LIFE SCIENCES

Programme Code: LIFE13

Programme Outcome:

Scientific Foundation & Interdisciplinarity - Apply comprehensive knowledge of the fundamental sciences to solve complex problems by systematically integrating concepts across Physics, Chemistry, Biology, and Mathematics.

- **Advanced Disciplinary Expertise** - Achieve in-depth competence and mastery in a chosen major stream (Biology, Chemistry, Computer Science, Earth and Planetary Sciences, Physics, or Mathematics) through core coursework starting from the second year.

- **Research Independence & Critical Thinking** - Develop the capacity to function as an independent researcher by formulating clear research objectives, designing experiments, and executing long-term projects (semester projects or a two-year Master's thesis). Cultivate the critical thought process required to analyze data, interpret results objectively, and innovate within a research setting under faculty mentorship.

- **Technical Proficiency & Digital Literacy** - Demonstrate proficiency in modern scientific tools and "state-of-the-art" technologies relevant to experimental and theoretical research. Apply computational thinking and programming basics (acquired in the first year) to analyze scientific data and simulate research problems.

- **Effective Communication** Articulate complex scientific concepts and research findings clearly through professional science writing and oral presentations suitable for academic and general audiences.

- **Social & Ethical Perspective** Evaluate the socio-economic and environmental implications of scientific research by applying principles from economics, sociology, and environmental science to professional practice.

FIRST YEAR COURSES: COMMON FOR ALL DISCIPLINES

S. No.	Course Code	Course Title	Hours	Credit
SEMSTER-I				
1	BIO101	Biology-I	45	3
2	CHE101	Chemistry-I	45	3
3	MAT101	Mathematics-I	45	3
4	PHY101	Physics-I	45	3
5	BIO141	Biology Laboratory	60	2
6	CHE141	Chemistry Laboratory	60	2
7	HSS109	Technical Communication	30	2
8	EPS101	Environmental and Earth Studies	30	2
SEMSTER-II				
9	BIO102	Biology-II	45	3
10	CHE102	Chemistry-II	45	3
11	MAT102	Mathematics-II	45	3
12	PHY102	Physics-II	45	3
13	PHY141	Physics Laboratory	60	2
14	CSE101	Introduction to Computer Programming	60	2
15	HSS101	Introduction to Economics	30	2
16	HSS133	2 Introduction to Sociology	30	2

DETAILED COURSE STRUCTURE

S. No	Course Code	Course Title	Hours	Credits
SECOND YEAR				
SEMESTER-III				
1	BIO201	Microbiology	60	4
2	BIO202	Biochemistry	60	4
3	BIO241	Laboratory-2 (Microbiology)	60	2
4	BIO242	Laboratory-3 (Biochemistry)	60	2
5	BIO203	Evolutionary Biology	60	4
6	HSS###	Elective from SHSS	30	2
7	HSS###	Elective from SHSS	30	2
SEMESTER-IV				
8	BIO204	Cell Biology	60	4
9	BIO205	Molecular Biology	60	4
10	BIO243	Laboratory-4 (Cell Biology)	60	2
11	BIO244	Laboratory-5 (Molecular Biology)	60	2
12	BIO206	Ecology	60	4
13	HSS###	Elective from SHSS	30	2
14	HSS###	Elective from SHSS	30	2
THIRD YEAR				
SEMESTER-V				
15	BIO301	Physiology-I (Animal)	60	4
16	BIO302	Physiology-II (Plant)	60	4
17	BIO341	Laboratory-6 (Animal Physiology)	60	2
18	BIO342	Laboratory-7 (Plant Physiology)	60	2
19	BIO303	Introductory Biophysics	60	4
20	**	Out-of-stream Elective 1	60	4
SEMESTER-VI				
21	BIO304	Immunology	60	4
22	BIO305	Genetics	60	4
23	BIO343	Laboratory-8 (Immunology)	60	2
24	BIO344	Laboratory-9 (Genetics)	60	2
25	BIO306	Bioinformatics and Computational Biology	60	4
26	**	Out-of-stream Elective -2	60	4
FOURTH YEAR				
SEMESTER-VII				
27	BIO401	Bio-techniques	60	4
28	*	Elective-1	60	4
29	*	Elective-2	60	4
30	BIO498	Biology Project	60	4
31	**	Out-of-stream Elective -3	60	4
SEMESTER-VIII				
32	BIO402	Developmental Biology	60	4
33	*	Elective-3	60	4
34	*	Elective-4	60	4
35	BIO499	Biology Project	60	4
36	**	Out-of-stream Elective - 4	60	4
FIVTH YEAR				

SEMESTER-IX				
37	BIO598	Biology Project /Dissertation	240	16
38	***	Elective-5/(In/Out-of-stream-5)	60	4
SEMESTER-X				
39	BIO599	Biology Project /Dissertation	240	16
40	***	Elective- 6/(In/Out-of-stream-6)	60	4

COURSES FOR BIOLOGY MINOR

Sr.No	Course Code	Course Title	Hours	Credits
1	BIO202	Biochemistry	60	4
2	BIO203	Evolutionary Biology	60	4
3	BIO204	Cell Biology	60	4
4	BIO205	Molecular Biology	60	4
5	BIO306	Genetics	60	4
Total				20

