BIOLOGY SYLLABUS FOR INTEGRATED M.Sc. COURSE - NISER

Semester 1

B101	**Biology I: Science of Life**	**3 Credits**
BL101	**Biology Laboratory**	**2 Credits**
General Course		**4 Credits**

Semester 2

B201	**Biology II: Cellular and Genetic basis of life**	**3 Credits**
BL201	**Biology Laboratory**	**2 Credits**
General Course		**4 Credits**

Semester 3

B301	**Microbiology**	**4 Credits**
B302	**Biochemistry**	**4 Credits**
B303/BEO	**Ecology**	**4 Credits**
EO1	**Chem/Phy/Maths**	**4 Credits**
BL301	**Microbiology Laboratory**	**2 Credits**
BL302	**Biochemistry Laboratory**	**2 Credits**
General Course		**4 Credits**

Semester 4

B401	**Cell Biology**	**4 Credits**
B402	**Genetics**	**4 Credits**
B403/BEO	**Biophysics & Biostatistics**	**4 Credits**
EO2	**Chem/Phy/Maths**	**4 Credits**
BL401	**Cell biology Laboratory**	**2 Credits**
BL402	**Genetics Laboratory**	**2 Credits**
General Course		**4 Credits**

Semester 5

B501	**Physiology I (Animal Physiology)**	**4 Credits**
B502	**Physiology II (Plant Physiology)**	**4 Credits**
B503/BEO	**Neurobiology**	**4 Credits**
EO3	**Chem/Phy/Maths**	**4 Credits**
BL501	**Physiology I (Animal Physiology) Laboratory**	**2 Credits**
BL502	**Physiology II (Plant Physiology) Laboratory**	**2 Credits**
EB501	**Elective course (Principles of Drug design or other courses yet to be determined)**	**4 Credits**

Semester 6

B601/BEO	**Molecular Biology**	**4 Credits**
B602	**Immunology**	**4 Credits**
B603/BEO	**Structural Biology**	**4 Credits**
EO4	**Chem/Phy/Maths**	**4 Credits**
BL601	**Molecular Biology Laboratory**	**2 Credits**
BL602	**Immunology Laboratory**	**2 Credits**
EB601	**Elective course (Enzymology or design or Other courses yet to be determined)**	**4 Credits**

Semester 7

B701	**Genetic Engineering**		**4 Credits**
B702	**Developmental Biology**		**4 Credits**
BL701	**Genetic Engineering Laboratory**		**2 Credits**
BL702	**Developmental Biology Laboratory**		**2 Credits**
BJ701	**Journal Club**		**4 Credits**
EB701	**Advanced/Elective course**	**(Cell Biology)**	**4 Credits**
EB702	**Advanced/Elective course**	**(Biotechniques)**	**4 Credits**

Semester 8

B801	**Bioinformatics & Computational Biology**		**4 Credits**
B802	**Evolutionary Biology**		**4 Credits**
BL801	**Bioinformatics Laboratory**		**2 Credits**
EB801	**Advanced/Elective course**	**(Biochemistry)**	**4 Credits**
EB802	**Advanced/Elective course**	**(Microbiology)**	**4 Credits**
BP801	**Project**		**6 Credits**

Semester 9

BR901	**Dissertation project**		**16 Credits**
EB901	**Advanced/Elective course**	**(Molecular biology)**	**4 Credits**
EB902	**Advanced/Elective course**	**(Immunology)**	**4 Credits**

Semester 10

BR1001	**Dissertation project**	**16 Credits**
EB1001	**Elective course (Infectious Disease Biology)**	**4 Credits**
EB1002	**Elective course (Cancer Biology)**	**4 Credits**

****In addition to the courses assigned for EB (elective Biology) any of the following subjects may be offered depending on the resources available:**

Elective courses are

Protein Chemistry, Endocrinology, Plant Development, Virology, Animal Behavior, Systems Biology, Ecosystem & Modeling, Radiation biology & medical physics, Genomics and proteomics, Bionanotechnology, Stem Cell Biology & Regenerative Medicine, Conservation Biology.

Detailed course plans will be developed at a later date.

