Courses Offered to the 1st & 2nd year BS – MS students of IISER – Kolkata

Course Name: **Introduction to Biology**
Course Type: **Core Theory**
Course Instructor: **Tapas Kumar Sengupta**

SYLLABUS

Introduction: Definition and origin of life; Chemical and Biological evolution.

Diversity and complexity of life forms; Interactions amongst different life forms.

Different approaches to understand the ever evolving biological world.

Cell (Structure and function): Cell theory, Cell structure, Broad functions of different cell types and cell compartments.

Molecules of life (structure-function): Water, Amino acids, Sugars, Fatty acids, Nucleotides , Proteins, Carbohydrates, Nucleic acids and Lipids. Enzymes.

Cellular events: Membrane Transport/ cellular transport ; Bioenergetics (Glycolysis, TCA cycle and ATP synthesis), Replication ; Transcription; Translation; Cell division ; Cell death

RECOMMENDED TEXT

1. Essential Cell Biology (Second Edition) : By Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter.
   Publisher: Garland Science; Year:2004

2. Molecular Cell Biology (Sixth Edition): By Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira.
   Publishers: W. H. Freeman; Year: 2008

Course Name: **Biology Lab I**
Course Type: **Core Laboratory**
Course Instructors: **Punyasloke Bhadury, Bidisha Sinha**

SYLLABUS

Module 1: Basic Cell Biology

1. Microscopic observation of prokaryotic and eukaryotic cells (bacteria, blue-gree algae, yeast, plant cells (onion peel), cheek epithelial cells)
2. Plasmolysis and deplasmolysis of onion cells.
3. Staining of blood film and identification of blood cells.

Module 2: Microbiology

1. Media preparation, plating, streaking of bacteria.
2. Gram staining.
3. Antibiotic sensitivity assay.

Module 3: Biochemistry

1. Spectrophotometric estimation of DNA.
2. Bradford's assay for protein concentration.
3. Enzyme kinetics of alkaline phosphatase (varying substrate conc. and varying enzyme conc.)

Course Name: **Molecular Genetics**
Course Type: **Core Theory**
Course Instructors: **Chanchal Das Gupta, Mohit Prasad**

SYLLABUS

Bacterial molecular genetics—Mutations, Transformation, Conjugation, Transduction, Lac operon,

Phages—Small SS-DNA phages—designing vectors; λ-phage: specialized transduction, P1 phage: general transduction;

Basics of DNA replication, transcription and translation :

Mendelian genetics;

Drosophila genetics- Introduction to Drosophila life cycle, polytene chromosomes, Drosophila transposons, common mutations, Recombination, importance of drosophila as a genetic model system,Mendelian principles, Extensions of Mendelian principles, Gene mapping methods

Pedigree analysis,

Genetic diseases.

RECOMMENDED TEXT

1. Introduction to Genetic Analysis (9th Edition), A.J.F. Griffihs, R Wessler, Richard C Lewontin & Sean B Carroll. W. H . Freeman & Company
2. Principles of genetics, 8th Edition, Gardner /Simmons/ Snustad. John wiley & sons Inc
3. Genetics 3rd edition Monroe W StrickbergerPrentice Hall of India Pvt Ltd. New Delhi

Course Name: **Biology Lab II**
Course Type: **Core Laboratory**
Course Instructors: **Partha Pratim Datta, Malancha Ta**

SYLABUS

- Blood group determination
- Bacterial growth curve
- Agarose gel electrophoresis
- Plasmid DNA isolation by alkaline lysis
- Transformation
- Conjugation
- Restriction digestion
- SDS PAGE
- An introduction to drosophila genetics (guest instructor: Mohit Prasad)

Course Name: **Biochemistry**
Course Type: **Core Theory**
Course Instructor: **Sankar Maiti**

SYLLABUS

Overview of Biochemistry

Acid Base concept, biological buffers

Biological interactions: hydrogen bonds, hydrophobic, electrostatic and Vander Waals forces

Biochemistry of macromolecules:

- Carbohydrates: Classification, composition and utilization**.**
- Proteins and Amino acids: Properties of amino acids, their ionization, pK values etc.
- Protein structure: Primary, secondary, tertiary and quaternary structures.
- Physical properties of proteins: Charge, size, hydrophobicity
- Separation of proteins based on the above properties; chromatography and electrophoresis

Enzymology:

- Classification and nomenclature of enzymes
- Structures and functions of vitamins and coenzymes
- Effects of temperature, PH, inhibitors etc on enzyme-catalyzed reactions
- Michaelis-Menten equation and estimation of kinetic parameters
- Enzyme regulation
- Zymogen activation and digestive enzymes
- Purification and characterization of enzymes
- Recent advances in enzymology

Fats and Lipid: Classification and function

Nucleic acid and nucleotides: classification and their uses; agarose gel electrophoresis

Nutrition: Digestion and absorption of food; Concepts of probiotics and prebiotics

