal vs. mutational origin of cancer
- Stem cells and cancer)

- **Different classes of cancers**

- Carcinoma, Sarcoma
- Leukemia, Lymphoma and myeloma
- Central nervous system cancer

- **Malignant transformation of cells**

- General causes of cancer, mechanisms
- Characteristics and phenotypes of cancer cells
- Process of metastasis and its significance.

- **Cancer induction and oncogenes**

- Stages in the development of tumorigenesis: initiation and promotion
- Tumor-suppressor genes and oncogenes and their differences
- The connection between oncogenes and proto-oncogenes.
- Cancer stem cells

- **Cellular response to Tumors:**

- Signal transductions in cancer, G protein coupled-receptors and secondary messengers
- Receptor tyrosine kinases and SH2-containing proteins
- Ras protein and the MAP kinase cascade in the control of cell function and aberrations in cancer
- Convergence, divergence and crosstalk among different signaling pathways
- Concept of apoptosis and its role in cancer.

- **Tumor Antigens and tumor immunity**

- Tumor-specific transplantation antigens (TSTAs) and tumor-associated transplantation antigens (TATAs)
- Tumor induced altered Immune response and immune-suppression.

- **Tumor Evasion mechanism:**

- Changes in tumor cells
- Alteration in antigen presenting cells
- Dysfunction of host effector cells.

- **Cancer Therapy**

Chemotherapy
- Radiation therapy
- Surgery
- Cancer immuno-therapy
- Other treatment methods including targeted therapy.
-

Course Outcomes:

- Understanding basic molecular and cellular mechanisms of carcinogenesis.
- Integrating knowledge to understand therapeutic approaches.
- Stimulate research interest.

Reference Books:

1. "Molecular Biology of the Cell" by Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter
2. "Molecular Cell Biology" by Lodish, Harvey; Berk, Arnold; Zipursky, S. Lawrence; Matsudaira, Paul; Baltimore, David; Darnell, James E
3. "The Biology of Cancer" by Weinberg, Robert A

BIO-721: Immune Regulation and Infection Immunity (60 Lecture Hrs)

Coordinators: Dr. Subhasis Chattopadhyay (subho@niser.ac.in)

Course Details:

- Introduction to Infectious Diseases and its worldwide scenario.
- Overview of Host cell immune response
- Outline of immuno- regulatory response and its role in infectious diseases
- Immuno-regulatory response to viral infection
- Immuno-regulatory response to bacterial infection
- Immuno-regulatory response to protozoan infection
- Immuno-regulatory response to helminth infection
- Immuno-therapeutic strategies targeting immuno-regulatory cells in Infectious diseases

Course Outcomes:

- Comprehensive understanding on Immune regulation, immune deviation in bacterial, viral and parasitic infections
- Insights in to Translational aspects of Immunology such as vaccines, immunomodulatory agents in infectious as well as autoimmune diseases.

Reference Books:

1. Kuby Immunology. Thomas J. Kindt, Richard A. Goldsby, Barbara Anne Osborne, Janis Kuby.

W.H. Freeman, 2007

2. b) Infection and Immunity. Huw Davies, D. H. Davies. Taylor & Francis, 1999

BIO-722: Macromolecular Crystallography (60 Lecture Hrs)

Coordinators: Dr. Rudresh Acharya
(Rudresh.acharya@niser.ac.in)

Course Details:

- **Basics of crystals, symmetry and crystal growth:–**

• Crystals, Crystal Systems, Crystal Lattice, Symmetry Elements, Point groups, Space groups, Unit cells, asymmetric units, Matrix representation of Symmetry, physical and energetic principles, Strategies and approaches for growing crystals (protein, DNA)

- **X-ray sources and detectors:**

• Sealed Tube, Rotating Anode, Synchrotron, Point detector, Area detectors

- **Theory of X-ray diffraction:**

• Scattering by an Atom, Diffraction from a Crystal: one dimensional, two-dimensional, and three-dimensional array of atoms, Structure Factor, Reciprocal Lattice, Bragg's law, Ewald Sphere, Resolution

- **Theory of Structure factor, Fourier Syntheses and Electron density:**

• The structure factor in exponential, and vector forms, Temperature factor, Fourier series, Fourier transform, Fourier synthesis, electron density equation, Fridel's law, Anomalous scattering.