DETAILED SYLLABUS

Semester 1

B101: Biology I: Science of Life, Credits - 3

Origin of life: Bioenergetics and concepts of evolution
Molecules of life: Proteins, Carbohydrates, Nucleic acids and Lipids
Unit of life: structure & function of organelles, cytoskeleton and extra cellular matrix

Reference:

i) Laboratory hand outs
ii) **Lehninger Principles of Biochemistry, Fourth Edition** by *David L. Nelson and Michael M. Cox*
iii) **"Molecular biology of the Cell"** *by Albert et.al*

BL101: Biology Laboratory, Credits – 2

1. Diversity of life forms & evolution of body plans using stored specimens and deduction of evolutionary relationship.
2. Preparation of Buffer and titration curve
3. Spectrophotometry: Introduction to Beer-Lambert Law; Demonstration of Beer's law
4. Amino acids: Separartion of amino acid and their detection
5. Proteins: Comparison of Bradford assay, Folin-Lowry assay and UV absorption methods for protein estimation
6. Carbohydrates: Benedict's test for reducing sugars
7. Iodine test for polysaccharides
8. Estimation of carbohydrate by Anthrone method
9. Isolation and quantification of DNA by agarose gel electrophoresis
10. Lipids: Separation of lipids by TLC / Paper Chromatography
11. DNA melting/Protein folding

Reference:

Class notes, handouts and other reading as suggested during the class

General Course **4 Credits**

Semester 2

B201: Biology II: Cellular and Genetic basis of life, Credits - 3

Cellular Mechanisms of Development: Cell Cycle, Cell-Cell communication, Cell differentiation
Evolutionary concepts: Lamarckism, Darwinism and Speciation
Basis of Inheritance: Chromosomal and molecular, Patterns of inheritance,
Basics of Replication, Transcription, Translation, DNA manipulation

Reference:

Class notes, handouts and other reading as suggested during the class or in Semester 1

BL201: Biology Laboratory, Credits – 2

1. Use of microscope
2. Study of various organelles using staining and microscopic techniques
3. Trypan blue exclusion – cell viability assay

4. Onion root tip as a model to see various stages of cell division
5. Cell division: Meiosis
6. Determination of human blood groups (ABO) Precipitin/Agglutination reaction
7. Plant cell growth and differentiation
8. Gene regulation experiments by using Drosophila mutants

Reference:
Laboratory hand outs and study material as suggested during the class

General Course **4 Credits**

Semester 3

B301: Microbiology, Credits - 4

1. 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
2. Microbial nutrition and physiology:
   - Metabolic diversity – Phototrophy, Autotrophy, Chemolithotrophy and Nitrogen fixation
   - Catabolism of organic compounds – fermentations, anaerobic respiration & aerobic chemorganotrophic processes.
   - Microbial growth
3. Microbial genetics: Overview
   - Bacterial genetics – chromosomes, plasmids & incompatibility, mutation, genetic exchange in prokaryotes – transformation, conjugation, transduction
4. Microbes in health & disease:
   - Beneficial microbial interactions with humans,
   - Harmful microbial interactions with humans: host-parasite interactions, overview of host defense system, pathogenesis & infection establishment, Virulence factors & toxins.
   - Brief overview of antibiotics, antibiotic resistance & their mechanism of action
5. Microbes in agriculture: Overview
   - Microbial diseases of economically important plants
   - Agrobacterium and crown gall disease, Transformation
6. 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
7. Microbes in industry: Brief over view of their roles in:
   - Food, health and fermentation sectors

Recommended Book:-

Class notes, handouts and other reading as suggested during the class

B302: Biochemistry, Credits – 4

1. Overview of Biochemistry
2. Protein structure & function, Protein Folding, Protein Degradation
3. Enzymes: Classification, Mode of action, kinetics, regulation and inhibition, examples of enzymatic reactions and regulatory enzymes
4. Lipids: Transmembrane lipids, receptors, lipids as signals, co-factors and pigments
5. Intermediary Metabolism and Energetics:
6. CarbohydrateMetabolism: Glycolysis, TCA cycle, Gluconeogensis, Pentose phosphate pathway, Glycogenesis and Glycogenolysis, co-ordianted regulation of glycolysis and gluconeogensis, Phosphorylation and bioenergetics of above processes.
7. Electron Transport Chain and Oxidative Phosphorylation
8. Fatty acid biosynthesis and degradation, Synthesis of Cholesterol, Steroid Hormones and Eicosanoids
9. Amino acid biosynthesis and degradation
10. Nucleotide biosynthesis and degradation
11. Hormones: Mechanism of action, regulation and integration in mammalian metabolism
12. Biochemistry of signal Transduction