Overview of cellular metabolism

RECOMMENDED TEXT

1. Biochemistry (6^{th} Edition) J. M. Berg, J. L. Tymoczko, L. Stryer. W. H.Freeman & Co Ltd.

2. Lehninger Principles of Biochemistry (4^{th} Edition) Nelson and Cox. W. H. Freeman & Co.

Course Name: **Biology Lab III**
Course Type: **Core Laboratory**
Course Instructors: **Rituparna Sinha Roy, Chanchal DasGupta**

SYLLABUS

1. Qualitative test for proteins, ultraviolet absorbance and fluorescence of aromatic amino acids.
2. Qualitative analysis of carbohydrates iodine test for polysaccharide, Fehling's test for reducing sugar, barfoed's test for monosaccharise, Seliwanoff's test for keto sugar and Phenyl Hydrazine Test for Osazone and estimation of Glucose by GOD-POD method.
3. Estimation of vitamin E by Baker and Frank Method
4. Estimation of inorganic phosphate (Fiske and Subbarow method)
5. Estimation of cholesterol content in blood serum
6. Protein labelling by bioconjugation chemistry and quantifying the labelling by UV and fluorescence .
7. Estimation of void volume in Gel Filtration and purification of protein.
8. Protease mediated protein digestion and checking the fragments by Gel Electrophoresis.

Course Name: **Evolutionary Biology**
Course Type: **Core Theory**
Course Instructor: **Anindita Bhadra**

SYLLABUS

A. Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; the evolutionary synthesis.

B. Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

C. Paleontology and evolutionary history: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants and animals; stages in primate evolution including Homo.

D. Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

E. The Mechanisms: Population genetics – populations, gene pool, gene frequency; Hardy-Weinberg law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; adaptive radiation and modifications; isolating mechanisms; speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.

RECOMMENDED TEXT

1. Evolution, Second Edition by Douglas J. Futuyma. 2009

2. Evolutionary Ecology (6th Edition) by Eric R. Pianka. 1999

Course Name: **Biology Lab IV**
Course Type: **Core Laboratory**
Course Instructors: **Annagiri Sumana, Anuradha Bhat**

SYLLABUS

- Variations in natural populations: differences in form and function
- Efficiency- characterizing the functional efficiency using tree canopies in their natural habitat
- Competition and its influence on phenotype: experiment on plants in their natural habitat
- Prey predator interaction: simulation model
- Adaptive Radiation: experiment with birds in their natural habitat
- Age structure of the human population
- Hardy Weinberg model : simulation model
- Adaptive significance of size: experiment with *Drosophila*
- Student projects: each student group (comprised of 2 students) will be selecting a project that runs through 3 weeks at the end of which they will be presenting their findings in the form of a seminar.

Courses Offered to the 3rd, 4th & 5th year BS – MS students and the integrated PhD students of IISER – Kolkata

Course Name: **Cell Biology**
Course Type: **Core Theory**
Course Instructors: **Rupak Datta, Malancha Ta**

SYLLABUS

1. Overview of cell biology
2. Biomembranes and cell architecture
3. Transport of ions and small molecules across membranes
4. Intracellular compartments and protein sorting
5. Vesicular trafficking, exocytosis and endocytosis
6. Cell signalling
7. Cytoskeleton dynamics
8. Cell junction, cell adhesion, integrating cells into tissues
9. Cell cycle, cell division and cancer cells
10. Embryonic stem cells, embryonic germ cells and adult stem cells
11. Cell death

RECOMMENDED TEXT:

1. Molecular Biology of the Cell (5^{th} Edition). Bruce Alberts, Alexander Johnson, Lulian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Garland Science, 2007.

2. Molecular Cell Biology (6^{th} Edition). Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh and Paul Matsudaira. W. H. Freeman & Co., 2008.

3. Essentials of Stem Cell Biology. Robert Lanza. Academic Press, 2005

Course Name: **Physiology**
Course Type: **Core Theory**
Course Instructor: **Partho Sarothi Ray**

SYLLABUS

1. Basic concepts in physiology: how physics and chemistry determines physiology, emergent properties of molecular assemblies: molecules-cells-tissues-organs-systems, integration of biochemical reactions in physiology.
2. Symmetry of human body: gravity as determining factor of symmetry.
3. Homeostasis: need to maintain steady-state conditions, perturbation, interactions with environment, functioning of organ systems to maintain homeostasis.
4. Tissue structure and function: tissues as building blocks of physiological systems, types and functions of tissues, different organ systems
5. Maintenance of body fluid homeostasis by physical processes: cardiovascular system.
6. Maintenance of body fluid homeostasis by biochemical processes: functions of blood.
7. Maintenance of body fluid homeostasis by combination of physical and biochemical processes: kidneys and excretory system.
8. Interaction of body fluid homeostasis with the environment: respiration and digestion.
9. Coordination of physiological functions: endocrine system.
10. Reception of external stimuli: special senses.

