LIFE SCIENCES

Programme Code: LIFE04

Programme Outcomes:

- **Specialized Domain Authority** Demonstrate authoritative knowledge and a deep conceptual understanding of a specialized niche within life sciences.

- **Original Hypothesis Generation & Innovation** Independently identify significant knowledge gaps and formulate original, testable hypotheses that contribute to the advancement of the chosen field of biological sciences.

- **Advanced Technical Mastery & Methodological Innovation** Execute complex experiments using state-of-the-art technologies and develop or optimize novel methodologies to solve sophisticated research problems.

- **Collaborative and team building skills** Demonstrate the ability to collaborate and work in interdisciplinary areas of science where Life Sciences knowledge is required

- **High-Impact Dissemination & Scholarly Ethics** Produce high-quality research findings suitable for publication in premier international journals while maintaining the highest standards of academic integrity and publication ethics.

- **Professional Leadership & Project Management** Manage complex, time-bound research projects independently and demonstrate the leadership skills required to mentor junior researchers and collaborate within international scientific networks.

DETAILED COURSE STRUCTURE

S. No	Course Code	Course Title	Hours	Credit
1	***	Theory course 1*	60	4
2	***	Theory course 2*	60	4
3	BIO700	Research Methodology & Research Publication Ethics	60	4
4	BIO699	Biology Research Project		6
5		Total		18

*The theory courses 1 and 2 are any two courses from the list below offered from the School of Biological Sciences or courses offered by other schools as recommended by the monitoring committee or standing academic committee to a student.

S. No	Course Code	Course Title	Hours	Credit
1	BIO601	Bioinformatics and computational biology	60	4
2	BIO602	Biotechniques	60	4
3	BIO701	Advanced molecular biology	60	4
4	BIO651	Advanced cell biology	60	4
5	BIO652	Genetic engineering	60	4
6	BIO653	Advanced biochemistry	60	4
7	BIO654	Advanced microbiology	60	4
8	BIO655	Enzymology	60	4
9	BIO656	Advanced neurobiology	60	4
10	BIO657	Chemical biology	60	4
11	BIO658	Virology	60	4
12	BIO659	Plant physiology	60	4
13	BIO660	Developmental biology	60	4
14	BIO751	Advanced immunology	60	4
15	BIO752	Infectious disease biology	60	4
16	BIO753	Cancer biology	60	4
17	BIO754	Advanced genetics	60	4

18	BIO755	Immune regulation and infection	60	4
19	BIO756	Macromolecular crystallography	60	4
20	BIO757	Quantitative biology	60	4
21	BIO758	Ion channels	60	4
22	BIO759	Concepts in mechanobiology	60	4
23	BIO760	Molecular errors in disease	60	4
24	BIO761	Plant developmental biology	60	4
25	BIO762	Translational control in biology	60	4
26	BIO763	Macroevolutionary principles and patterns	60	4
27	BIO764	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*)

Course Coordinators:

Course	Coordinators	E-mail
Bioinformatics and computational biology	Dr. Badireenath V. Konkimalla & Dr. Saleem Mohammed	badireenath@niser.ac.in saleem@niser.ac.in
Biotechniques	Dr. Rudresh Acharya & Prof. Palok Aich	rudresh.acharya@niser.ac.in palok@niser.ac.in
Advanced molecular biology	Dr. Pankaj V. Alone	pankaj@niser.ac.in
Advanced cell biology	Prof. Chandan Goswami	chandan@niser.ac.in
Genetic engineering	Dr. Manjusha Dixit & Dr. Tridib Mahata	Manjusha@niser.ac.in tridibmahata@niser.ac.in
Advanced biochemistry	Dr. Abdur Rahaman	arahaman@niser.ac.in
Advanced microbiology	Dr. Harapriya Mohapatra	hm@niser.ac.in
Enzymology	Dr. Tirumala Kumar Chowdary	tkchowdary@niser.ac.in
Advanced neurobiology	Dr. Subhasis Chattopadhyay	subho@niser.ac.in
Chemical biology	Prof. Palok Aich	palok@niser.ac.in
Virology	Dr. Tirumala Kumar Chowdary	tkchowdary@niser.ac.in
Plant physiology	Dr. Kishore C. Panigrahi & Dr. Himabindu Vasuki K.	panigrahi@niser.ac.in hvk@niser.ac.in
Developmental biology	Dr. Debasmita P. Alone & Dr. Swagata Ghatak	debasmita@niser.ac.in swagata@niser.ac.in
Advanced immunology	Dr. Subhasis Chattopadhyay	subho@niser.ac.in
Infectious disease biology	Dr. Harapriya Mohapatra	hm@niser.ac.in
Cancer biology	Dr. Asima Bhattacharyya	asima@niser.ac.in
Advanced genetics	Dr. Manjusha Dixit	manjusha@niser.ac.in
Immune regulation and infection	Dr. Subhasis Chattopadhyay	subho@niser.ac.in
Macromolecular crystallography	Dr. Rudresh Acharya	rudresh.acharya@niser.ac.in
Quantitative biology	Prof. Palok Aich	palok@niser.ac.in
Ion channels	Prof. Chandan Goswami	chandan@niser.ac.in
Concepts in mechanobiology	Dr. Ramanujam Srinivasan	rsrini@niser.ac.in
Molecular errors in disease	Dr. Manjusha Dixit & Dr. Debasmita P. Alone	manjusha@niser.ac.in & debasmita@niser.ac.in
Plant developmental 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
Research Methodology & Research Publication Ethics	Dr. Abdur Rahaman & Dr. Himabindu Vasuki K.	arahaman@niser.ac.in hvk@niser.ac.in

Detailed Syllabus for Various Courses

BIO-601: Bioinformatics and Computational Biology (60 Lecture Hrs)

Coordinators: Dr. Badireenath V. Konkimalla,
Dr. Saleem Mohammed
(badireenath@niser.ac.in & saleem@niser.ac.in)

Course Details:

- **Origin Introduction to bio-informatics**

- Introduction; History and importance; Field and scope.

- **Databases and Database searching**

- Importance, classification; Annotation and File formats
- 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 Matrice**

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

- **Algorithms behind pair wise sequence alignments**

- Dynamic programming, Smith-Watermann, Needleman-Wunsch, Heuristic algorithms BLAST, FASTA
- applications, statistical parameters governing BLAST results
- Demo: database searching using BLAST.

- **Multiple sequence alignments**

- Importance, progressive sequence alignment, ClustalW, statistical parameters governing clustalW, Applications Demo: ClustalW

- **Phylogenetic tree construction and different approaches**

- Introduction, importance, classification and parts of tree,
- predicting number of root and unrooted trees, orthologs and paralogs, transitions and

transversions, substitutions matrices,
- different methods to construct phylogenetic tree,
- Neighbour-Joining (star decomposition method), Bootstrapping
- Demo: MEGA software.

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

- Importance of patterns, motifs, deriving PSSM, sequence logo
- Demo: Prosite, Pfam.

- **Structural Bioinformatics**

- Introduction to structural bioinformatics and protein structure, Ramachandran plot
- Secondary structure prediction and methods
- Hydropathy plot, helical wheel, signal peptide prediction, transmembrane prediction, Demo: Tertiary structure prediction: RMSD and Homology modelling
- Demo: Swiss Model and evaluation
- Concepts related to Drug design: Lipinski Rule of 5 and Molecular docking

- **Systems**

- Introduction, need for computers in system biology
- High-throughput and omic approaches, difference and application
- Graph theory
- Gene Ontology
- Demo: KEGG and gene ontology.

Course Outcomes:

Students are expected to develop an understanding of:
- 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.

References:

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

BIO-602: 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.

References:

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 Biolo
6.

BIO-701: Advanced Molecular Biology (60 Lecture Hrs)

Coordinators: Dr. Pankaj V. Alone
(pankaj@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.

- 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.