Recommended Books:-

1. Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson, Michael M. Cox
2. Biochemistry by Berg and Stryer
3. Biochemistry by Voet and Voet
4. Harper's book of Biochemistry

B303/ BEO1: Ecology, Credits - 4

1. Overview of ecology
2. Ecological setting the biogeography of the earth & the climatic zones of the earth
3. The individual
4. Autecology-single species ecology
5. Population and population dynamics
6. Regulation of population
7. Ecological genetics
8. Behavioral ecology
9. Sociobiology
10. The environment
11. Habitats and niches
12. Trophic levels
13. Energy transfer
14. Nutrient cycling and pollution
15. Communities
16. Ecosystems
17. Succession
18. Biomes
19. Co-evolution
20. Conservation
21. Human ecology
22. Evolution ecology, mass extinction & their reasons
23. Climate change

24. Ecological studies of Chilka lake, Bhitarkanika biosphere reserves (Saturday visits)
25. Olive Ridley turtle and their preservation
26. Biodiversity and its maintenance

Recommended Books:

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

BL301: Microbiology Laboratory, Credits - 2

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

Reference

Laboratory hand outs and study material as suggested during the class

BL302: Biochemistry Laboratory, Credits-2

1. Isolation, Estimation and purification of protein
2. SDS-PAGE
3. Enzyme kinetics (catalase, peroxidase)
4. Isolation of genomic DNA
5. Estimation and quantification of DNA
6. Agarose gel electrophoresis for DNA
7. Isolation of Plasmid DNA
8. Isolation and estimation of RNA
9. Thin layer Chromatography

Recommended 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

General Course **4 Credits**

Semester 4

B401: Cell Biology, Credits – 4

1. Overview of Cell biology
2. Universal features of cells
5. Basic microscopy, Visualization of cell, its fine structure, molecules and different functions
6. The cell membrane, its structure and its dynamics
7. Transport across membrane
8. Ion channels

9. Cellular compartments and function, protein sorting
10. Vesicular traffic inside the cells
11. Mitochondria and chloroplast and their genetic system, fission and fusion of mitochondria
12. Cellular communication and cell signaling
13. Cytoskeleton of cells, cytoskeleton filaments, molecular motors, cell junction, extra cellular matrix, cell adhesion
14. Cell cycle, Cell division- Mitosis, meiosis and the mechanism of cell division
15. Cell biology of nucleus and chromatin
16. Cell biology of Germ cells, neuronal cells, stem cells, gametes, immune cells
17. Cell biology of cancer cells
18. Cell survival and cell death
19. Cell biology of model organisms and plant cells
20. Advancement in microscopic techniques

Recommended Books:-
"Molecular biology of the Cell" by Albert et.al

B402: Genetics, Credits - 4
1. Overview of Genetics and terminology
2. Model Genetic systems
3. Mendelian Inheritance
4. Deviations from Mendelian Inheritance- Linkage and Sex linked Inheritance, Gene Interactions, Maternal and Extranuclear Inheritance
5. Recombination, Recombination mapping and mechanism of recombination
6. Transposable Elements
7. Mechanisms of Genetic Diseases- Chromosome number variation, changes in chromosome structure, Gene mutation, mutagenesis and mutant selection, X-chromosome inactivation, Genetic imprinting
8. Elements of human genetics-genetic disorders, patterns of inheritance, molecular diagnosis
9. Cytogenetics
10. Prenatal Diagnosis and Genetic Counseling
11. Epigenetics
12. Cancer Genetics
13. Population Genetics
14. Developmental Genetics
15. Immunogenetics
16. Genes and Evolution

Recommended Readings:
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

B403/BEO2: Biophysics & Biostatistics, Credits – 4
Biostatistics
1. Simple Statistics & Effect Statistics
2. Precision of Measurement
3. Generalizing to a Population
    a. Confidence Limits, Statistical Models
4. Models: Important Details
    a. Complex Models