RECOMMENDED TEXT

Course Name: **Microbiology**
Course Type: **Core Theory**
Course Instructors: **Rupak Datta, Punyasloke Bhadury**

SYLLABUS

MICROBIAL PHYSIOLOGY

Morphological characteristics and reproduction strategies of various microorganisms like bacteria, fungus, algae, protozoa and virus
Microbial metabolism

ENVIRONMENTAL MICROBIOLOGY

Microbiology of soil
Aquatic microbiology
Microbiology of domestic and waste water

DISEASE MICROBIOLOGY

Types of symbiosis and basic concepts of host-pathogen interactions
Resistance and susceptibility to infectious diseases
Recognition and entry mechanism of pathogens into host cells
Immune responses to pathogens
Host cell damage and alteration of host cell behaviour by pathogens
Nutritional status of the host in determining susceptibility to infectious diseases
Viral diseases and virus-induced cell transformation
Discussion on pathogenesis of various infectious diseases

CONTROL OF MICROORGANISMS

Control of microorganisms by physical and chemical agents
Antibiotics and targeted therapeutic approaches against pathogens

RECOMMENDED TEXT

1. Microbiology by Pelczar et. al. Fifth edition; Tata McGraw Hill.
2. Schaechter's Mechanism of Microbial Disease by Engleberg et. al. Fourth edition; Lippincott Williams & Wilkins.
3. Brock Biology of Microorganisms by Madigan et. al. 13th edition; Benjamin Cummings.

Course Name: **Plant Biology**
Course Type: **Core Theory**
Course Instructors: **Robert John Chandran, Shree Prakash Pandey**

SYLLABUS

PLANT DIVERSITY

Plants colonized land, evolutionary innovations of land plants, alternation of generations, plant life cycles, further adaptations of land plants, phylogeny of plants, groups of non-vascular and vascular plants, evolution of seed plants, major clades in seed plants, seed plant reproduction and life cycles, seed plants and human welfare.

PLANT ANATOMY

Structural characteristics of mature and developing cells, tissues, and organs of vascular plants, with special emphasis on the vegetative parts of flowering plants.

PLANT REPRODUCTION (ANGIOSPERMS)

Flowering plant reproduction, angiosperm alternation of generations, fertilization, development of the seed and fruit, fruits and seed dispersal, seed dormancy, and allocation to reproduction.

SYSTEMATICS OF FLOWERING PLANTS

Introduces the principles and methods of the identification, naming, classification, systematics, and evolution of flowering plants; includes a survey of selected flowering plant families with information on their interrelationships.

PHOTOSYNTHESIS

Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C3, C4 and CAM pathways.

RESPIRATION AND PHOTORESPIRATION

Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.

NITROGEN METABOLISM

Nitrate and ammonium assimilation; amino acid biosynthesis.

PLANT HORMONES

Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.

SENSORY PHOTOBIOLOGY

Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.

SOLUTE TRANSPORT AND PHOTOASSIMILATE TRANSLOCATION

Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilates.

SECONDARY METABOLITES
Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

STRESS PHYSIOLOGY
Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress

RECOMMENDED TEXT

1. Biology of Plants. Peter H. Raven, R. F. Evert, S. E. Eichhorn. 7th Ed.. W. H. Freeman 2005.
2. Plant Physiology, Fifth Edition by Lincoln Taiz and Eduardo Zeiger. 2010
3. Mechanisms in Plant Development by Ottoline Leyser and Stephen Day (2003)
4. Plant Systematics. By Michael G. Simpson, Elsevier Academic Press, 2006
5. Plant Structure: Function and Development. J. A. Romberger, Z. Hejnowicz and J.F. Hill. 2004

Course Name: **Gene Regulation and Cellular Communication**
Course Type: **Core Theory**
Course Instructor: **Partho Sarothi Ray**

SYLLABUS

1. Basic concepts in regulation of gene expression: requirement for regulation, advantages of regulation (robustness, fine-tunedness etc.), features of regulatory systems, natural selection of regulatory systems, spatial and temporal regulation, signal processing and information transduction, signal transduction pathways.

2. Physical chemistry of regulation: equilibria of biological reactions, effects on molecular affinity and concentrations.

3. Systems biology of gene regulation: Regulatory networks, network motifs, negative feedback as a conserved regulatory system, advantages of autoregulation: calculation of response time and robustness, feed forward loops.

4. Mechanisms of gene expression: DNA replication and repair, prokaryotic and eukaryotic transcription, post-transcriptional processes (splicing, mRNA export, localization, translation, decay), post-translational modifications as means of regulation of gene function.

5. Structure and function of gene regulatory proteins.

6. Concepts in cellular communication: response to stimuli as determinant of gene regulation, ligand-receptor interactions, calculation of dissociation constants and Scatchard analysis, nature and variety of signal transduction pathways.

7. Regulatory systems: Phage strategies.

8. Regulatory systems: Prokaryotic transcription regulation, operon concept, regulation of transcription termination, attenuation.

9. Regulatory systems: Eukaryotic transcription regulation, epigenetic regulation of transcription through reversible chromatin modification, transcription factors.