References:

1. "Immunology "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-651: Advanced Cell Biology (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 probes
  - Auto fluorescence and its application
  - Others
- **Homeostasis a quantitative science**
  - Fluorescence microscope
  - Phase contrast microscope
  - DIC microscope
  - Confocal microscope, Spectral detection
  - Total internal reflection fluorescence microscope (TIRF), 6) 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.
- Biochemcial, 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.
- Importance of ion channels in health and disease, pharmacology and applications.
- Bridging the gap between theory and research methodology.

References

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

BIO-652: Genetic Engineering (60 Lecture Hrs)

Coordinators: Dr. Manjusha Dixit,
Dr. Tridib Mahata
(Manjusha@niser.ac.in & tridibmahata@niser.ac.in)

Course Details:

- Growth and maintenance of bacterial cultures, bacteriophages plasmids
- Growth and maintenance of animal cells and viruses.
- Mutation, mutagenesis and mutant screening.
- Enzymes used in genetic engineering experiments, DNA, polymerases, ligase, reverse transcriptase, restriction endonucleases and other enzymes.
- Oligonucleotides synthesis & purification.
- Antisense DNA/RNA in genetic engineering.
- Radio labelling of nucleic acids.
- Transformation & transfection.
- Construction of genomic & cDNA library.
- Genomic DNA & cDNA cloning. Genomic DNA & cDNA cloning
- Analysis of protein sequencing products & cloned genes
- Nucleic acid & protein sequencing technology
- Protein nucleic interaction and the methods to study those.
- Polymerase Chain Reactions, types of PCRs and analysis of PCR, products; Application of PCRs.
- Site directed mutagenesis.
- Recombination, site specific recombination
- Transgenic Plants.
- Transgenic Animal.
- Other transgenic life forms
- Ethics and economic 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.

BIO-653: Advanced 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.

References:

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 Strye*

BIO-654: 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, Biofilms.

Course Outcomes:

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

References:

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, Marine microbiology: ecology and applications by Munn, CB

BIO-655: 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

References:

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

BIO-656: Advanced Neurobiology (60 Lecture Hrs)

Coordinators: Dr. Subhasis Chattopadhyay

(subho@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.

References:

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-657: 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.

References:

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-658: 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 proteins.
- 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.

    - Ortho myxoviridae (Influenza virus)
    - Flaviviridae (Dengue, Japanese encephalitis, Tickborne encephalitis, West Nile and Hepatitis C viruses)
    - Coronaviridae (SARS virus)
    - Retroviridae (HIV)
    - Papillo maviridae (Human Papilloma viruses)
    - Reoviridae (Rotavirus)
    - Pico rnoviridae (common cold and Polio viruses)
    - Herpes viridae (Herpes Simplex, Chickenpox, Kaposi's sarcoma and Epstein Barr viruses)

Course Outcomes:

- 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.

References:

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:ASMpress.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-659: Plant Physiology (60 Lecture Hrs)

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

Course Details:

- Gross anatomy of plants and Plant Cell architecture.
- Transpiration.
- Plant transformation.
- Photosynthesis.
- Protein trafficking in plants
- Macromolecular complexes in plants.
- Gene expression and transgene Silencing mechanisms in plant.
- Phytochrome, Photomorphogenesis
- Cryptochromes, Phtotrophins and UV light responses.
- Plant growth regulators: Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid, Stirgolactone, Jasmonate and Salicylate.
- Plant photoreceptors and light signalling in plants.
- Control of flowering time.

Course Outcomes:

- Entrain the students with different hormone physiology and its interaction.
- Learning light physiology, transformation and photosynthesis.

References:

1. "Plant Physiology" by Taiz & Zeiger Sinaue
2. "Plant Physiology" by Salisbury and Ross

BIO-660: Developmental Biology (60 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 Amphibia
  - 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.

