

BIOLOGY SYLLABUS FOR INTEGRATED M.SC COURSE - NISER

Semester 1

B 101 Biology I (Organismic Biology and Cell Biology)
BL101 Biology Laboratory

Semester 2

B 201 Biology II (Molecules of living systems)
BL201 Biology Laboratory

Semester 3

B 301 Cell Biology
B 302 Microbiology
B 303 Biochemistry
EO 1 Catalysis
BL 301 Microbiology & Cell Biology Lab
BL 302 Biochemistry & instrumentation Lab

Semester 4

B 401 Plant physiology
B 402 Animal physiology
B 403 Genetics
EO 2 Mathematical Biology
BL 401 Plant & animal physiology lab
BL 402 Genetics & instrumentation lab

Semester 5

B 501 Molecular Biology
B 502 Immunology
B 503 Developmental Biology
EO 3 Radiation biology & medical physics
BL 501 Molecular Biology lab
BL 502 Immunology lab

Semester 6

B 601 Genetic engineering
B 602 Biophysics and structural biology
B 603 Computational biology and bioinformatics
EO 4 Chemical biology
BL 601 Genetic engineering lab
BL 602 Bioinformatics lab

Semester 7

B 701 Evolutionary biology
B 702 Ecology
Elective courses (2 nos)
Project Work

Semester 8

Only Electives (3 nos)
Project Work

Semester 9

Dissertation project
Seminar course
Optional elective

Semester 10

Dissertation project
Journal Club
Optional elective

B101 Biology I

(Credits: 3)

A. Organismic Biology

Origin of life, chemical evolution and theories of origin of life
Diversity of biological species
Evolution of biological species
Classic experiments in biology
Interface of biology and physical sciences

B. Cell Biology

Prokaryotic & eukaryotic cells, plant and animal cells
Cell wall of bacteria, plant and fungal cells
Structure of cell membrane, cytoskeleton
Nucleus and nuclear components – structure & function
Cell division, cell cycle

BL 101 Biology Practical I

(Credits: 2)

Microtomy - sectioning of plant animal tissue, staining, histological observations, preparation and preservation of slides. Use of microscope, Comparative anatomy using stored specimens and deduction of evolutionary relationship. Cell homogenization and isolation of protein, DNA and RNA

B201 Biology II

(Credits: 3)

Molecules of Living systems

Water, chemical and physical properties, dissociation constant, PK_a , p^H , buffer, buffering capacity
Carbohydrates- classification
Amino acids and proteins: types, zwitter ionic forms, peptide bonds, proteins – primary, secondary and tertiary structures, functions
Nucleic acids – physical, chemical properties, basic units, types.
Lipids – classification, fats, fatty acids.
Other biologically relevant molecules such as vitamins, hormones, trace elements.

BL 201 Biology Practical II

(Credits: 2)

Biochemical analysis of protein, DNA, RNA, carbohydrate and lipids. Paper and thin layer chromatography, Electrophoresis of proteins & DNA.

B301 Cell Biology

(Credits-4)

1. Overview of Cell biology
2. Universal features of cells
3. Diversity of genomes
4. Overview of cell chemistry
5. Visualization of cell, its fine structure and molecules
6. The cell membrane and its structure
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 its genetic system
12. Cell signaling, receptor, ligands, signaling pathways

13. Cytoskeleton of cells, cytoskeleton filaments, molecular motors
14. Cell cycle
15. Cell division- Mitosis, meiosis and the mechanism of cell division
16. Germ cells
17. Stem cells
18. Cancer cells
19. Necrotic & Apoptotic cell death

Recommended Books:-

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

B302 Microbiology

(Credits-4)

1. Overview of Microbial world & development Microbiology as a science
2. Isolation, characterization & growth of microorganisms & control of microbial growth (disinfection & sterilization)
3. Gross and time structure of bacteria, viruses and eukaryotic Microbes
4. Microbial nutrition and physiology
5. Microbial genetics
6. Microbial evolution and taxonomy
7. Microbial ecology, associations and environmental microbiology
8. Industrial microbiology- brief over view
9. Microbes in health & disease & host parasite relationship
10. Microbes in Agriculture, microbial diseases of plants & nitrogen fixation.
11. Antibiotics, Antibiotic resistance & their mechanism of action (brief overview)
12. Selected organisms: (*E.coli*, *M.tuberculosis*, *S. cerevisiae*, Cyanobacteria, Plasmodium, Pox Virus, Influenza virus & λ phage)
13. Prions: a non-microbial infectious agent
14. Genetically modified organisms

Recommended Books:-

"Brock Biology of Micro-organisms 10e" Michael M. Madigan, John Martinko, Jack Parker.