10. Regulatory systems: Post-transcriptional regulation in prokaryotes and eukaryotes, regulation mediated by cis-acting and trans-acting RNAs, riboswitches, regulation mediated by mRNA transport, splicing and localization, translation regulation: global and transcript specific, protein-mediated translation regulation, miRNA-mediated translation regulation.

11. Seminars covering examples of various regulatory systems.

RECOMMENDED TEXT

Course Name: **Developmental Biology**
Course Type: **Core Theory**
Course Instructor: **Mohit Prasad**

SYLLABUS

BASIC CONCEPTS OF DEVELOPMENT
Definitions and Historical concepts of developmental biology, Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; Regulation of gene expression in development; Reaction diffusion and embryonic development; imprinting; mutants and transgenics in analysis of development.

GAMETOGENESIS,
Fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animal ; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis,

MORPHOGENESIS AND ORGANOGENESIS IN ANIMALS
Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans; eye lens induction, limb development and regeneration in vertebrates; post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.

AGING AND SENESCENCE

RECOMMENDED TEXT

1. Developmental Biology (8th Edition), S. F. Gilbert; Sinauer Associates, Sunderland, MA.
2. Principles of Development, Lewis Wolpert; Oxford University Press

Course Name: **Principles of Ecology and Conservation**
Course Type: **Core Theory**
Course Instructor: **Anuradha Bhat**

SYLLABUS

THE ENVIRONMENT
Physical environment; biotic environment; biotic and abiotic interactions.

HABITAT AND NICHE
Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

POPULATION ECOLOGY
Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

SPECIES INTERACTIONS
Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

COMMUNITY ECOLOGY
Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

ECOLOGICAL SUCCESSION
Types; mechanisms; changes involved in succession; concept of climax.

ECOSYSTEM
Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).

BIOGEOGRAPHY
Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

APPLIED ECOLOGY
Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

CONSERVATION BIOLOGY
Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

RECOMMENDED TEXT

1. Ecology. Charles Krebs. Benjamin Cummins, 5th Edition.
2. Ecology. Robert Ricklefs. W. H. Freeman, 6th Edition

Course Name: **Immunology**
Course Type: **Core Theory**
Course Instructors: **Jayasri Das Sarma**

SYLLABUS

AN INTRODUCTION TO IMMUNOLOGY
Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cells epitopes, structure and function of antibody molecules, generation of antibody diversity, monoclonal antibodies, antigen-antibody interactions, MHC molecules. Evolution of immune system

INNATE IMMUNITY
Recognition of antigen: Antigen recognition by B and T cell receptor, the generation of Lymphocytes antigen receptor, Antigen presentation to T lymphocytes

THE DEVELOPMENT AND SURVIVAL OF LYMPHOCYTES

THE ADAPTIVE IMMUNE RESPONSE
T cell mediated immunity, the humoral immune response, Dynamics of adaptive immunity

THE MUCOSAL IMMUNE SYSTEM

THE IMMUNE SYSTEM IN HEALTH AND DISEASES
Failure of host defense mechanism; Acquired immunodeficiency; Allergy and hypersensivity; Autoimmunity and transplantation Manipulation of the immune system

TOOLS AND TECHNIQUES USED IN IMMUNOLOGY

RECOMMENDED TEXT

1. Janeway's Immunobiology. Kenneth Murphy, Paul Travers, Mark Walport. 7th Edition, Garland Science.
2. Kuby Immunology. Thomas J. Kindt, Richard A. Goldsby, Barbara A Osborne. 6th Edition. W.H. Freeman.
3. Roitt's Essential Immunology. Peter J. Delves. 11th Edition. Blackwell

Course Name: **Advanced biochemistry and cellular metabolism**

Course Type: **Core Theory**

Course Instructors: **Sankar Maiti, Rupak Datta**

SYLLABUS

Metabolism of Carbohydrates:
Degradation and digestion of carbohydrates; Glycolysis; Tricarboxylic acid cycle; Phosphogluconate pathway; Glyoxylate pathway; Pentose phosphate pathway; Cori cycle; Calvin cycle; Gluconeogenesis; Glycogenolysis; Disorders of carbohydrate metabolism.

Bioenergetics:
High-energy compounds; Chemical potentials; Electrochemical potentials; Electron transport system and oxidative phosphorylation; Regulation of ATP production; Photophosphorylation.

Metabolism of Lipids:
Oxidation and synthesis of fatty acids; Choloesterol synthesis; Formation of ketone bodies; Integration of lipid metabolism; Acetic acid as a central precursor for biosynthesis of lipids; Disorder of lipid metabolism.

Metabolism of Amino Acids and Proteins:
Biosynthesis and degradation of amino acids; Urea cycle; Disorders of amino acid metabolism.