- **Data collection:**

• Rotation and oscillation theory, Diffractometer theory, Goniometer, Data collection Strategy, Partial and fully recorded reflections, Wide and fine slicing, Blind region, Total range of data collection, interpretation of diffraction images, Cryo data, Single/Multiple wavelength anomalous dispersion data collection.

- **Data Indexing, integration, scaling (Data reduction), and statistics:**

• Indexing, Integration, Theory of Lorentz and Polarization corrections, Scaling, R-factors, I/sigma (I), completeness, X-ray data quality indicators, Space Group determination.

- **Electron density maps, Refinement and Model building::**

• Difference Fourier map, locating heavy atoms, and anomalous scatter, locating water, ligand molecules, Refinement at atomic resolution: Refinement by Fourier syntheses, Series termination, Locating Hydrogen atoms, Optimization methods, Least-square refinement, full matrix solution, Maximum likelihood, Target function for refinement, Bulk solvent, A prior knowledge, Restrains and Constrains, Non-crystallographic symmetry, Cross-validation, R-factors (Rwork & Rfree) Density modification, Good practice for refinement.

•

Course Outcomes:

• Understand theory behind the X-ray diffraction to structure determination. Data collection strategy, processing, interpretation of data statistics, structure solution

- methods, refinement methods, interpretation of electron density map.
- Introduction to X-ray crystallography, highlights from 54 years of macromolecular crystallography, future directions [1].

Reference Books:

1. X-ray structure determination, a practical guide edited by G. H. Stout and L. H. Jensen ISBN-10:
2. 0471607118
3. Internal tables for crystallography Vol. F Crystallography of biological macromolecules
4. Internal tables for crystallography Vol. A Space Group Symmetry
5. Crystallization of Biological Macromolecules by Alexander MacPherson ISBN-13: 978-0879695279
6. An introduction to X-ray Crystallography M.M. Woolfson
7. Biomolecular Crystallography by Bernard Rupp ISBN-13: 978-0815340812
8. Internal tables for crystallography Vol. F Crystallography of biological macromolecules
9. Original research articles and reviews for each topic will be provided in the classes
10. Fundamentals of crystallography" by Giacovazzo.

BIO-723: Structural Biology (60 Lecture Hrs)

Coordinators: Dr. Rudresh Acharya
(Rudresh.acharya@niser.ac.in)

Details:

- Introduction to Structural Biology: Scope and definition of Structural Biology.
- Methodologies:
- Macromolecular Structure: Structure of proteins (including protein folding), nucleic acids; membranes, action of other biologically important molecules and molecular assemblies like ribosomes, nucleosomes; functional significance of structure.
- Conformational analysis: Van der Waals radii of atoms (equilibrium separation between non covalently bonded atoms) – contact distance criteria; Noncovalent forces determining biopolymer structure; dispersion; forces; electrostatic interactions; van der Waals interactions; hydrogen bonds; hydrophobic interactions; distortional energies; description of various interactions by potential functions; principles of minimization of conformational energy.

Course Outcomes:

- Understanding the protein structures in modular approach, correlating the structure to function, and deducing the mechanistic models for the functioning, methods for 3D-structure determination, validation of structures.

Reference Books:

1. "Proteins: structures and molecular properties" by T.E. Creighton

BIO-724: Ion Channels (60 Lecture Hrs)

Coordinators: Prof. Chandan Goswami
(Chandan@niser.ac.in)

Course Details:

- **Introduction to different ion channels:–**

- (Difference between ion channels with pumps and carriers, ion channels in prokaryotes, Fungus, animal and plant systems, selective and non-selective ion channels)

- **Expression of different ion channels in different systems.:**

- (Why channel expression are specific in certain tissues, Examples: neurons, sperm, bones, keratinocytes, immune cells, retina, pancreas, cardiac muscle, other specific tissues, Pharmacological advantages/disadvantages of expression, useful systems to study ion channels)

- **Importance of ion channels in evolution:**

- (Evolution of different structural parts such as transmembrane regions, cytosolic domains, loop regions, ligand binding regions, voltage-sensor regions, selection pressure on the ion channels, ion channels and toxins: Pray predator relationship, ion channels and environmental cues, ion channels in reproduction)

- **Structural and functional uniqueness of ion channels:**

- (Q10 values, thermodynamic properties behind channel opening and closing, conformational changes, ionic filter, voltage gating, ligand gating, voltage sensor, examples of high-resolution ion channel structures).