5. Repeated-Measures ANOVA
6. Dimension Reduction
    a. Principal Components · Factor Analysis · Cluster Analysis
7. Estimating Sample Size
8. On the Fly: Miscellaneous
9. Simulation for Sample Size

Biophysics

1. Introduction: What is biophysics
2. Basic techniques in life sciences
3. Energetics and Thermodynamics (reversible and irreversible)
4. Kinetics & Catalysis mechanisms (emphasis on enzymes)
5. Structure-function relationship
6. Models in evolution and agricultural sciences
7. Recent advances in biophysics with an overview of Omics and systems biology

References:

i) Class notes, handouts
ii) Statistics at the Bench: A Step-by-Step Handbook for Biologists By Martina Bremer
iii) Introductory Biophysics by V. Pattabhi & N. Gautham
iv) Biophysical Chemistry, Part 1, 2, 3. by Cantor & Schimmel
v) Principles of Fluorescence Spectroscopy by J. R. Lacowicz
vi) Physical Biochemistry by David Freifelder.
vii) Biological Spectroscopy by Iain D. Campbell, Raymond A. Dwek

BL401: Cell Biology Laboratory, Credits – 2

1. Culture and growing of different type of cells
2. Staining and visualization of different cellular organelles
3. Analysis of cellular functions like endocytosis, exocytosis, cell migration, attachment, cell division, cell death

BL402: Genetics Laboratory, Credits – 2

1. Introduction to a model genetic system: Drosophila and demonstration of laws of inheritance
2. Demonstration of linkage and crossing over through genetic crosses
3. Squash preparation of polytene chromosomes from Drosophila larvae
4. Induction and characterization of insertional mutations in Drosophila
5. Mutation Detection- Sequencing, RFLP, insertion-deletion, VNTR, AFLP
6. Karyotyping of Human chromosomes
7. Banding Techniques
8. Pedigree Analysis
9. FISH
10. PLANT EXPERIMENT (chi square test)

General Course **4 Credits**

Semester 5

B501: Physiology I (Animal Physiology), Credits – 4

1. Overview of animal anatomy and body plan
2. Fundamentals of animal physiology

3. Homeostasis
4. Biomembranes & transport across membrane
5. Membrane potential
6. Neurophysiology
7. Sensory physiology
8. Physiology of muscle
9. Cardiovascular systems or cardiac physiology
10. Respiratory system access animal phyla & gas exchange
11. Excretory systems
12. Osmoregulation
13. Fluid and acid base balance
14. Digestive system
15. Endocrine system
16. Reproductive system
17. Lymphatics and immune system

Recommended Book:-
"Animal Physiology", *Hill R, Wise G A & Anderson M Sinauer*.

B502: Physiology II (Plant Physiology), Credits - 4
1. Gross anatomy of plants and Plant Cell architecture
2. Transpiration
3. Mendelian Genetics
4. Plant transformation
4. Photosynthesis
5. Respiration
6. Protein trafficking in plants,
7. Macromolecular complexes in plants
8. Gene expression and trangene Silencing mechanisms in plant
9. Phytochrome, Photomorphogenesis
10. Cryptochromes, Phtotrophins and UV light responses
11. Plant growth regulators: auxins, gibberellins, cytokinins, ethylene abscisic acid
12. Plant photoreceptors and light signaling in plants
13. Control of flowering time
14. Ethylene signaling and fruit ripening
15. Stress response in plants
16. Plant pathogen interaction, Symbiosis vs. Parasitic
17. Leaf Senescence
18. Medicinal plants and its importance

Recommended Books:-
"Plant Physiology" by Taiz & Zeiger Sinaue,
"Plant Physiology" by Salisbury and Ross

B503/BE03: Neurobiology, Credits – 4 (to be developed)

BL501: Physiology I (Animal Physiology) Laboratory, Credits – 2 (to be developed)

BL 502: Physiology II lab (Plant Physiology), Credits - 2
1. To study the phenomenon of plasmolysis
2. Measurement of imbibitions

3. Measurement of transpiration by using photometer
4. To compare the rate of photosynthesis under different environmental condition
5. Quantification of pigment content in leaves.
6. Measurement of Chl a fluorescence
7. Isolation and quantification of anthocyanin components in plants.
8. Isolation of chloroplast and observation of absorption spectra
9. Phototropism
10. Genetic control of light signaling: Photoreceptor mutants and Over-expressors
11. Purification of plant nuclei and observation of Phytochrome nuclear complexes in them.
12. Genetic control of Flowering time : mutants in this pathways