Metabolism of Nucleic Acids:
Metabolism of nucleotides; Abnormalities in nucleic acid metabolism

Integration of Metabolism: Hormonal regulation of metabolism

Secondary metabolites and metabolic engineering

Recommended Text Books:

1. Biochemistry 6th edition by JM Berg, JL Tymoczko, L Stryer. W.H.Freeman & Co Ltd.
2. Lehninger Principles of Biochemistry Forth edition by Nelson and Cox. W. H. Freeman & Co.

Course Name: **Structural Biology**
Course Type: **Core/ Interdisciplinary Theory**
Course Instructors: **Chancha DasGupta, Partha Pratim Datta, Rituparna Sinha Roy**

SYLLABUS

STRUCTURES
Structure of Proteins, Nucleic acids and Membranes: Functional significance of structures.

PHYSICAL INSTRUMENTS AND METHODS
Diffusion, Sedimentation, Electrophoresis, Separation techniques, Biomolecular structure determination using IR-Raman, UV-visible spectroscopy, CD, ORD, NMR, Fluorescence spectroscopy, Mass spectroscopy and X-ray diffraction.

Basics of Scanning and Transmission Electron Microscopy, Sample preparation, single particle Cryo-Transmission Electron Microscopy, 3D Image processing from EM data, Molecular docking, Model building, computer simulation and graphics, Tomography.

RECOMMENDED TEXT

1. Physical Biochemistry : Kensal E van Holde, Curtis Johnson, Pui Shing H
2. Physical Chemistry with Applications to the Life Sciences : Eisenberg & Crothers (1979).
3. Molecular Biology of the Cell by Albert et al., (Electron microscopy)
4. SPIDER: http://www.wadsworth.org/spider_doc/spider/docs/spider.html (Image processing)
5. EMAN2: http://blake.bcm.edu/emanwiki/EMAN2 (Image processing)
6. CHIMERA: http://www.cgl.ucsf.edu/chimera/ (Structure analysis)
7. Additional reading: Three-Dimensional Electron Microscopy ofMacromolecular Assemblies, by Joachim Frank, Oxford university press, 2006.

Course Name: **Biostatistics**
Course Type: **Core/ Interdisciplinary Theory**
Course Instructors: **Partha P. Majumder, Robert J. Chandran**

Pre-requisite: **Probability and Statistics [4th Semester]**

SYLLABUS

Introduction: the need for statistical analyses and models in biology. Testing relationships among biological/biophysical variables: regression and correlation. Univariate models. Testing covariates and multiple variables: multiple linear regression. Experimental Design and ANOVA: fixed effects, random effects, mixed effects models, interactions. Multivariate analyses: multivariate data, multivariate normal distribution, principal components, ordination. Cluster Analyses: distance function, UPGMA/average linkage clustering, construction of phylogenetic trees. Non-parametric Methods: signed-rank test, Mann-Whitney test, Kruskal-Wallis test, rank correlation.

Teaching Methods

Since the basic principles of probability and statistics are already covered in the "*Probability and Statistics*" course in the 4th Semester, this course will proceed straight to the topics mentioned above, focusing on the principles in brief, and illustrating the applications with numerous examples and exercises. In addition, there will also be invited guest lectures on specific topics.

RECOMMENDED TEXT

1. Statistical Methods by George W. Snedecor and William G. Cochran (1989). Eighth Edition.
2. Biometry: The Principles and Practices of Statistics in Biological Research by Robert R. Sokal and F. James Rohlf (1994)
3. Applied Multivariate Statistical Analysis (6th Edition) by Richard A. Johnson and Dean W. Wichern (2007)
4. A Primer Of Ecological Statistics by Nicholas J. Gotelli and Aaron M. Ellison (May 1, 2004).
5. Cluster Analysis (Wiley Series in Probability and Statistics) by Brian S. Everitt, Dr Sabine Landau, Dr Morven Leese and Dr Daniel Stahl (Mar 8, 2011)

Course Name: **Biophysics**
Course Type: **Core/ Interdisciplinary Theory**
Course Instructor: **Bidisha Sinha**

SYLLABUS

This course will cover basic biophysics concepts through the most relevant systems and experimental and analytical techniques.

Topics to be covered:

At the molecular to cellular scale:

- Molecular interactions – force/energy scales - kinds of interactions.
- Diffusion of molecules in the cell: what is diffusion, 3D, 2D and 1D diffusion; Impact on biological processes.
- Aqueous, Ionic equilibrium of a living cell, osmotic pressure, non-equilibrium distributions of ions.
- Protein-DNA interactions (kinetics of repressor-DNA interaction, eukaryotic gene expression and chromatin deformability, packing).
- Membrane mechanics/dynamics, protein-membrane interactions.
- Ion transport in membranes, action potential, role of membrane geometry.
- Cell adhesion.
- Mechano-transduction.
- Molecular motors: understanding single motors and their collective properties.
- Stochasticity (origin, impact on gene expression, molecular interactions during signaling).

At the multicellular lengthscale :

- Distributions in nature.
- Biophysical characteristics of a tissue: Surface and interfacial tensions, rheology, cell migration.
- Biophysics of cancer.