References:

1. "Developmental biology" by Scott Gilbert
2. "Principles of Development" by Lewis Wolper

BIO-751: Advanced Immunology (60 Lecture Hrs)

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

Course Details:

- Basics of Immune system: Cells and organs of Immune system; Innate and Adaptive Immune Response.
- Current perspective of Humoral and Cell Mediated immune response.
- Current perspective of MHC and Antigen presentation.
- Photosynthesis.
- Current perspective of Cellular interaction in immune system
- Signal transduction in immune system.
- Current perspective of Cooperation of Innate and Adaptive immunity.
- Translational Immunology: Immuno-therapy and Vaccine strategy for Infection Immunity, Cancer Immunity and regulation of Autoimmunity

Course Outcomes:

- Understating the current concepts of immunological processes associated to infection immunity, tumor immunity, autoimmunity and other immuno-regulatory states of altered host immune system.

References:

1. Kuby IMMUNOLGY 6th Edition by Richard A. Goldsby, Barbara Anne Osborne, Janis Kuby. Publisher: W.H. Freeman
2. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai. Publisher: Saunders/Elsevier

BIO-752: 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**
  - Microbial Flora of the Healthy Human Host, Natural Resistance and Nonspecific Defense Mechanisms, Basic and Theoretical Aspects of the Immune Response
- **Evolutionary Biology of Infectious Diseases:**
  - Emerging, Reemerging and Deliberately introduced 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.
- **Bacterial 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.

References:

1. Alcamo's fundamentals of Microbiology by Jeffrey C. Pommervill

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 5thed, Michael Z Pelczar Jr.

BIO-753: Cancer Biology (60 Lecture Hrs)

Coordinators: Dr. Asima Bhattacharyya
(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 cancers
- **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

References:

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-754: Advanced Genetics (60 Lecture Hrs)

Coordinators: Dr. Manjusha Dixit

(Manjusha@niser.ac.in)

Course Details:

- Overview of Genetics and terminology.
- Human Genome- Structure, mapping and sequencing.
- Advanced Principles of Inheritance: Genetic variation and heterogeneity, Gene interaction, Polygenic inheritance, Penetrance and expressivity, Epigenetic Inheritance, Genetic Imprinting, Cytoplasmic Inheritance and Maternal Effects.
- Gene Discovery approaches using Model Organisms: Mutant screens and selections, Tools for testing gene function, Mutagenesis and Transgenics.
- Molecular diagnosis of human diseases: Cytogenetics and Molecular cytogenetics, Molecular genetics
- Identification of genetic component of diseases: Molecular basis of human diseases, Identifying genes for Mendelian traits, Linkage disequilibrium and haplotype analysis, Identifying genes for complex traits.
- Gene therapy

Course Outcomes:

- Integrating knowledge of Basic genetics, molecular biology and genomics to understand advances in the field of Genetics.
- Stimulate research interest

References:

1. *Concepts of Genetics* (8th Edition) By William S. *Klug*, Michael R. *Cummings*Publisher: Prentice Hall

2. *Human Molecular Genetics* (2nd edition) by Peter Sudbery, published by Pearson/Prentice Hall

3. *Human Genetics* (2nd edition) by A. Gardener and T. Davies Publisher: Scion

BIO-755: 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 cts.
- 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

References:

1. Kuby Immunology. Thomas J. Kindt, Richard A. Goldsby, Barbara Anne Osborne, Janis Kuby,
2. Infection and Immunity. Huw Davies, D. H. Davies. Taylor & Francis, 1999

BIO-756: 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, twodimensional, 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.

Reference Books:

1. X-ray structure determination, a practical guide edited by G. H. Stout and L. H. Jensen
2. ISBN-10: 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-757: Quantitative Biology (60 Lecture Hrs)

Coordinators: Prof. Palok Aich

(palok@niser.ac.in)

Course Details:

- **Recent Trends in Biology and Health Research**:
    - 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 n.
    - Lotka-Volterra Model.
    - B-Z reaction, population genetics
- **Statistics-Introduction**
    - 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 (Author)
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 for Biologists by Martina Bremer
5. Nonlinear dynamics and chaos:with applications to physics, biology, chemistry, and engineering; Steven Henry Strogatz.