Recommended Books:-

"Experimental Plant Physiology" by Joseph Arditti and Arnold Dunn
"Human Anatomy and Physiology Laboratory Mannual" by Elaine and Blinda

EB501: Elective course (Principles of Drug design), Credits - 4

1. Introduction to the Drug Discovery
2. Drug Development
3. Source of Drugs
4. Pharmacology of drug action
5. Identification of target for drug discovery
6. Approaches towards drug design
7. Computer-aided drug design
8. High throughput technologies in drug discovery

Reference Books

a. Principles of Drug Action: The Basis of Pharmacology. William B. Pratt, Palmer Taylor.
b. High-Throughput Screening in Drug Discovery (Methods and Principles in Medicinal Chemistry). Jörg Hüser, Raimund Mannhold, Hugo Kubinyi, Gerd Folkers.
c. Drug Design: Structure- and Ligand-Based Approaches. Kenneth M. Merz, Dagmar Ringe, Charles H. Reynolds.

Semester 6

B601/BEO4: Molecular Biology, Credits – 4

1. Molecular biology an overview
2. Discovery of DNA as genetic material.
3. Structure of DNA
4. RNAs and their structure & function
5. Chromosomes, chromatin and function
6. Replication of DNA
7. Mutations and their consequences
8. Repair of DNA
9. Recombination
10. Transposons & retroposons
11. Transcription
12. Translation
13. Genetic code

Recommended Books:

"Molecular Biology of Gene" 6th Edition By Watson
"Gene X" By Lewin

B602: Immunology, Credits – 4

1. Overview of the Immune system
2. Cells and organs of the immune system
3. Innate immunity
4. Adaptive immunity
5. MHC, Antigen processing & presentation
6. Cell mediated Immunity: T cell response and its diversity.
7. Humoral Immunity: B cell response and its diversity.
8. Cytokines and Chemokines
9. Self Non-self immune response
10. Altered Immune response and disease pathology: Autoimmunity,
11. Transplantation Immunity, Tumor Immunity, Infection Immunity.
12. Translational Immunology: Animal models, Vaccine and Immunotherapy

Recommended 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

B603/BEO4: Structural Biology, Credits - 4

1. **Introduction to Structural Biology:** Scope and definition of Structural Biology.
2. **Methodologies:**
3. **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.
4. **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 interations; van der Waals interactions; hydrogen bonds; hydrophobic interactions; distortional energies; description of various interactions by potential functions; principles of minimization of conformational energy.

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

BL601: Molecular Biology Laboratory, Credits - 2

1. Plasmid DNA isolation by alkaline lysis method
2. Analysis of DNA gyrase and topoisomerase properties.
3. Confirmation of DNA fragment by Southern Hybridization.
4. In-vitro transcription of tRNA and ribozyme treatment.
5. Expression and purification of "tRNA synthetase" and RNA polymerase.
6. Interaction studies by Biacore.
7. Protein translation in wheat germ extract, Protein synthesis inhibitor.

BL602: Immunology Laboratory, Credits - 2

1. Maintenance of T cell and Macrophage cell line

2. Isolation and characterization of lymphocytes from human blood samples and mouse spleen cells
3. Microscopic estimation of dead and live lymphocytes; T cell and Macrophage cell lines
4. Estimation of antigen content by ELISA
5. Immuno-diffusion
6. Immuno- fluorescence staining of lymphocytes and cell lines
7. Flow Cytometric analysis of lymphocytes, cell lines
8. *In vitro* Immune assay(s) with T cell line, Macrophage cell line and lymphocytes

EB601: Elective course (Enzymology), Credits - 4

1. General properties of enzymes
2. Enzyme nomenclature
3. Activation energy and reaction coordinates
4. Denaturation of Enzyme
5. Enzyme purification
6. Enzyme kinetics: Michaelis Menten Equation, Line-Weaver Burk plot
7. Enzyme catalytic mechanism: Acid-Base catalysis, covalent catalysis, Metal ion catalysis
8. Enzymes in food technology
9. Immobilization of enzyme, biosensor, Bioreactor
10. Stucture and function of specific enzymes: Lysozyme, serine protease
11. Enzyme inhibition: Competitive inhibition, non-competitive inhibition, uncompetitive inhibition
12. Allosteric regulation of enzyme activity: Carbonic anhydrase, Chymotrypsin, ATCase
13. Allosteric enzyme inhibition