Throughout the course, the relevant experimental techniques will be discussed. Techniques covered: Single Particle Imaging, Fluorescence Spectroscopy (FCS, FRAP, Fluorescence Polarization, FRET), Atomic force microscopy, Optical force spectroscopy.

RECOMMENDED TEXT

1. Biophysics. Roland Glasser. Springer (2001)
2. Random walks in biology. H. Berg. Princeton University Press (1993)
3. Molecular Biology of the cell. Alberts et al. Garland Science (2007)
4. Physical Biology of the cell. Rob Phillips, Jane Kondev, Julie Theriot. Garland Science (2008).
5. Principles of Fluorescence Spectroscopy. Joseph R. Lackowitz. Springer (1999)

Course Name: **Neurobiology**
Course Type: **Interdisciplinary Theory**
Course Instructors: **Jayasri Das Sarma**

SYLLABUS

Cell and Molecular Biology of the Neuron

Development of nervous system: Development of nervous system (Development of nervous system (introduction and patterning of nervous system), the generation and survival of nerve cells, the guidance of axons to their targets.

Synthesis and trafficking of neuronal proteins.

Ion Channels, Membrane Potential and generation of Action potential

Ion Channels: What are ion channels? There importance for signaling in Nervous system. Ion channels as membrane proteins, how they can be investigated using functional methods? Patch Clamp technique. Different gating pathways for opening and closing of channels. Structure of Ion channels. Different families of K+ -selective ion channels.

Membrane Potentials: Resting potential and its origin. Recording membrane potential. Equilibrium potential: Nernst Equation. Passive flux of Na+ and K+ through the ion channels. Action potential, its generation after depolarization. Goldman Equation. Neuron and its equivalence to electrical circuit. Current flow in neuron. and cable theory

Elementary Interactions between Neurons: Synaptic transmission: Overview of synaptic transmission; formation and regeneration of synapse, fine tuning of synaptic connections). Signaling at the nerve-Muscle Synapse: Directly Gated Transmission. Synaptic integrationModulation of synaptic-Transmission: Second messenger. Transmitter release, Neurotransmitters and Diseases of the altered Chemical Transmission.

Neuroanatomy (Anatomic organization of the Central and peripheral nervous system): Gross Anatomy and general Organization of the Central nervous system. Meningial Coverings of the Brain and spinal cord. Ventricles and cerebrospinal fluid. Blood supply of the brain

Plasticity and Learning: Molecular and cellular basis of learning; handing over to AB/AG: Basic Hebb rule-supervised and unsupervised learning-classical conditioning and reinforcement learning-representational learning.

Complexity of the nervous system: Network Models: firing rate models - feed-forward - recurrent networks - network stability - associative memory - excitatory-inhibitory networks - stochastic networks.

Neuroimaging

Neurobiological Diseases

RECOMMENDED TEXT

1. Principles of neural science / edited by Eric R. Kandel, James H. Schwartz, Thomas M. Jessell.4th ed. New York: McGraw-Hill, Health Professions Division, c2000.

2. The human brain: an introduction to its functional anatomy / John Nolte; three-dimensional brain reconstruction by John Sundsten.5th Ed. Missouri: Mosby, c2002.

Course Name: **Bioinformatics**
Course Type: **Interdisciplinary Theory**
Course Instructors: **Anirban Banerjee, Shree Prakash Pandey, Saroj Mohapatra (NIBMG)**

SYLLABUS

DNA AND AMINO ACID SEQUENCES: FEATURE EXTRACTION, ALIGNMENT AND INFERENCES

Exploration of biological features; exploration of quantitative characteristics; alignment algorithms (Needleman-Wunsch, Smith-Waterman, BLAST); algorithms for determination of higher order structure

EVOLUTIONARY INFERENCE FROM SEQUENCE DATA: ESTIMATING RATES OF EVOLUTION

Jukes and Cantor model; Kimura's two-parameter model; Tajima and Nei's method;

BIOINFORMATICS APPROACHES TO OMICS ANALYSIS

Exploration of trends in high-throughput data using Principal Component Analysis (PCA) and hierarchical clustering; differential gene expression using moderated t-tests and Receiver Operating Characteristic (ROC); Gene set (pathway) enrichment analysis; exploration of correlation gene networks

METHODS OF SYSTEMS BIOLOGICAL INFERENCE

RECOMMENDED TEXT

1. Biological Sequence analysis by Durbin, Eddy, Krogh, Mitchison (Cambridge University Press, 1998).
2. Fundamentals of Molecular Evolution by Dan Graur and Wen-Hsiung Li (Sinauer, 2000, Second Edition).
3. Bioinformatics: Sequence and Genome Analysis by David W Mount (Cold Spring Laboratory Press 2004, Second Edition).

Course Name: **Behavioural Biology**
Course Type: **Interdisciplinary Theory**
Course Instructor: **Annagiri Sumana**

SYLLABUS

Introduction to biology beyond sub-organismal level, Homeostasis, Introduction to the study of behaviour.