LIST OF ELECTIVES

S. No	Course Code	Course Title	Hours	Credits
1	BIO451	Advanced Cell Biology	60	4
2	BIO452	Genetic engineering	60	4
3	BIO453	Advance Biochemistry	60	4
4	BIO454	Advance Microbiology	60	4
5	BIO455	Enzymology	60	4
6	BIO458	Quantitative and Systems Biology	60	4
7	BIO456	Advance Neurobiology	60	4
8	BIO457	Chemical Biology	60	4
9	BIO460	Virology	60	4
10	BIO461	Principles of Drug Design	60	4
11	BIO462	Endocrinology	60	4
12	BIO463	Plant Developmental Biology	60	4
13	BIO464	Neurobiology	60	4
14	BIO465	Structural Biology	60	4
15	BIO466	Model Organisms in Biomedical Research	60	4
16	BIO551	Advanced Molecular Biology	60	4
17	BIO552	Advanced Immunology	60	4
18	BIO553	Infectious Disease Biology	60	4
19	BIO554	Cancer Biology	60	4
20	BIO555	Advanced Genetics	60	4
21	BIO556	Immune regulation and Infection immunity	60	4
22	BIO557	Macromolecular crystallography	60	4
23	BIO559	Ion Channels	60	4
24	BIO561	Concepts in Mechanobiology	60	4
25	BIO562	Molecular errors in disease pathogenesis	60	4
26	BIO563	Translational Control in Biology	60	4

COORDINATORS

Chief Program Coordinators:

Dr. Manjusha Dixit, Convener, Undergraduate Committee of the School of Biological Sciences (E-mail: *manjusha@niser.ac.in*)

Dr. Asima Bhattacharya, Chairperson, School of Biological Sciences (E-mail: asima@niser.ac.in)

Core courses coordinators:

	Coordinators	**E-mail**
Microbiology	Dr. Harapriya Mohapatra & Dr. Ramanujam Srinivasan	hm@niser.ac.in rsrini@niser.ac.in
Biochemistry	Dr. Abdur Rahaman & Dr. Tirumala Kumar Chowdary	arahaman@niser.ac.in tkchowdary@niser.ac.in
Laboratory-2 (Microbiology)	Dr. Harapriya Mohapatra & Dr. Ramanujam Srinivasan	hm@niser.ac.in rsrini@niser.ac.in
Laboratory-3 (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
Cell Biology	Prof. Chandan Goswami	chandan@niser.ac.in
Molecular Biology	Dr. Pankaj V. Alone & Dr. Tridib Mahata	pankaj@niser.ac.in tridibmahata@niser.ac.in
Laboratory-4 (Cell Biology)	Prof. Chandan Goswami	chandan@niser.ac.in
Laboratory-5 (Molecular Biology)	Dr. Pankaj V. Alone & Dr. Tridib Mahata	pankaj@niser.ac.in tridibmahata@niser.ac.in
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Physiology-II (Plant)	Dr. Kishore C. Panigrahi & Dr. Himabindu Vasuki K.	panigrahi@niser.ac.in hvk@niser.ac.in
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Introductory Biophysics	Dr. Saleem Mohammed	saleem@niser.ac.in
Immunology	Dr. Subhasis Chattopadhyay	subho@niser.ac.in

Genetics	Dr. Manjusha Dixit & Dr. Debasmita P. Alone	manjusha@niser.ac.in debasmita@niser.ac.in
Laboratory-8 (Immunology)	Dr. Subhasis Chattopadhyay	subho@niser.ac.in
Laboratory-9 (Genetics)	Dr. Manjusha Dixit & Dr. Debasmita P. Alone	manjusha@niser.ac.in debasmita@niser.ac.in
Bioinformatics and Computational Biology	Dr. Badireenath V. Konkimalla	badireenath@niser.ac.in
Developmental Biology	Dr. Debasmita P. Alone & Dr. Swagata Ghatak	debasmita@niser.ac.in

Elective courses coordinators

Course name	**Coordinator/s name/s**	**Coordinator emails**
Advanced Cell Biology	Prof. Chandan Goswami	chandan@niser.ac.in
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Quantitative and Systems Biology	Prof. Palok Aich	palok@niser.acin
Advance Neurobiology	Dr. Praful S. Singru	pssingru@niser.acin
Chemical Biology	Prof. Palok Aich	palok@niser.ac.in
Virology	Dr. Tirumala Kumar Chowdary	tkchowdary@niser.ac.in
Principles of Drug Design	Dr. V. Badireenath Konkimalla	badireenath@niser.ac.in
Endocrinology	Dr. Praful S. Singru	pssingru@niser.ac.in & swagata@niser.ac.in
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Structural Biology	Dr. Rudresh Acharya	rudresh.acharya@niser.ac.in
Model Organisms in Biomedical Research	Dr. Debasmita P. Alone	debasmita@niser.ac.in
Advanced Molecular Biology	Dr. Pankaj V. Alone	pankaj@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 Bhattacharya	asima@niser.ac.in
Advanced Genetics	Dr. Manjusha Dixit	manjusha@niser.ac.in
Immune regulation and Infection immunity	Dr. Subhasis Chattopadhyay	subho@niser.ac.in
Macromolecular crystallography	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
Molecular errors in disease pathogenesis	Dr. Manjusha Dixit & Dr. Debasmita P. Alone	manjusha@niser.ac.in & debasmita@niser.ac.in
Translational Control in Biology	Dr. Pankaj V. Alone	pankaj@niser.ac.in

COMPULSORY COURSES

BIO-101: Biology I (45 Lecture Hrs)

Course Details:

- **Origin of life: Bioenergetics and concepts of evolution What is life?**
    - Origin (s) of life on planet earth.
    - First cellular forms to current day view of 'Tree of life'.
    - Basics of evolution – natural selection, adaptive evolution, genetic drift, neutral evolution, molecular clock and molecular systematics.
- **Molecules of life**
    - Nucleic acids – architecture (structure), physico-chemical properties and importance in biology.
    - Proteins – structure, biochemical properties, functions as major biological workhorses.
    - Lipids – membrane architecture, composition and lipid constituents of membranes, importance of membrane lipids and proteins in cellular function.
    - Brief introduction to metabolism and energy cycles in cellular forms.
- **Unit of life:**
    - Basic unit of life (introduction to architecture and composition).
    - Structure & function of organelles.
    - Cytoskeleton
    - Extracellular matrix

Course Outcomes:

Students are expected to develop an understanding of:

- The concept of origin and evolution of life.
- Fundamental understanding of the structure and function of the molecules of life.
- Fundamental understanding of the structure & function of cellular organelles.

References

1. Biology by Campbell and Reece, Eighth Edition.
2. Lehninger Principles of Biochemistry, by DL Nelson and Michael M Cox., Sixth Edition.
3. Molecular biology of the Cell by Albert et.al, Sixth Edition.

BIO-102: Biology II (45 Lecture Hrs)

Course Details:

- **Cellular Mechanisms of Development**
    - Cell Cycle
    - Cell-Cell communication
    - Cell differentiation.
- **Evolutionary concepts**
    - Lamarckism
    - Darwinism
    - Speciation.
- **Basis of Inheritance**
-
    - Chromosomal patterns of inheritance
    - Molecular patterns of inheritance
- **Molecular Biology**
    - Basics of Replication
    - Basics of Transcription
    - Basics of Translation
    - Basics of DNA manipulation.

Course Outcomes:

Students are expected to develop an understanding of:

- The principles of cellular mechanisms driving development of an organism
- Key evolutionary concepts in Lamarckism, Darwinism and Speciation
- Understanding the genetic basis of inheritance
- Fundamental understanding of molecular Biology.

References:

1. Biology by Campbell and Reece

BIO-201: Microbiology (60 Lecture Hrs)

Coordinators: Dr. Harapriya Mohapatra,
Dr. Ramanujam Srinivasan
(hm@niser.ac.in & rsrini@niser.ac.in)

Course Details:

- **Development Microbiology as a science and Microbial world**
    - Microbial diversity: Microbial evolution and systematic, Eukaryotic microorganisms – Protists,
      Fungi, Unicellular red & green algae. Overview of viruses and their classification, overview of
      viral replication, Prions – non-microbial infectious agent
    - Cell structure and function of bacteria, archaea and eukaryotic microorganisms
    - Role of microorganisms in understanding biological systems.
- **Microbial nutrition and physiology:**
    - Metabolic diversity – Phototrophy, Autotrophy, Chemolithotrophy and Nitrogen fixation
    - Catabolism of organic compounds – fermentations, anaerobic respiration & aerobic
      chemorganotrophic processes.
    - Microbial growth.
- **Microbial genetics: Overview**
    - Bacterial genetics – chromosomes, plasmids & incompatibility, mutation, genetic exchange in
      prokaryotes – transformation, conjugation, transduction
- **Microbes in health & disease:**
    - Beneficial microbial interactions with humans,
    - Harmful microbial interactions with humans: host-parasite interactions, overview of host system, pathogenesis & infection establishment, Virulence factors & toxins.
    - Brief overview of antibiotics, antibiotic resistance & their mechanism of action.
- **Microbes in agriculture: Overview**
    - Microbial diseases of economically important plants
    - Agrobacterium and crown gall disease, Transformation.
- **Microbes in environment:**

- Brief overview of role of microbes in nutrient cycling
- Microbial bioremediation: leaching of ores, mercury & heavy metal transformation, petroleum
  degradation, biodegradation of xenobiotics
- Animal-microbial symbiosis: rumen and ruminant animals,

- Plant-microbial symbiosis: Lichens- mycorrhizae, Agrobacterium and crown gall disease,
- Legume-root nodule symbiosis

- **Microbes in industry: Brief over view of their roles in:**

  - Food, health and fermentation sectors.

Course Outcomes:

Students are expected to develop an understanding of:

- Microbiology as a science.
- Key concepts in microbes in health & disease.
- Overview of role of microbes in nutrient cycling
- Implications in Evolution, Health and disease.

References:

1. Brock's Biology of Microorganisms by Madigan et al.
2. Microbiology by Prescott et al.
2. Class notes, handouts and other reading as suggested during the class.

BIO-202: Biochemistry (60 Lecture Hrs)

Coordinators: Dr. Abdur Rahaman,
Dr. Tirumala Kumar Chowdary
(arahaman@niser.ac.in tkchowdary@niser.ac.in)

Course Details:

- **Development Overview of Biochemistry**
- **Protein structure & function, Protein Folding, Protein Degradation**
- **Enzymes: Classification, Mode of action, kinetics, regulation and inhibition, examples of**
- **enzymatic reactions and regulatory enzymes**
- **Lipids: Transmembrane lipids, receptors, lipids as signals, co-factors and pigments**
- **Membrane**
- **Intermediary Metabolism and Energetics:**
- **Carbohydrate Metabolism: Glycolysis, TCA cycle, Gluconeogensis, Pentose phosphate pathway,**

  Glycogenesis and Glycogenolysis, co-ordinated regulation of glycolysis and gluconeogensis,

  Phosphorylation and bioenergetics of above processes.
- **Electron Transport Chain and Oxidative Phosphorylation**
- **Fatty acid biosynthesis and degradation, Synthesis of Cholesterol, Steroid Hormones and**

  Eicosanoids
- **10. Amino acid biosynthesis and degradation**
- **Nucleotide biosynthesis and degradation**
- **Hormones: Mechanism of action, regulation and integration in mammalian metabolism**
- **Biochemistry of signal Transduction**

Course Outcomes:

Students are expected to develop an understanding of:

- The principles governing Protein structure & function
- Basic concepts on metabolism and their implications in living organisms
- Concept on signal transduction

- Implications in Evolution, Health and disease.