BIO-758: 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-, Ca^{2+}, 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
- **Channelopathy 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-759: 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.**
- **Cytoskeletal structure and dynamics.**
- **Mechanics of cell membrane.**
- **Mechanics of cellular polymer.**
- **Controlling Cell and nuclear Morphology.**
- **Polymers Networks.**
- **Molecular motors.**
- **Tensegrity**
- **Foams**
- **Soft Glassy Material**
- **Biphasic models of cells**
- **Mechanosensing and Mechanotransduction**
- **Mechanical Signals**
- **Mechanosensing 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**
- **Mechanobiology in tissue engineering - Biomimetics and Cell-like Materials**
- **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 mechanobiology 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

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

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

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

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

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

BIO-760: Molecular Errors in Disease (60 Lecture Hrs)

Coordinators: Dr. Manjusha Dixit,
Dr. Debasmita P. Alone
(manjusha@niser.ac.in & debasmita@niser.ac.in)

Course Details:

- **General introduction to concepts of molecular pathogenesis**:

- **Cardiovascular system**

  - Heart failure
  - Genetic cardiac diseases
  - Cholesterol metabolism and vascular diseases
  - Sudden cardiac death
  - Gender and cardiovascular system diseases

- **Respiratory system**

  - Novel pathways in pathogenesis of asthma
  - Cell signalling in asthma
  - Chronic Obstructive Pulmonary Disease
  - Lung matrix remodelling disorders

- **Infectious diseases:**

  - Anti-malarial resistance
  - General vaccine strategies
  - Vaccine development against malaria
  - HIV, SARS, Dengue pathogenesis
  - Biofilms and chronic bacterial infections
  - Quorum sensing, its pharmacological inhibition and quorum sensing as an intervention target
  - Bacterial vaccines
  - Puzzles in sepsis pathogenesi

- **Oncology**

  - Oncogenes
  - Tumour suppressors
  - Specific example cancers
  - Receptor Tyrosine kinases in cancer
  - Cellular stress and cancer
  - Integrins, Cadherins, Catenins,
  - Polarity and cancer
  - Relationship between cellular senescence and cancer
  - Cancer vaccines

- **Neurological diseases**

- Pathogenesis of neuro-degenerative disorders
- Ageing
- Mitochondrial dysfunction
- Oxidative stress and neuro-degeneration
- Genetics of psychiatric disorders eg. Schizophrenia.

- **Genetics**

  - Complex genetic diseases
  - Gene therapy
  - Human embryonic stem cell applications, associated issues and debates.

- **Ageing and Regeneration**

  - Pathophysiology of tissue ageing
  - Cellular reprogramming
  - Regeneration of cells

- **Haematology**

  - Genomics and proteomics of blood cells in disease
  - Platelets, inflammation and atherosclerosis, thromboses
  - Issues associated with cord blood banking

- **Endocrinology:**

  - Diabetes mellitus pathogenesis
  - Cell biology and signalling
  - Islet transplantation
  - Gestational diabetes
  - Metabolic syndrome

- **Musculoskeletal system**

  - Osteoporosis
  - Menopause and bone metabolism
  - Muscle dystrophies
  - Stem cells in muscle degeneration

- **Summary discussions:**

  - Analyses and review of future perspectives in the field of molecular pathogenesis

Course Outcomes:

- Understanding the concepts of molecular pathogenesis.
- Basic understanding of the common pathologies of organ systems.
- Understanding of the recent advances in molecular explanation for such pathologies

Reference Books:

1. Introduction to Molecular Medicine, by Dennis W. Ross(ISBN 0-387-95372-8)
2. Principles of Molecular Medicine, by M. S. Runge and C. Patterson
3. Robbins and Cotran Pathologic basis of disease

BIO-761: Plant Development 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 photomorphogenesis
- 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-762: 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-764: Model Organisms in Biomedical Research (60 Lecture Hrs)

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
- 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 anticancer 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)