- **Organization in membranous environment, effect of lipid bilayer and specific lipids on ionic functions**

- (Need of specific lipid microenvironments for proper channel functions).

- **Different types of ion channels:**

- (Different anion and cation channels, basics of Na+, K+, Cl-, Ca2+, transport of other heavy metals).

- **Heteromeric and homomeric ion channels**

- (Organization of different polypeptides).

- **How natural and synthetic activators and inhibitors modulate ion channels:**

- (Importance of different metabolites, Chemistry and pharmacology of different activators and inhibitors, effect on metabolism)

- **Measuring ionic conductivity by electrophysiology and imaging:**

- ((Electrophysiological parameters and methods to analyze channel function, different types of

channel recording, Cell biological parameters and methods to analyze channel function, metal imaging and different sensors).

- **Trafficking of ion channels**

- (Different modes of trafficking of ion channels to ER to Golgi, Golgi to plasma membrane, to Lysosomes, Other organelles, prerequisites for such trafficking)

- **Channel-opathy and human diseases, potential remedy:**

- (Genetic variations in ion channel sequences, information from recent genome sequencing data sets, penetrance effect of mutations).

Course Outcomes:

- Understanding the principles governing ion channel functions
- Biochemcial, biophysical, genetical basis of ion channel and its response
- Key concepts in maintenance of ion channel structure, function and ionic homeostasis of the cell
- Importance of ion channels in health and disease, pharmacology and applications
- Advanced knowledge of details of microscopy
- Bridging the gap between theory and research methodology

Reference Books:

1. Principles of biochemistry, Channels journal, other journals, distributed hand outs, notes, specific reviews and papers

BIO-725: Concepts in Mechano Biology (60 Lecture Hrs)

Coordinators: Dr. Ramanujam Srinivasan (rsrini@niser.ac.in)

Course Details:

- Mechanical framework for understanding biological systems 2. Cell mechanics in basic cellular and pathological processes.
- Cell architecture
- Cytoskeletal structure and dynamics
- Cell mechanics
- Basics of Mechanics
- Viscoelasticity / basic rheology
- Mechanics of cell membrane
- Mechanics of cellular polymers
- Controlling Cell and nuclear Morphology
- Polymers Networks
- Molecular motors
- Tensegrity
- Foams
- Soft Glassy Material
- Biphasic models of cells
- Mechano sensing and Mechano transduction
- Mechanical Signals
- Mechano sensing organelles and structures
- Mechanics of receptor binding
- Intracellular signaling
- Mechano-chemical coupling
- Cellular interactions with biomaterials
- Mechanical regulation of cell fate
- Mechanics of cell proliferation
- Cytokinesis
- Cancer cells and stem cells
- Apoptosis
- Mechanics of cell adhesion & migration
- Adhesion proteins
- Cytoskeletal structures & Forces
- Molecular motors
- Extracellular matrix mechanics
- Mechano biology in tissue engineering – Bio mimetics and Cell-like Materials
- Mechanical testing of cells
- Instrumentation tools used for mechanical characterization of cells – Microneedles, Micropipette Aspiration, Atomic Force Microscopy, Microrheology, Magnetic Twisting

Cytometry, Optical Tweezers, Traction Force Microscopy, Nanofabrication – introduce to MEMS tools, Microfluidics & Lab-on-chip concepts.

Course Outcomes:

- Comprehend the concept that cells are complex micron-sized machines/ nano machines.
- Understanding of the mechanical behavior of cell and tissues and the biological responses of these biological systems to mechanical stimuli.
- Gain knowledge on how cells generate and sustain mechanical forces within their environment, as part of their normal physiology.
- Ability to visualize that cells are active materials that can detect mechanical stimulation by the activation of mechanosensitive signaling pathways, and respond to physical cues through cytoskeletal re-organization and force generation
- Competence in reading and interpretation of primary literature in the area of mechano biology and address research questions relating to cell processes using mechano biological approaches.
- Enable students of disciplines other than biology to understand how principles of mechanics and engineering can be applied to biological systems and problems.
-

Reference Books:

1. Jacobs, Huang, & Kwon. Introduction to Cell Mechanics and Mechanobiology. Garland Science, ISBN-10: 0815344252

2. Boal, Mechanics of the Cell. Cambridge University Press, ISBN-10: 0521796814; ISBN-13: 9780521130691

3. Ethier and Simmons, Introduction to Biomechanics: From Cells to Organisms. Cambridge University Press, ISBN: 0521841127