Recommended Books: -

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

Semester 7

B701: Genetic Engineering, Credits – 4

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

18. Transgenic plants
19. Transgenic animals
20. Other transgenic life forms
21. Ethics and economics of GM crops and GM organisms

Recommended Books:-
"Genetic Engineering" by *Reece*

B702: Developmental Biology, Credits – 4
1. 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
2. Early embryonic development
    - Gametogenesis
    - Fertilization
    - Cleavage
    - Gastrulation
3. 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
    - Developmental biology of plants: Seed Germination, Hormonal control of seed germination, Plant growth regulators Auxin , cytokinin and GA, Plant cell division, Meristem development and patterning, Root development, Leaf development, Flower development, Stomata development and patterning, Homeotic genes and its role in Development
4.Later embryonic development
    - Patterning in Central nervous system
    - Ectoderm
    - Mesoderm
    - Endoderm
5.Post embryonic development
    - Sex determination in Drosophila, mammals and other species
    - Regeneration
    - Aging & Senescence
6.Implications of Developmental Biology
    - Medical implications
    - Cancer as a developmental disease
    - Environmental regulation and development
    - Developmental mechanisms and evolutionary change

Recommended Books:-
"Developmental biology" by *Scott Gilbert*
"Principles of Development" by *Lewis Wolpert*

BL701: Genetic Engineering Laboratory, Credits – 2

1. Primer designing
2. PCR
3. Gene cloning- Vector and host selection, ligation of transgene in vector, preparation of competent cells, transformation of *E. coli*.
4. Selection methods for transformed cells
5. Nucleic acid sequencing
6. Growth and maintenance of animal cells
7. Transfection in higher eukaryotic cells
8. Expression analysis using real time PCR and western blotting

BL702: Developmental Biology Laboratory, Credits – 2

1. Study of an invertebrate model of Development: Drosophila
2. "Find it, Block it, Move it" experiments
3. Study of Homeotic mutants of Drosophila
4. Study of a vertebrate model of Development: Chick
5. Effect of auxin on abscission and its role on root inhibition.
6. Effect of Gibberellins on plant development
7. Changes of protein profile by hormones

EB701: Advanced/Elective course (Cell Biology), Credits - 4

Understanding cellular structure and function

Part A: <u>Understanding the cell</u>

1) Various cell types as model systems
2) Different sub-cellular structures and their function
3) Ultra structure of subcellular organelles
4) Others

Part B) <u>Microscopy as tools for understanding cellular structure function</u>

1) Biological sample preparation. Difficulties and advancements
2) Various fluorescence proteins and their applications
3) Other fluorescence probes
4) Autofluorescence and its application
5) Others

Part C) <u>Principle, uniqueness and application of different microscopes</u>

1) Fluorescence microscope
2) Phase contrast microscope,
3) DIC microscope
4) Confocal microscope, Spectral detection
5) Total internal reflection fluorescence microscope (TIRF),
6) Electron microscope,
7) Atomic force microscope,
8) Others

Part D) <u>Application of microscopes</u>

1) Live cell imaging difficulties and advantages
2) FLIM application
3) FRET
4) FRAP
5) Photo-activation
6) Metal imaging
7) Others

Part E) <u>Understanding cellular dynamics</u>

a) Cell division
b) Cytoskeletal reorganization, microtubule and actin cytoskeleton
c) Vesicle trafficking and recycling, endocytosis and exocytosis
d) Nuclear dynamics
e) Efflux and influx of ions and others
e) Others