Asking questions, Approaches and methods in study of behavior; Proximate and Ultimate Xausation

Altruism, Kin selection, Cooperation. Social Dominance; use of Space and Territoriality

Speciation, Interaction between species, Life history strategies,

Origin of Sex and Mating systems, Mate choice. parental care, parental investment and reproductive success

Sensory capacities and Animal signals, Social Communication, Biological clocks.

Migration, Orientation and Navigation. Learning, Imprinting, Cultural transmission.

Development of behaviour, Domestication and behavioral changes.

Habitat selection and optimality in foraging

RECOMMENDED TEXT

1. Introduction to Animal Behaviour. Aubrey Manning and Marian Stamp Dawkins. Cambridge University Press 2000.
2. Principles of Animal Behaviour. Lee Allan Dugatkin. W. W. Norton and Company. 2004.
3. Animal Behaviour. John Alcock. Sinauer Associates Inc. 2005

Course Name: **Systems Biology**
Course Type: **Interdisciplinary Theory**
Course Instructors: **Partho Sarothi Ray, Anirban Banerjee, Anandamohan Ghosh**

SYLLABUS

Partho Sarothi Ray [3 lectures]:
Introduction to Systems Biology
Gene Regulation
Basic concepts of network

Anirban Banerjee [~6-9 lectures]:
Heuristic parameters (deg distbn,z-score...)
Network motifs
Autoregulation - FFL
Structural robustness
Types of network model (scale free, small world....)

Anandamohan Ghosh [~24-27 lectures]:
Dynamical systems basic concepts
Oscillations - lambda phage
Reaction kinetics - Michaelis Menten - Hill equation (transcription network)
Stochastic process
Robustness - chemotaxis
Optimality in gene circuit design
Population dynamics - pattern formation in reaction diffusion systems

RECOMMENDED TEXT

1. An Introduction to Systems Biology: Design Principles of Biological Circuits - Uri Alon Chapman & Hall/CRC Mathematical & Computational Biology.
2. Nonlinear Dynamics and Chaos: With Applications To Physics, Biology, Chemistry, and Engineering - Steven Strogatz; Westview Press.
3. Mathematical Biology I and II (3rd Edition) - J.D. Murray; Springer

Course Name: **Applied Biochemistry**
Course Type: **Interdisciplinary Theory**
Course Instructor: **Supratim Datta**

This course designed to provide undergraduate students with an introduction to biochemistry of fuels. We will start by reviewing briefly organic chemistry – the mechanisms by which organic molecules react and the functional groups found in biomolecules. We will then take a look at the structures and characteristics of main groups of biomolecules. In the final portion of the first part of the course, we will look at carbohydrate degrading pathways and try to understand the how and why of these pathways. In the second part of the course we will apply this knowledge and learn about the biochemistry of fuels. After the introductory material the rest of the course will concentrate on different facets of biofuels production.

Lecture plan:

1. Biochemical processes from a chemical perspective – Connection between chemistry and biology (~5 lectures).
2. Biomolecules (~3 lectures)
3. Carbohydrate metabolism (~10 lectures)
4. Protein engineering (~3 lectures)
5. Biochemistry of fuels – different energy sources, biofuels and the biomolecules that catalyze these reactions (~25 lectures)

Evaluations will be through homework sets, mid-term exams etc that would be announced in class.

RECOMMENDED TEXT

Course Name: **Cancer Biology**
Course Type: **Interdisciplinary Theory**
Course Instructor: **Tapas Kumar Sengupta**

Syllabus:

- Introduction to Cancer Biology: Definitions, Classifications, Nomenclature
- Hallmarks of cancer: Six hall marks of cancer and brief discussion on them, Steps of cancer progression
- Introduction to oncogenes and tumor suppressor genes
- Retro-virus and cancer
- Growth factors and anti-growth factors and receptors related to cancer
- Cell cycle
- Apoptosis
- Telomere and telomerase
- Chromosome instability and epigenetic regulations
- Angiogenesis
- Metastasis.
- Tumor immunology
- Cancer therapeutics

.

RECOMMENDED TEXT

Course Name: **Cognition**
Course Type: **Interdisciplinary Theory**
Course Instructors: **Annagiri Sumana, Anuradha Bhat, Anindita Bhadra**

SYLLABUS

1. Introduction to cognition, Evolutionary perspective

2. Brain and nervous system and molecular mechanisms of cognition

3. Learning: Instrumental and Associative, social learning among different groups of organisms (insects, fish, mammals etc.), physiology of learning

4. Biological rhythms and orientation mechanisms

5. Memory, consciousness (Discussions: "Are Animals intelligent- Problems of Other Species of Mind: Explaining Intelligent Behavior")

6. Decision making and rational behaviour

7. Social cognition- recognition, communication, game theory

8. Theory of mind

The course will also have a few guest lectures, student seminars, reading assignments and limited practical exercises.