4. Mofrad & Kamm, Cytoskeletal Mechanics – Models and Measurements. Cambridge University Press, ISBN-10: 0521846374

5. Bray, Cell Movements. Garland Science, ISBN-10: 0815332823; ISBN-13: 9780815332824

6. Alberts et al., Molecular Biology of the Cell. Garland Science, ISBN-10: 0815332181 7. Discher and Wang, Methods in Cell Biology 83: Cell Mechanics. Academic Press. ISBN-10: 0123705002

8. Philip Nelson, Biological Physics, Energy, Information, Life. W.H. Freeman, ISBN10: 0716798972; ISBN-13: 978-0716798972

9. Jonathon Howard, Mechanics of Motor Proteins and the Cytoskeleton. Sinauer Associates Inc. ISBN-10: 0878933344; ISBN-13: 978-0878933341

10.D'Arcy Wentworth Thompson, On Growth and Form. Dover Publications Inc. ISBN10: 0486671360; ISBN-13: 978-0486671352

11.Gabor Forgacs, Stuart A. Newman, Biological Physics of the Developing Embryo. Cambridge University Press, ISBN-10: 0521783372; ISBN-13: 978-0521783378

BIO-726: Endocrinology (60 Lecture Hrs)

Coordinators: Dr. Praful S. Singru
(pssingru@niser.ac.in)

Course Details:

▪ Introduction to endocrine glands, hormones and their classificationHormone biochemistry, mechanism of hormone synthesis and their transport to target organs or tissues.

▪ Hormone receptors and mechanism of hormone action, Methods of measurement of hormones.

▪ Hypothalamus; Neuroendocrinology: Neuro hormones and Neurotransmitters.

▪ Structure, function, hormones and clinical disorders of following mammalian endocrine glands. Pituitary, Pineal, Adrenal, Thyroid, Parathyroid, Pancreas, Gonads, Gastro intestinal tract, Thymus

▪ Endocrine control of sexual differentiation

▪ Endocrine control of appetite and feeding.

▪ Calcium homeostasis: role of PTH, Vitamin D and calcitonin.

▪ Growth hormone and Insulin like growth factor (IGF)

▪ Important facts of vertebrate endocrinology.

▪ Invertebrate endocrinology.

▪ Environmental endocrinology: endocrine disrupting chemicals

Course Outcomes:

• Understanding the concepts of hormones and endocrine regulation.
• Knowledge about the structure and function of different endocrine glands and evolutionary significance.
• Applying the knowledge of endocrine regulation to analyze disorders associates with hormonal im-balance.

Reference Books:

1. AM Etgen and DW Pfaff (2009): Molecular Mechanisms of Hormone Action on Behaviour. Academic Press, USA
2. Bentley, PJ (1998): Comparative Vertebrate Endocrinology. Cambridge University Press. 3rd Edition
3. Hall J. (2011). Guyton and Hall: Textbook of Medical Physiology, Saunders Publishers, 12th Edition
4. Larsen P., Kronenberg HM, Melmed S, Polonsky KS, Wilson JD, Foster D. (2002) Williams Test Book of Endocrinology. Saunders Publishers, 10th Edition

BIO-727: Plant Developmental Biology (60 Lecture Hrs)

Coordinators: Dr. Kishore C. Panigrahi,
Dr. Himabindu Vasuki K
(panigrahi@niser.ac.in & hvk@niser.ac.in)

Course Details:

- Plant Development overview
- Hormones influencing plant organogenesis and signaling
- Light and plant development and photo morphogenesis
- Leaf and flower development
- Circadian clock and plant development
- Epigenetics, siRNA world and plant development

Course Outcomes:

- Learning molecular genetics approaches to understand plant development.
- Understanding the interaction of biotic and abiotic component is major focus.
- Designing experimental strategies understanding plant development.

Reference Books:

1. Plant Physiology Taiz and Zeiger: 5th Ed, 2010, Sinauer Associates Inc. Publishers

2. Plant Biology by Alison M. Smith et al., 2010, Garland Science, Taylor and Francis Gp. "Research articles"

BIO-728: Translational Control in Biology (60 Lecture Hrs)

Coordinators: Dr. Pankaj V. Alone (pankaj@niser.ac.in)

Course Details:

- Recent advances in the general translation (structure-function and genetics).
- IRES elements and control of viral translation.
- IRES elements in cellular translation control.
- Cis-acting element and trans-activing factors in translation regulation
- Role of microRNA in translation control.
- Signaling in translation.
- Role of eIF2a kinase in translational control.
- Translational control in cancer development.
- Translational control during apoptosis.
- Translational control in metabolic disorder.
- Translational control in synaptic plasticity, memory and learning.
- Translational control in development.
- mRNA localization and turnover.
- Mitochondrial translation and human diseases.