B303 BIOCHEMISTRY

(Credits-4)

1. Overview of Biochemistry
2. Amino acids and proteins
3. Carbohydrates
4. Nucleotides and nucleic acids
5. Lipids
6. Vitamins
7. Hormones
8. Protein structure, folding, modification, targeting & degradation
9. Protein function: - enzymes, enzyme kinetics, enzyme regulation and inhibition
10. Metabolism and metabolic pathways
11. Glycolysis
12. TCA cycle
13. Oxidative Phosphorylation
14. Photophosphorylation
15. Fatty acid degradation
16. Carbohydrate biosynthesis (Pentose phosphate pathway)
17. Fatty acid synthesis
18. Cholesterol of steroid biogenesis
19. Amino acid biosynthesis & degradation
20. Nucleotide biosynthesis & degradation
21. Membrane structure function & transport across membrane
22. Biochemistry of signal transduction
23. Biochemistry of hormone action

Recommended Books:-

Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson (Author),
Michael M. Cox (Author)

B401 Plant anatomy & physiology

(Credits-4)

1. Overview of plant kingdom
2. Gross anatomy of plants
3. Plant cell architecture
4. Water & plant cells
5. Water balance of plants
6. Mineral nutrition
7. Transport of nutrients
8. Photosynthesis
9. Phloem translocation
10. Respiration
11. Nutrient assimilation
12. Gene expression and signal transduction
13. Cell walls: structure & biosynthesis
14. Senescence & programmed cell death
15. Phytochrome, photomorphogenesis
16. Blue light responses
17. Plant growth regulator: auxins, gibberellins, cytokinins, ethylene abscisic acid
18. Control of flowering and physiology of plant reproduction, fruit ripening
19. Stress physiology and stress resistance
20. Plant pathogen interaction

Recommended Books:-

"Plant Physiology" Taiz & Zeiger Sinauer.

B402 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 across 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 Books:-

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

B403 Genetics

(Credits- 4)

1. Introduction and overview of genetics
2. Information transfer DNA-RNA-Protein/genotype & phenotype

3. Eukaryotics & Prokaryotic genes, Pseudogenes
4. Cell division- mitosis & meiosis
5. Model genetic systems
6. Mutation, mutagenesis & mutant selection
7. Mendelian inheritance
8. Alleles, Complementation
9. Deviation from mendelian inheritance, Linkage & Sex-linked inheritance
10. Recombination, recombination mapping and mechanism off recombination
11. Gene expression and its characterization
12. Gene function and phenotype loss of function & gain of function
13. Gene interaction – suppressors & enhancers redundancy & epistasis
14. Bacterial gene regulation
15. λ phage
16. Eukaryotic gene regulation
17. Epigenesis
18. Reverse genetics, genomes and genomics
19. Elements of human genetics & genetic disorders
20. Population genetics
21. Immunogenetics
22. Genes and Evolution

Recommended Books:-

Principles of Genetics, by Eldon J. Gardner (Author), D.Peter Snustad (Editor), Michael J. Simmons (Editor)

B501 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. RNA processing and RNA splicing
13. Translation
14. Genetic code
15. Gene regulation in Prokaryotes
16. Gene regulation in Eukaryotes
17. Gene regulation during development
18. Genomic & evolution of diversity
19. Model organisms

Recommended Books:-

“Text Molecular Biology of the gene” by *Watson et.al Pearson.*

B502 Immunology

(Credits-4)

1. Overview of the Immune system
2. Cells and organs of the immune system
3. Antigens
4. Innate immunity
5. Adaptive immune response
6. Immunoglobulins- structure and function