Reference Books:

1. Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson, Michael M. Cox b)
2. Biochemistry by Berg and Stryer
3. Biochemistry by Voet and Voet
4. Harper's book of Biochemistry
5. Relevant research articles with updates in knowledge as decided by the Instructor.

BIO-203: 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:

- 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-204: Cell Biology (60 Lecture Hrs)

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

Course Details:

- **Overview of Cell biology**
- **Universal features of cells**
- **Basic microscopy, Visualization of cell, its fine structure, molecules and different functions**
- **The cell membrane, its structure and its dynamics**
- **Transport across membrane**
- **Ion channels**
- **Cellular compartments and function, protein sorting**
- **Vesicular traffic inside the cells**
- **Mitochondria and chloroplast and their genetic system, fission and fusion of mitochondria**
- **Cellular communication and cell signaling**
- **Cytoskeleton of cells, cytoskeleton filaments, molecular motors, cell junction, extra cellular matrix, cell adhesion**
- **Cell cycle, Cell division- Mitosis, meiosis and the mechanism of cell division**
- **Cell biology of nucleus and chromatin**
- **Cell biology of Germ cells, neuronal cells, stem cells, gametes, immune cells**

- **Cell biology of cancer cells**
- **Cell survival and cell death**
- **Cell biology of model organisms and plant cells**
- **Advancement in microscopic techniques**

Course Outcomes:

- Understanding the basic principles governing cell structure and functions
- Bio chemical, biophysical, genetical basis of cell and its response
- Key concepts in maintenance of cell structure
- Evolution of cell organelles, importance in health and disease

Reference Books:

1. "Molecular biology of the Cell" by Albert et.al.

BIO-205: Molecular Biology (60 Lecture Hrs)

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

Course Details:

- **Molecular biology an overview, discovery of DNA as genetic material**
  - Genes, proteins and function.
  - Historic perspectives and identification of DNA as genetic material
  - Central Dogma of Molecular Biology.
- **Model organism used in molecular biology**
  - Escherichia coli, Saccharomyces cerevisiae, Caenorhabdits elegans, Drosophila melanogaster, Danio rerio, Arabdiopsis thaliana, Mus musculus,
  - Virus and Tissue culture.
- **Nucleic acid structure and function**
  - Bacterial Structure and components of nucleic acids
  - Chemical and physical properties of nucleic acids
  - Enzymes in DNA topology
- **Chromosome, chromatin structure and function**
  - Nucleosome structure
  - Chromatin remodeling complexes
  - Histone code
  - Structural maintenance of chromosome.
- **DNA replication**
  - Components of DNA replication
  - Regulation of DNA replication
  - End replication problem, teleomere and telomerase.
- **Mutations and DNA repair**
  - Different types of mutations
  - Chemical and physical agents of mutation
  - Mechanism of mutations
  - Repair system, components and their mechanism
- **Recombination and Transposons**
  - Homologous recombination: Holliday junction and its resolution
  - Components of homologous recombination system
  - Cre recombinase and its mechanism
  - Gene conversion
  - Transposable elements
  - LINEs and SINEs.
- **Transcription and Gene Regulation**
  - Transcription and Gene Regulation.
- **Genetic code**

- The information problem
- Experimental evidence that genetic code is triplet, identification of different codons, start
  and stop codon, genetic code table and AA classification,
- The decoding system, necessity of adaptor molecule in translation
- tRNA structure, aminoacyl synthetase mechanism of tRNA charging.

- **Protein translation**
  - Introduction to protein translation apparatus
  - Difference between prokaryote and eukaryotic translation initiation
  - Cap binding complex, 43S, 48S scanning complex, Kozak consensus sequence and its
    importance in scanning
  - Mechanism of ORF selection, structure-function studies
  - Ribonucloproteins involved in translation process, factors involved in and mechanism of
    elongation cycle, peptidyl transferase reaction,
  - Factors involved in and mechanism of translation termination
  - Ribosome recycling
  - Quality control mechanism in translation: breakage mRNA (tmRNA rescue), nonstop
    mediated decay, Nonsense mediated decay, antibiotics and toxins useful in translation
    study.

- **Gene Family and Developmental regulation**
  - Evolution of concept of gene, gene families, simple and complex multigene family, gene
  - alteration, gene evolution, regulatory sequences in developmental decisions.

Course Outcomes:

- Understanding the key components of cell involved in central dogma of molecular biology.
- Understanding of structure-function of genetic material, replication, repair, transcription and
  translation.