Course Outcomes:

• This course is design to understand the recent advancements in the fundamentals of protein translation and its control. Translation is a fundamental step in the central dogma of molecular biology. The regulation of translation is key to all basic cellular processes. Metabolic pathways, signaling, developmental decisions are tightly linked with the regulation of translation. Any defects associated with this process and its repercussion in cancer, metabolic disorders and human diseases will be covered.

Reference Books:

1. Translational control in Biology and Medicine (Mathews, Sonenberg, Hershey, CSHL press)
2. Translational control in gene expression (Sonenberg, Hershey, Mathews, CSHL press)
3. Class notes and research articles

BIO-729: Macro evolutionary and patterns (60 Lecture Hrs)

Coordinators: Dr. Aniruddha Datta Roy
(datta.roy@niser.ac.in)

Course Details:

- Evolution of life on Earth
- Geological Eras and the five mass extinction events
- Schools of systematics
- Species concepts
- Patterns of change in evolution
- Phylogenetics and tree building
- Adaptive radiations
- Co-evolution
- Convergent evolution
- Applications of phylogenetics
- Introduction to biogeography
- patterns

Course Outcomes:

- Understanding macro evolutionary principles with detailed module on tree building
- Working on real data using the latest phylogenetic approaches
- Understanding principles of biogeography and pattern created by dispersal and vicariance events.

Reference Books:

1. Lemey, P., Salemi, M. and Vandamme, A.M. eds., 2009. The phylogenetic handbook: a practical approach to phylogenetic analysis and hypothesis testing. Cambridge University Press.
2. Lomolino, M.V., Riddle, B.R., Whittaker, R.J. and Brown, J.H., 2010. Biogeography (Sinauer, Sunderland, MA).
3. Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V. and Jackson, R.B., 2014. Campbell Biology (No. s 1309). Boston: Pearson.
4. Stearns, S.C. and Hoekstra, R.F., 2000. Evolution, an introduction. Oxford University Press

BIO-730: Model Organisms in Biomedical Research

Coordinators: Dr. Debasmita P. Alone (debasmita@niser.ac.in)

Course Details:

- Model organisms and the history behind coining the term giving examples of different fields of biology.

- Commonly used model organisms (*E. coli, S. cerevisiae, D. discoideum, C. elegans, D. melanogaster, H. vulgaris, A. thaliana, N. crassa, X. tropicalis, D. rerio, G. gallus, M. musculus*) and the experimental advantages and disadvantages of each.

- Concept of Non-model model organisms including but not limited to the social insects, flatworms, stem cells and organoids.

- Experimental methods: genetic, physiological and postgenomic technologies that are currently being used in research involving model organisms (6 Lectures + 2 tutorial).

- Techniques used to produce loss-of-function or gain-of-function variants of a gene.

- Models suited to address specific biological or medical questions pertaining to neurodegeneration, drug screening, metastasis, wound healing, blindness and deafness, addiction and sleep disorders.

- Demonstration of disease modelling using model organisms: Drosophila, Hydra, Xenopus, Tetrahymena and Arabidopsis e.g. neurodegeneration using UAS-GAL4 system in Drosophila, metastasis and drug screening using anti-cancer agents in established human cell lines and Drosophila, blindness and deafness using Drosophila mating assays, and sleep disorders using circadian rhythm assays in Drosophila; regeneration using Hydra/Xenopus/Tetrahymena; Regulated exocytosis using Tetrahymena.

Course Outcomes:

- Developing an understanding of how and when model organisms can be utilized for biological research.
- Getting familiar with the some commonly used model organisms in biology.
- Knowing how to go about choosing one or other models in order to address a given problem.

Reference Books:

1. The Biological Resources of model organisms (Edited by Robert L. Jarret, Kevin McCluskey, CRC Press; First Edition, published on 9th August, 2019).
2. Emerging model organisms: A Laboratory Manual, Volume 1 & 2, (CSHL Press; Volume1 published in 2009 and Volume 2 published in 2010)