7. Immunoglobulin genes- Organization and rearrangement
8. Antibody diversity
9. Antigen antibody reactions
10. MHC (antigens and genes)
11. Antigen processing & presentation
12. T cell receptors, T cell receptor genes & gene rearrangements
13. T cell maturation, activation & differentiation
14. B cell generation, activation & development
15. Self Non-self discrimination (mechanism)
16. Clonal selection theory & idiotypic network hypothesis
17. Cytokines
18. The complement system
19. Cell mediated effector response
20. Leukocyte migration and inflammation
21. Hypersensitive reactions
22. Immune regulation
23. Immune response to infectious organisms
24. Vaccines
25. Immunodeficiency diseases (AIDS)
26. Autoimmunity
27. Transplantation immunology
28. Tumour immunology
29. Immunotechnology
30. Animal models

Recommended Books:-

"Kuby Immunology" by *Goldsby, Kindt, and Osborne*

B503 Developmental Biology

(Credits-4)

1. Development Biology: Overview
2. Developmental genetics
3. Cell fate determination in *C. elegans*
4. Gametogenesis
5. Fertilization
6. Cleavage
7. Gastrulation
8. Axis formation in amphibian
9. Anterior posterior patterning in amphibians
10. Anterior posterior patterning in drosophila
11. Hox gene and dorsoventral patterning
12. Early mammalian development
13. Left right patterning
14. Plant embryogenesis
15. Patterning in early embryo- plant homeotics in flowers
16. Plant homeotics- overview
17. Patterning in Central nervous system
18. Ectoderm-eye development, epidermis, hair development, neural crest, tooth development and axon guidance
19. Mesoderm- somites, development of muscle, bone, kidney, heart and vessels, formation of limbs
20. Endoderm
21. Sex determination in Drosophila, mammals and other species
22. Regeneration
23. Environmental regulation and development
24. Aging & Senescence
25. Infertility

26. Cancer as a developmental disease
27. Death and the end of development

Recommended Books:-

"Developmental biology" by *Scott Gilbert*

B601 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

B602 Biophysics and structural biology

(Credits-4)

STRUCTURE: Scope and definition of Biophysics. Biophysics at macroscopic, microscopic level and at the molecular level. Biophysical Chemistry: structure of atoms, molecules; energy, structure of atoms and molecules, elementary quantum mechanics, stereochemistry, molecular orbitals & chirality.

PHYSICAL INSTRUMENTS AND METHODS IN BIOLOGY: Diffusion, sedimentation, electrophoresis, separation techniques, Biomolecular structure determination using X-ray diffraction, electron microscopy, IR - Raman and laser spectrometry, UV-visible spectroscopy, CD, ORD, NMR, model building, computer simulation and graphics.

MACROMOLECULAR STRUCTURE: Structure of proteins. 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.

PRINCIPLES OF PROTEIN STRUCTURE: Structural implications of the peptide bond; rigid planar peptide unit; cis and trans configuration; conformations of a pair of linked peptide units;

torsion angles phi and psi -steric hindrance; hardsphere approximation; allowed and disallowed conformations; Ramachandran Diagram; conformational maps for glycine and other natural amino acids; conformationally constrained amino acids and their importance.

THE NERVOUS SYSTEM: Membrane potentials; origins of membrane potential; electrochemical potentials; Donnan equilibrium; Nernst equation; Goldman equation. Membrane transport; diffusion; facilitated diffusion; membrane transport proteins; carrier mediated transport; channel mediated transport.

RADIATION PHYSICS: Radiation Quantities; units and definitions; Radiation measurement; Radiation Biology of Normal tissue system; Biological effects of ionizing radiation; structural changes in chromosomes; Gene mutation; metabolism and biological effects of radionuclide; Radiation hazards; Evaluation control and regulatory aspects of radiological safety; disposal of radioactive waste; Physics of laser - different types of lasers - biomedical applications -C.T.scan - ultra sonography. NMR Imaging – Principles – Applications.