Reference Books:

1. Molecular Biology of Gene by Watson et.al Pearson.
2. Biochemistry, by Voet and Voet..

BIO-206: Ecology (60 Lecture Hrs)

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

Course Details:

- **General principles**
  - Geographical variation in climate on Earth
  - Major ecological patterns in relation to climate
  - Major biomes and their geographic distribution.
- **Ecology and society**
  - Human society and environment: past and present
  - History of ecology as a science
  - Relevance of ecology in the modern world.
- **Ecology as a quantitative science**
  - What are data?
  - How are data collected, summarized and interpreted?
  - Basic statistical techniques used for making inference
  - Computer applications
- **Ecology of populations**
  - Single-species population dynamics under unrestricted resources
  - Single-species population dynamics under limited resources
- **Species interactions**
  - Various types of species interactions
  - Dynamics of two-species competition
  - Multi-species coexistence and the 'niche' concept
  - Succession
  - Dynamics of predator-prey interaction
- **E Food-webs**
  - Trophic dynamics and energy transfer
  - Interaction between competition and predation
  - Trophic cascades.
- **Behavioural Ecology**
  - Behaviour and natural selection; behaviour and sexual selection; co-evolution
- **Ecosystems**
  - Material and energy flow; Biogeochemical cycles; Case study of a grazing

ecosystem

- **Global change**

  - Trophic dynamics and energy transfer
  - Interaction between competition and predation
  - Trophic cascades.

- **Biodiversity**

  - Various aspects of global change
  - Climate and the earth's geological history
  - Mitigating the effects of ongoing global change: science and policy

- **11. Field Methods and Field trips**

Course Outcomes:

- Understanding biotic and biotic factors governing the distributions of organisms
- Understanding the biosphere from the viewpoint of organism, population, community andecosystem
- Understand organismal diversity and functional diversity of organisms in a landscape or ecosystem

References:

1. Ecology-Principles and Applications by Chapman and Reiss Cambridge
2. Essentials of Ecology by Townsend C, Begun M and Harper
3. Fundamentals of Ecology by M. C. Dash.

BIO-301: Physiology I (60 Lecture Hrs)

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

Course Details:

- **Overview of animal anatomy and body plan**
  - Animal kingdom and classification
  - Relationships between phyla
  - Body plan, symmetry and cavities.
- **Fundamentals of animal physiology**
  - Adaptation
  - Acclimatization, acclimation
  - Conformity and regulation.
- **Homeostasis a quantitative science**
  - Milieu internae, Feedback and control systems
  - Feedforward systems
  - Nonpysiological homeostasis
- **Bio membranes & transport across membrane**
  - Membrane composition, models
  - Transmembrane movement of ions, diffusion, osmosis
- **Membrane potential**
  - Electrical properties of membrane and resting membrane potential
  - Action potential
- **Neurophysiology**
  - Neurons and synapses
  - Neurotransmitters: classification and receptors.
- **Sensory physiology**
  - Photoreception, olfaction
  - Taste, hearing
  - Mecahnoreception and heat receptions
- **Physiology of muscle**
  - Skeletal muscle and mechanism of contraction
  - Cardiac muscle and mechanism of contraction
  - Smooth muscle and mechanism of contraction
- **Cardiovascular systems or cardiac physiology**

- Open and closed circulation
- Heart: electrical and mechanical properties
- Regulation of the cardiovascular system

- **Respiratory system across animal phyla & gas exchange**
  - Lungs and other systems, lung volumes and capacities
  - Regulation of respiration.
- **Excretory systems**
  - Excretory organs in aquatic and terrestrial animals
  - Urine-concentrating mechanisms, countercurrent mechanism
- **Osmoregulation**
  - Osmotic responses of animals
  - Vertebrate and invertebrate osmoregulation
- **Fluid and acid base balance**
  - Regulation of acid-base balance by blood buffers, lungs and kidneys.
  - Hormonal and renal regulation of body fluids and electrolyte balance.
- **Digestive system**
  - Anatomy of the digestive system, variations
  - Digestion and absorption
  - Gastric hormones and reflexes.
- **Endocrine system**
  - Glands, hormones and classification
  - Regulation of endocrine secretion
  - Mechanisms of hormonal action, receptors
- **Reproductive system**
  - Male and female reproductive systems
  - Fertilization and embryogenesis
- **Lymphatics and immune system**
  - Lymphatic system: organization and function
  - Organization of immune system.

Course Outcomes:

- Learning molecular, chemical and physical principles of animal body plan.
- Understanding structure-function relationships and how various physiological systems work.
- Integrating knowledge to understand health and disease.

References:

1. "Animal Physiology", Hill R, Wise G A & Anderson M Sinauer.

BIO-302: Physiology II (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 signaling in plants**
- **Control of flowering time membrane**

Course Outcomes:

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

Reference Books:

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

BIO-303: 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
- **3) 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 proteins
- **Protein Folding:**
  - 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:**

  - Cell communication, nerves, action potential, resting potential
  - 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 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.

References:

1. Charles R Cantor and Paul R Schimmel. Biophysical Chemistry Part 1 - The Conformation of
   Biological Macromolecules. W. H. Freeman. ISBN - 0716711885
2. Charles R Cantor and Paul R Schimmel. Biophysical Chemistry Part 2 - Techniques for the study
   of biological structure and function. W. H. Freeman. ISBN - 0716711907
3. Rob Phillips, Jane Kondev, Julie Theriot, Hernan Garcia, Jane Kondev. Physical Biology of the
   Cell. 2nd Edition. Garland Science. ISBN: 9780815344506
4. Philip Nelson. Biological Physics - Energy, Information, Life (Student Edition). Chiliagon
   Science. ISBN - 057868702X

BIO-304: Immunology (60 Lecture Hrs)

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

Course Details:

- **Gross 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:

- Introduction 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-305: Genetics (60 Lecture Hrs)

Coordinators: Dr. Manjusha Dixit & Dr. Debasmita P. Alone

(manjusha@niser.ac.in & debasmita@niser.ac.in)

Course Details:

- **Overview of Genetics and terminology**
- **Model Genetic systems**
- **Mendelian Inheritance**
- **Deviations from Mendelian Inheritance- Linkage and Sex linked Inheritance, Gene Interactions,**
  maternal and extranuclear Inheritance
- **Recombination, Recombination mapping and mechanism of recombination**
- **Transposable Elements**
- **Mechanisms of Genetic Diseases- Chromosome number variation, changes in chromosome structure, Gene mutation, mutagenesis and mutant selection, X-chromosome inactivation, Genetic imprinting**
- **Elements of human genetics-genetic disorders, patterns of inheritance, molecular diagnosis**
- **Cytogenetics**
- **Prenatal Diagnosis and Genetic Counseling**
- **Epigenetics**
- **Cancer Genetics**
- **Population Genetics**
- **Developmental Genetics**
- **Immuno genetics**
- **Genes and Evolution**

Course Outcomes:

- Understanding the basic principles of inheritance
- Knowledge of genetic disease mechanism
- Comprehension of monogenic, polygenic and multifactorial diseases

Application in health and diseases

Reference Books:

1. “Genetics” by M. W. Strickberger
2. “Principles of Genetics” by E. J. Gardner, M. J. Simmons, D. P. Snudstad
3. “Human Genetics” by A. Gardner, R.T. Howell, and T. Davis

BIO-306: Bio Informatics and Computational Biology (60 Lecture Hrs)

Coordinators: Dr. Badireenath V. Konkimalla

(badireenath@niser.ac.in)

Course Details:

- **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 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
  - 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, susbstitutions 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, Ramachandrean 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 Biology:**

  - 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:

- 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-401: Bio Techniques (60 Lecture Hrs)

Course Details:

- **Overview 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). (3 Lectures + 1 Tutorial)**
- **Principles of Centrifugation. (3 Lectures + 1 Tutorial)**
- **Uses of radioactive isotopes and autoradiography. (3 Lectures + 1 Tutorial)**
- **Biophysical techniques: X-ray crystallography; NMR; ORD. (3 Lectures + 1 Tutorial)**
- **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-402: 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 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 changes.

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-141: Biology Laboratory (60 Lecture Hrs)

Course Details:

- **Spectrophotometry: Introduction to Beer-Lambert Law; Demonstration of Beer's law**
- **Proteins: Protein Estimation by Bradford Method**
- **Carbohydrates: Benedict's test for reducing sugars**
- **Iodine test for polysaccharides**
- **Isolation and quantification of DNA by agarose gel electrophoresis**
- **Lipids: Emulsification Test, Saponification Test**
- **Onion root tip as a model to see various stages of cell division**
- **Differential staining of bacteria**
- **Study of blood cells**
- **Determination of human blood groups (ABO) Precipitin/Agglutination reaction;**

Course Outcomes:

- Introduce to students analytical tools/approaches to study biomolecules and cell structure.
- Build basics of experimentation and data recording in biology labs.

BIO-241: Microbiology Laboratory (60 Lecture Hrs)

Coordinators: Dr. Harapriya Mohapatra,

Dr. Ramanujam Srinivasan
(hm@niser.ac.in & rsrini@niser.ac.in)

Course Details:

- **Culture media preparation, Control of microbial growth disinfection & sterilization.**
- **Enrichment and isolation and characterization of pure culture, use of selective and**
  differential media
- **Microscopic examination of fresh culture with different staining procedures**
- **Culture dependent analysis of microbial communities**
- **Culture independent analysis of microbial communities**
- **Identification of genus of unknown bacterial cultures**
- **Antibiotic susceptibility testing: (i) Disk diffusion (ii) MIC by tube dilution**

Course Outcomes:

- Culturing of microbes as pure culture, growth disinfection & sterilization.
- Microscopic examination of microbial communities.
- Identification of unknown bacterial cultures
- Antibiotic susceptibility testing.

BIO-242: Biochemistry Laboratory (60 Lecture Hrs)

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

Course Details:

- **Isolation, Estimation and purification of protein**
- **SDS-PAGE**
- **Enzyme kinetics (catalase, peroxidase)**
- **Isolation of genomic DNA**
- **Estimation and quantification of DNA**
- **Agarose gel electrophoresis for DNA**
- **Isolation of Plasmid DNA**
- **Isolation and estimation of RNA**
- **Thin layer Chromatography**

Course Outcomes:

- Understanding the principles and methodology to isolate, purify, quantitate and separate
  various biomolecules such as protein, DNA, RNA
- Concept and practical experience about the enzyme kinetics, enzyme activity and effect
  of temperature and pH.

Reference Books

1. Principle and techniques of Biochemistry and Molecular Biology by K. Wilson & J. Walker
2. Introduction to Practical Biochemistry by S. K. Sawhney and Randhir Singh
3. Introduction to Practical Biochemistry by David T. Plummer

BIO-243: Cell Biology Laboratory (60 Lecture Hrs)

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

Course Details:

- **Staining of haploid and diploid cell nucleus (sperm and mammalian cell)**
- **Antibody Staining: Visulatization of Histone, Vimentin, Lamin in mammalian cells**
- **Cell splitting and Counting of cells by using haemocytometer (Mammalian cells as model system)**
- **Visualisation of Actin and Tubulin cytoskeleton in mammalian cells after stabilization or destabilization of cytoskeleton**
- **Visualisation of mitochondria, lysosome and nuclei by Mitotracker Red, Lysotracker Red and DAPI in mammalian cells (with/without treatment with disruptors)**
- **Analysis of cell adhesion using mammalian cells (after stabilization or destabilization of cytoskeleton)**
- **Analysis of endocytosis and exocytosis in mammalian cells (Using Alexa-labelled Transferrin incorporation assay)**
- **Culturing of plant cells and visualization of chloroplast (moss cells as a model system)**
- **Image analysis and extracting information from images**
- **Visualization of a Fluorescent tagged protein in mammalian cells**
- **Visualization of Intracellular Metal concentration fluctuations in real time in Osteoblasts and Osteoclasts.**

Course Outcomes:

- Direct exposure to different types of plant and animal cells
- Direct labelling of different
- cell organelles and visualization.
- Direct exposure to different cell biology related techniques and high-end instruments
- Learning of research methodology and conducting experiments.