Part F) <u>Super resolution</u>

a) STED
b) PALM
c) STROM
d) Others

EB702: Advanced/Elective course (Biotechniques), Credits - 4

1. Techniques use in DNA characterization: Construction of genomic & cDNA library; Agarose gel electrophoresis; Northern blotting; Southern blotting; RFLP; AFLP; microarray.
2. Techniques use in DNA manipulations: PCR and its application; Restriction digestion; Ligation; Site directed mutagenesis.
3. Enzymes used in genetic engineering experiments: DNA polymerases; Ligase; Reverse transcriptase; Restriction endonucleases and other enzymes.
4. 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.
5. Spectrophotometry (UV-Vis, CD, Fluorescence).
6. Principles of Centrifugation.
7. Uses of radioactive isotopes and autoradiography.
8. Biophysical techniques: X-ray crystallography; NMR; ORD.
9. Principals of chromatography: Ion exchange; Gel filtration; Affinity; Reverse flow; HPLC
10. Immunological techniques: Generation of hybridoma and production of Ab; FACS; ELISA.
11. Microscopy (light, Fluorescence, UV, Atomic absorption; Confocal).
12. Cell culture and developmental biology techniques (FISH); Genetic crosses in model organism.

Recommended Books:

"Immunology Laboratory Mannual" *by Myers and Richard L*
"Molecular Cloning" *by Sambrook and Russel*
"Genetic Engineering" by *Reece*

<u>Semester – 8</u>

B801: Bioinformatics & Computational Biology, Credits – 4

1. Introduction to bio-informatics
2. Databases and Database searching
3. Locating Coding regions
4. Algorithms behind pairwise sequence alignments
5. Multiple sequence alignments
6. Phylogenetic tree construction and different approaches

7. Pattern matching/position specific scoring matrices
8. Structural Bio informatics
9. Introduction to Homology modeling and Drug design
10. Systems Biology

BL801: Bioinformatics Lab. Credits – 2

1. Introduction to LINUX computing platform
2. PERL scripting
3. Database mining
4. Multiple sequence alignment
5. Molecular evolutionary phylogenetic inference
6. DNA fragment contig assembly
7. Restriction enzyme mapping
8. Structure database
9. Molecular modeling and visualization

Recommended Books:-

Beginning PERL in Bioinformatics. O'Reilly Media.
Sequence and genome analysis. David Mount.
Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis

B802: Evolutionary Biology, Credits – 4

1. Introduction to evolutionary Biology
2. Classification, Phylogeny & the tree of life
3. Patterns of evolution
4. Evolution & fossil record
5. History of life on earth
6. Geography of evolution
7. Evolution of biodiversity
8. Genetic variation
9. Phenotypic variation
10. Genetic drift
11. Natural selection and adaptation
12. Genetic theory of natural selection
13. Evolution of phenotypic traits
14. Conflict and cooperation
15. Species and speciation
16. Reproductive success
17. Co-evolution- interactions amongst species
18. Evolution of genes and genomics
19. Evolution and development
20. Macroevolution
21. Evolution & society
22. Human evolution

Recommended Book:

"Evolution" by *D. J. Futuyma*.

EB801: Advanced/Elective course (Biochemistry), Credits - 4

1. Protein secretion
2. Protein folding: In vivo - In vitro
3. Conditional enzyme kinetics

4. Post translational modification
5. Protein degradation

EB802: Advanced/Elective course (Microbiology), Credits - 4

1. Molecular microbial genetics
2. Molecular medical microbiology: microbial pathogenesis & infectious diseases, study of selected pathogenic organisms with emphasis on recent insights into their mechanism of pathogenesis
3. Environmental microbiology
4. Microbial interactions

Semester - 9

EB901: Advanced/Elective course (Molecular biology), Credits - 4

1. Gene regulation in Prokaryotes
2. Gene regulation in Eukaryotes (RNA splicing, RNAi, P bodies)
3. Gene regulation during development
4. Genomic & evolution of diversity
5. Antibody diversity, Immunoglobulin & T cell regulation, gene rearrangements.

Recommended Books:

"Molecular Biology of Gene" 6th Edition By Watson
"Gene X" By Lewin
"Translational Control in Biology and Medicine" By Michael B. Mathews, Nahum Sonenberg, John W.B. Hershey. CSH press
"Prokaryotic Gene Expression (Frontiers in Molecular Biology)" Oxford University Press, USA; First edition (July 29, 1999)

EB902: Advanced/Elective course (Immunology), Credits - 4

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

Recommended Books:

1. Kuby IMMUNOLGY 6^{th} 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

Semester - 10

EB 1001 Elective course (Infectious Disease Biology) (to be developed) 4 Credits
EB 1002 Elective course (Cancer Biology) (to be developed) 4 Credits