RECOMMENDED TEXT

1. Neil R Carlson (2010) Physiology of Behavior, Tenth Edition, Pearson Publishers
2. Pearce, J. (2008) Animal learning & Cognition, an introduction. 3rd edition, Psychology Press, Hove. Pp 35 – 42; 46 – 74.
3. Buss, D.M. (2005). The Handbook of Evolutionary Psychology. John Wiley and Sons, Inc.

Some more suggested readings

Pennartz, C. M. a., Ito, R., Verschure, P. F. M. J., Battaglia, F. P., & Robbins, T. W. (2011). The hippocampal–striatal axis in learning, prediction and goal-directed behavior. Trends in neurosciences., 34(10), 548-559. Elsevier Ltd. doi:10.1016/j.tins.2011.08.001

Bird, C. M., & Burgess, N. (2008). The hippocampus and memory: insights from spatial processing. Nature reviews neuroscience., 9(3), 182-94. doi:10.1038/nrn2335

CDL Wynne *Animal Cognition – Mental Lives of Animals;*

JJ Bolhuis, LA Giraldeau *The Behavior of Animals*

Course Name: **Marine Biology**
Course Type: **Interdisciplinary Theory**
Course Instructor: **Punyasloke Bhadury**

SYLLABUS

Introduction to Marine Biology: Basic knowledge of the range of organisms, both plant and animal, in the sea; fundamentals of chemical oceanography; structure of ocean basins, marine sediments; fundamentals of water movement, tides and currents

Functional Biology of Marine Organisms: Functional biology of selected invertebrate and vertebrate marine groups including benthic, nektonic, planktonic and pelagic organisms; Marine organism assemblages in reefs, mangroves, intertidal, coastal and deep-sea environments

Marine Ecology: An overview of tropical marine ecology; Introduction to natural and anthropogenic processes that can influence the biotic communities in the marine environment; Impact assessment and monitoring

Biological Oceanography: Plankton community structure and its interactions with the physical and chemical environment; Nutrients and productivity, zooplankton behaviour and life cycles and the distribution of planktonic species over space and time on a broad range of scales and factors influencing the survival of larval fish.

Coral reef ecology: Major aspects of coral reef ecology to be covered including population dynamics, reef community structure and diversity, effects of environmental disturbances, competition and predation, and reef management.

This course will also include practical components including a trip to the near-shore ecosystem as well as getting students acquainted with measurements of basic hydrological and nutrient parameters in estuarine and coastal waters.

RECOMMENDED TEXT

Marine Biology. Peter Castro and Michael Huber. McGraw-Hill 4th edition (2003)

Course Name: **Biology Lab V**
Course Type: **Core Laboratory (for 3rd year)**
Course Instructors: **Jayasri Das Sarma, Bidisha Sinha**

Experiments:
Animal dissection and histology (JDS)
Immunohistochemistry, immunofluorescence and quantitative image analysis (BS)

Course Name: **Biology Lab VI**
Course Type: **Core Laboratory (for 3rd year)**
Course Instructors: **Anindita Bhadra, Annagiri Sumana**

Experiments
Ecology

Course Name: **Biology Lab VII**
Course Type: **Core Laboratory (for 3rd year)**
Course Instructors: **Partho Sarothi Ray, Rupak Datta, Chanchal DasGupta, Partha Pratim Datta, Rituparna Sinha Roy**

Experiments
Molecular cloning (PSR) + Protein expression in bacterial system (RD)
Structural Biology (CKDG, PD, RSR)

Course Name: **Biology Lab VIII**
Course Type: **Core Laboratory (for 3rd year)**
Course Instructors: **Punyasloke Bhadury, Tapas Kumar Sengupta**

Experiments
Realtime PCR (PB)
Elisa and western blot (TKS)

Course Name: **Biology Lab IX**
Course Type: **Core Laboratory (for 4th year)**
Course Instructors: **Tapas Kumar Sengupta, Sankar Maiti, Mohit Prasad**

Experiments
Drosophila genetics and developmental Biology (MP)
Tissue Culture and cell fractionation (TKS, SM)

Course Name: **Biology Lab X**
Course Type: **Core Laboratory (for 4th year)**
Course Instructors: **Anindita Bhadra, Anuradha Bhat**

Experiments

Animal Behaviour

Course Name: **Seminar and scientific presentation**
Course Type: **Core Seminar**
Course Instructors: **Robert John Chandran and Partha Pratim Datta**

COURSE CONTENT AND METHOD

Scientific presentation skills

- Scientific talks

- Posters

- Popular Talks

Method: Lectures by the instructors and presentations/posters by the students; videos and text of famous talks, speeches etc.

Writing skills:

- popular writing

- technical reviews and summaries of a body of scientific knowledge

- formal scientific communication

- writing responses to comments

- ethics of scientific communication

Method: Lectures by the instructors and written exercises by the students

Critiquing scientific articles:

- summarising a critique

- formal communication of a letter of critique to a journal editor

Method: Lectures by the instructors and group exercises by students