BIO-244: Molecular Biology Laboratory (60 Lecture Hrs)

Coordinators: Dr. Pankaj V. Alone,

Dr. Tridib Mahata
(pankaj@niser.ac.in & tridibmahata@niser.ac.in)

Course Details:

- **Preparation of competent cell by CaCl2 method and testing its transformation efficiency.**
- **Plasmid DNA isolation by alkaline lysis method.**
- **Analysis of DNA gyrase and topoisomerase properties.**
- **Restriction digestion and cloning of DNA into a given vector.**
- **To study the importance of the 3` nucleotide of the primer in DNA polymerization (PCR).**
- **Confirmation of DNA fragment by Southern Hybridization.**
- **Protein-Protein interaction study by Yeast-two hybridization techniques.**

Course Outcomes:

- Hands on training of techniques used in Molecular biology research
- Understanding the working principles by experimental verification

BIO-341: Animal Physiology Laboratory (60 Lecture Hrs)

Coordinators: Dr. Asima Bhattacharya,

Dr. Swagata Ghatak

(asima@niser.ac.in & swagata@niser.ac.in)

Course Details:

- **Study of haemin crystal formation**
- **Hb content measurement by Sahli's haemoglobinometer**
- **Learning to measure pulse rate, heart rate, blood pressure by sphygmomanometer**
- **Amylase activity in human saliva**
- **Histological slide identifications of various tissues (Mus musculus)**
- **Video demonstration of different organs in mouse**
- **Dissection of gills of Labio rohita or Clarias batrachus**
- **Dissection of fish eye (Labio rohita).**

Course Outcomes:

- Basic understanding of animal tissues, organs and their structure-function relationship.

BIO-342: Plant Physiology Laboratory (60 Lecture Hrs)

Coordinators: Dr. Kishore C. Panigrahi,

Dr. Himabindu Vasuki K.

(panigrahi@niser.ac.in & hvk@niser.ac.in)

Course Details:

- **To study the phenomenon of plasmolysis**
- **Measurement of imbibitions**
- **To compare the rate of photosynthesis under different environmental condition**
- **Quantification of pigment content in leaves.**
- **Measurement of Chl a fluorescence**
- **Field trip to a natural ecosystem to evaluate algal/microfloral/macrofloral photosynthesis in natural environment.**
- **Isolation of chloroplast and observation of absorption spectra**
- **Phototropism**
- **Genetic control of light signaling: Photoreceptor mutants and Over-expressors**
- **Purification and observation of Phytochrome nuclear complexes.**

Course Outcomes:

- Train students with tissue culture techniques and plant physiology experiments.
- Aims to bring physiology, biochemistry and molecular biology together

Reference Books

1. “Experimental Plant Physiology” by Joseph Arditti and Arnold Dunn
2. “Human Anatomy and Physiology Laboratory Manual” by Elaine and Blinda
3. Class notes, handouts and other reading materials as suggested during the class

BIO-343: Immunology Laboratory (60 Lecture Hrs)

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

Course Details:

- **Isolation and characterization of lymphocytes from human blood samples and mouse**
  spleen cells
- **Estimation of antigen content by ELISA**
- **Immuno-diffusion**
- **Immuno- fluorescence staining of lymphocytes and cell lines**
- **Flow Cytometric analysis of lymphocytes, cell lines**
- **In vitro Immune assay(s) with T cell line, Macrophage cell line and lymphocytes.**

Course Outcomes:

- Understating the basic concepts and training of immunological
- techniques associated to experimentation in the field of immunology.

BIO-344: Genetics Laboratory (60 Lecture Hrs)

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

Course Details:

- **Introduction to a model genetic system: Drosophila and demonstration of laws of inheritance**
- **Demonstration of linkage and crossing over through genetic crosses**
- **Squash preparation of polytene chromosomes from Drosophila larvae**
- **Induction and characterization of insertional mutations in Drosophila**
- **Mutation Detection- Sequencing, RFLP, insertion-deletion, VNTR, AFLP**
- **Karyotyping of Human chromosomes**
- **Banding Techniques**
- **Pedigree Analysis**

Course Outcomes:

- Understanding the basic principles of inheritance

Knowledge of basic techniques used in population genetics and cytogenetics.

BIO-451: 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
  - Autofluorescence 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
- 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
- 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, New York and London: Garland Science

BIO-452: Genetic Engineering (60 Lecture Hrs)

Coordinators: Dr. Manjusha Dixit
(manjusha@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**
- **Radiolabelling of nucleic acids**
- **Transformation & transfection**
- **Construction of genomic & cDNA library**
- **Genomic DNA & cDNA cloning**
- **Analysis of DNA of cloned genes**
- **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 animals**
- **Other transgenic life forms**
- **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 Reece

BIO-453: Advanced Biochemistry (60)

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:

- 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-454: 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.

