

SCHOOL OF BIOLOGICAL SCIENCES

NATIONAL INSTITUTE OF SCIENCE

EDUCATION AND RESEARCH

BHUBANESWAR

SYLLABUS FOR Ph.D PROGRAMME

Ph.D Programme in Biological Sciences

Minimum Essential qualification for entry into the programme

- **Masters in any branches of Biological Sciences including Agriculture, Bioinformatics, Biotechnology, Fisheries, Veterinary sciences and other equivalent courses**
- **Masters in Chemistry/ Physics/ Mathematics**

Candidates must qualify in one of the following National Level Eligibility Test such as NET (CSIR-UGC), ICMR, DBT, ICAR, GATE etc. or Tests conducted by NISER for admission to its Ph.D Programme

The minimum cut-off marks as per NISER norms.

Research training as per the allotted syllabus of School of Biological Sciences.

Research credits-as per NISER norms.

The final selection of the candidates for PhD training will be made after an in-depth comprehensive examination through departmental personal interview or written test or both.

SCHOOL OF BIOLOGICAL SCIENCES

Syllabus for PhD Course

Number of Compulsory courses: 3 (4 credits each)

Number of Elective courses : 3 (4 credits each)

Total Number of Courses : 6 (4 credits each)*

Seminar & Journal Club : For all Semesters and compulsory for all students.

Laboratory Research work : To be carried out simultaneously along with course work.

***A student may opt for more than minimum prescribed elective courses as desired by the student & his/ her PhD supervisor**

SEMESTER – I: COMPULSORY COURSES

B1101 – Advanced Molecular Biology

B1102 – Bioinformatics and Computational Biology

B1103 – Biological Techniques: Theory & Practice

SEMESTER – II: ELECTIVE COURSES

A student has to choose at least two elective courses depending on his/ her area of interest for research from a list of courses offered during a particular Semester. It may be noted that the courses offered will depend on the availability of faculty with expertise in a particular area as well as critical number of students opting for the course. It is also proposed that some of the elective courses offered may be common for both PhD and MSc scholars/ students and/or may be shared between two Schools in an interdisciplinary approach. The School will retain authority to make the final decisions in this regard depending on the individual need of the student.

B1201 – Mathematics, Statistics & Informatics for Biologists

B1202 - Advanced Biochemistry

B1203 - Advanced Microbiology

B1204 – Infectious Disease Biology

B1205 – Evolutionary Biology

B1206- Ecology

B1207 – Structural Biology & Biophysics

B1208 - Plant Molecular Biology

B1209 – Cell Biology

B1210 - Spectroscopy

B1211 – Advanced Immunology

B1212 - Enzymology

B1213 - Virology

B1214 - Stem Cell Biology and Regenerative Medicine

B1215 – Neurobiology

B1216 - Cancer Biology

B1217 - Vaccinology

B1218 - Protein Chemistry

B1219 - Genomics and Proteomics
B1220 - Endocrinology
B1221 - Human Genetics
B1222- Molecular Medicine
B1223- Molecular Genetics
B1224- Perspectives in Biological Sciences
B1225– Developmental Biology
B1226– Reproductive Biology

Electives will be offered depending on the availability of faculty in relevant field. New electives will be offered when new faculty with different expertise joins the School of Biology.

The students are expected to give at least one Seminar/ Journal presentation in each Semester.

The details of the following course curriculum will be developed on a later date.

B 1202 Advanced Biochemistry
B 1205 Advanced Bioinformatics & System Biology.
B 1207 Structural Biology & Biophysics
B 1208 Plant Molecular Biology
B 1210 Spectroscopy
B 1214 Stem Cell Biology & Regenerative Medicine
B 1215 Neurobiology
B 1216 Cancer Biology
B 1219 Genomics & Proteomics
B 1221 Human Genetics
B 1224 Perspectives in Biological Sciences
B 1225 Developmental Biology
B 1226 Reproductive Biology

B1101 – Advanced Molecular Biology**(Credits-4)**

DNA and RNAs structure & function; Chromosomes and its arrangements; DNA replication; Mutations and their consequences; DNA repair; DNA recombination; Transposons & retrotransposons; Transcription; RNA processing and RNA splicing; Genetic code; Translation apparatus: initiation, elongation and termination factors, Ribosome structure, tRNA structure; Mechanism of translation in prokaryotes and eukaryotes; Gene regulation & expression in prokaryotes and eukaryotes (RNAi, P bodies); Antibody diversity, Immunoglobulin & T cell regulation, gene rearrangements.