COMPUTERS IN BIOLOGY: Use of computers in sequence analysis and structure analysis – sequence projects structure projects – definitions– structural and functional genomics. The digital nature of biological information – elements of molecular biology – the transfer of information in biological systems –representation of biological molecules as strings of symbols – correspondences to other branches of computation, including computational linguistics, pattern recognition, image processing, etc. Elements of computer science – hardware – software – hierarchies in software –operating systems and application software – algorithms and computational complexity –examples – travelling salesman problem – protein folding problem – the internet.

DATABASES AND ALGORITHMS FOR ANALYSIS OF SEQUENCE: Computer databases – bio molecular databases – sequence databases – structural databases – details of organisation, access and deposition – derived and specialised databases - data mining -homology v/s similarity – dot matrices – sequence comparison using Needleman and Wunsch method – Hash coding – BLAST and FASTA – Structure analysis – distance matrices –examples.

CRYSTALLOGRAPHY: External features and symmetry – unit cell and Miller indices – seven crystal systems – Bravais lattices – point groups and space groups – X-ray diffraction – Bragg's law –Generation, detection and properties of X-rays-choice of radiation, synchrotron radiation Powder photographs – interpretation of powder photograph – ASTM index. Theory of diffraction by helical structures and application to alpha-helix and DNA.

Recommended Books:-

1. Introductory Biophysics , V. Pattabhi & N. Gautham, Narosa Publications (1999).
2. Radiation Biophysics, E. L. Alpen, Prentice-Hall, New Jersey, USA, (1990).
3. Introduction to Bioinformatics. T.K. Attwood and D.J. Parry-Smith, Addison Wesley Longman Ltd. (1999).
4. Bioinformatics – Data bases and Algorithms N. Gautham, Narosa Publications (2006).
5. X-ray Structure Determination, G.H. Stout and L.H. Jensen, John Wiley and Sons Inc., New York (1989).
6. The Basics of Crystallography & Diffraction, C. Hammond, IUCr – Oxford University Press (1997).

B603 Computational Biology & Bioinformatics

(Credits-4)

1. Introduction to computational biology & bioinformatics
2. Genomics & proteomics
3. Database searching
4. Multiple sequencing alignment & Database making
5. Phylogenetics

6. Comparative genomics
7. Locating coding regions
8. Pattern matching/position specific scoring matrices
9. Proteomics & mass spectrometry
10. Hidden Markov Model
11. Gene patenting
12. Biomarker discovery for clinical mass spectra
13. Protein structure
14. Structure bioinformatics (Homology modeling)
15. Molecular dynamics
16. Spatially realistic computational physiology
17. Drug design
18. Vaccine design
19. Human Genome Project
20. System Biology

Recommended Books:-

Compulsory-

1. **Introduction to Bioinformatics** by Arthur M. Lesk, University of Cambridge.

Optional-

2. Learning the UNIX Operating System, Fifth Edition by Peek, Jerry; Todino- Gouquet, Grace; Strang, John.
3. Beginning Perl for Bioinformatics, 1st edition by O'Reilly & Associates, Inc. Sebastopol, CA, USA.

B701 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 Books:-

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

B702 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:-

“Ecology-Principles and Applications” by Chapman and Reiss Cambridge

Biology Practical

- BL 101 Biology Practical I
- BL 201 Biology Practical II
- BL301 Microbiology & Cell Biology laboratory
- BL302 Biochemistry & instrumentation laboratory
- BL401 Plant & animal laboratory
- BL402 Genetics & instrumentation lab
- BL501 Molecular biology laboratory
- BL502 Immunology lab
- BL601 Genetic engineering lab
- BL602 Bioinformatics laboratory

Electives (Details to be worked out later)

1. Mathematical biology
2. Virology
3. Neurobiology
4. Advanced Immunology
5. Conservation Biology
5. Genomics & Proteomics
6. Molecular Evolution
7. Animal Behavior
8. Endocrinology
9. Bio-nanotechnology
10. Molecular Medicine
11. Cell signaling
12. Stem Cell Biology & Regenerative Medicine

13. Enzymology
 14. Systems Biology
 15. Ecosystem & Modeling
 16. Cancer Biology
 17. Infection Biology
 18. Bio safety
 19. Intellectual property Rights
 20. Vaccinology
 21. Radiation biology & medical physics
 22. Chemical biology
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