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-455: 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-458: Quantitative and Systems Biology (60 Lecture Hrs)

Coordinators: Prof. Palok Aich

(palok@niser.acin)

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
  - Lotka-Volterra Model
  - B-Z reaction, population
- **Recent 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, DC
- **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-456: Advanced Neurobiology (60 Lecture Hrs)

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

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-457: Chemical Biology (60 Lecture Hrs)

Coordinators: Prof. Palok Aich
(palok@niser.acin)

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. Zigmond, 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-460: 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**
- **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 andCrimean-**
  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-461: Principle of Drug Design (60 Lecture Hrs)

Coordinators: Dr. V. Badireenath 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**
- **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-462: Endocrinology (60 Lecture Hrs)

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

Course Details:

- **Introduction to endocrine glands, hormones and their classification.**
- **Hormone 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: Neurohormones 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 imbalance.

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-463: Plant Development Biology (60 Lecture Hrs)

Coordinators: Dr. Kishore C. Panigrahi,
Dr. Himabindu V. Kilambi
(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-464: Neuro Biology (60 Lecture Hrs)

Coordinators: Dr. Praful S. Singru,
Dr. Swagata Ghatak
(pssingru@niser.acin)

Course Details:

- **Organization of the nervous system.**
- **Introduction to Neurons, the neuron doctrine, components of neurons, types, organization of a neuron, and functions**
- **Glial cells: structure and function, types, glial neuronal relationship, importance of astrocytes in glutamate uptake and blood-brain barrier, role of tanycytes in the hypothalamus**
- **Membrane channels, ionic basis of resting potential and action potential**
- **Neurotransmitters, neurotransmitter receptors, chemical transmission, electrical synapses**
- **Autonomic nervous system**
- **Neurobiology of sensory systems: taste, olfaction, vision, auditory perception**
- **Neuroanatomy of the hypothalamus and neuroendocrine regulation. Central regulation of feeding, appetite, stress and Circadian rhythms, neurobiology of behavior**
- **Learning and memory, Neurological disorders, Techniques in neuroscience**

Course Outcomes:

- Understanding the organization of nervous system, structure and function of neuron and glial cells.
- Knowledge about the ion basis of action potential, synapse, neurotransmitter release, neural circuits, and behavior.
- Leaning the key techniques in neuroscience research, organization and evolution of the brain.
- Analyzing the neural basis of behavior and neurological disorders.

Reference Books

1. Hall (2011): Guyton and Hall: Text book of Medical Physiology, Saunders Publishers, 12th Edition.
2. MJ Zigmond, FE Bloom, SC Landis, JL Roberts, LR Squire. (2008). Fundamental Neuroscience. Academic Press.
3. E Kandel, J Schwartz, T Jessell. (2000). Principles of Neural Science. McGraw Hill.

BIO-465: Structural Biology (60 Lecture Hrs)

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

Course Details:

Prerequisite: Basic understanding of Biochemistry,

- **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:

- The protein structures in modular approach, correlating the structure to function, and deducting 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-466: Model Organisms in Biomedical Research (60 Lecture Hrs)

Coordinators: Dr. Debasmita P. Alone

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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**
- **6. 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 Mc Cluskey, 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).

BIO-551: 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 homeo stasis.
- **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: Natural product synthesis:**
- **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 pseudo substrate:**
- **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.
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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-552: 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 anAdaptive Immune Response**
- **Current perspective of Humoral and Cell Mediated immune response.**
- **Current perspective of MHC and Antigen presentation**
- **Current perspective of Cellular interaction in immune system**
- **Signal transduction in immune system**
- **Current perspective of Cooperation of Innate and Adaptive immunity**
- **Current perspective of cellular immune-regulation**
- **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
- Prerequisite: Basic understanding of cell biology, animal physiology, molecular biology, biochemistry, microbiology, immunology.

Reference Books

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 l

BIO-553: 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 will focus on the major bacterial infections. The infections can be considered in groups related to the body systems infected.

▪ **Viral infections:**

• Host- 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-554: 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 presentingcells
- 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 EThe Biology of Cancer” by Weinberg, Robert A.

BIO-555: 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.

Reference Books

1. Concepts of Genetics (8th Edition) By William S. Klug, Michael R. Cummings Publisher: Prentice Hall
Human Molecular Genetics (2nd edition) by Peter Sudbery, published by Pearson/Prentice Hall
2. Human Genetics (2nd edition) by A. Gardener and T. Davies Publisher: Scion

BIO-556: 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. Infection and Immunity. Huw Davies, D. H. Davies. Taylor & Francis, 1999

BIO-557: Macro Molecular Crystallography (60 Lecture Hrs)

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

Course Details:

- **Course Contents:**
  - Introduction to X-ray crystallography, highlights from 54 years of macromolecular crystallography, future Directions.

- **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:**

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

BIO-559: 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).

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

  - (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-561: Concepts in Mechanobiology (60 Lecture Hrs)

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

Course Details:

- **Mechanical framework for understanding biological systems:**
    - Cell mechanics in basic
    - cellular and pathological processes.
    - Cell architecture
- **Cytoskeletal structure and dynamics:**
    - Cell mechanics
    - Basics of Mechanics
    - Viscoelasticity / basic rheology
- **Introduction 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 Mechanos ensing 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/ nanomachines.
- 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 mechanobiological 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 Mechano biology. 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.

BIO-562: Molecular Errors in Disease Pathogenesis (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 diseasess
- **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 pathogenesis.
- **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.

- **Hematology:**
  - 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-563: 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