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

Gene IX by *Lewin*

B1102 – Bioinformatics and Computational Biology (B802)**(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

B1103 – Biological Techniques: Theory & Practice**(Credits-4)**

- Techniques use in DNA characterization: Construction of genomic & cDNA library; Agarose gel electrophoresis; Northern blotting; Southern blotting; RFLP; AFLP; microarray.
- Techniques use in DNA manipulations: PCR and its application; Restriction digestion; Ligation; Site directed mutagenesis.
- Enzymes used in genetic engineering experiments: DNA polymerases; Ligase; Reverse transcriptase; Restriction endonucleases and other enzymes.
- Techniques use in protein characterization: SDS-Gel electrophoresis; Western blotting; IEF-2D gel electrophoresis; FRET; Co-Immunoprecipitation; CHIP; Protein-ligand interactions and affinity studies by Surface Plasmon resonance; Density gradient separation.
- Spectrophotometry (UV-Vis, CD, Fluorescence).
- Principles of Centrifugation.
- Uses of radioactive isotopes and autoradiography.
- Biophysical techniques: X-ray crystallography; NMR; ORD.
- Principles of chromatography: Ion exchange; Gel filtration; Affinity; Reverse flow; HPLC.
- Immunological techniques: Generation of hybridoma and production of Ab; FACS; ELISA.

- Microscopy (light, Fluorescence, UV, Atomic absorption; Confocal).
- Cell culture and developmental biology techniques (FISH); Genetic crosses in model organism.

Recommended Books:

Immunology Laboratory Manual” by Myers and Richard L

Molecular Cloning” by Sambrook and Russel

Genetic Engineering” by Reece

B1201: Mathematics, Statistics and Informatics for Biologists (Credits-4)

- Single species and interacting population dynamics,
- Discrete time models, continuous time models, delay effects, age structured models, size structured models.
- Interacting Species Models – Host-parasite interactions, Predator-prey model, competition model, ecosystem model
- Infectious Disease Models - Simple epidemic and SIS diseases, SIR epidemics, age-structured populations, vector-borne diseases.
- Population Genetics and Evolution -Mendelian genetics in populations, selection pressure, balance between mutation and selection, evolution of a genetic system.
- Fundamental concepts in applied probability;
- Exploratory data analysis and statistical inference;
- Probability and analysis of one and two way samples;
- Chi-square test for independence;
- P-value of the statistic;
- Confidence limits;
- Introduction to one way and two-way analysis of variance;
- Data transformations
- Introduction to computational biology & bioinformatics
- Database searching

- Multiple sequencing alignment & Database making
- Comparative genomics
- Locating coding regions
- Pattern matching/position specific scoring matrices
- Proteomics & mass spectrometry
- Hidden Markov Model
- Gene patenting
- Protein structure
- Structure bioinformatics (Homology modeling)
- Molecular dynamics
- Drug design
- Vaccine design

Recommended Books:-

- 1 Introduction to Bioinformatics by Arthur M. Lesk.
- 2 Learning the UNIX Operating System by Peek, Jerry; Todino- Gonguet, Grace; Strang, John.
- 3 Beginning Perl for Bioinformatics, 1st edition by O'Reilly & Associates, Inc. Sebastopol, CA, USA.
- 4 Biostatistics: A foundation for Analysis in the Health Sciences, 8th W.W. Daniel, Edition, Wiley Series in Probability and Statistics.
- 5 Introductory Statistics, P.S. Mann 5th Edition, John Wiley and Sons (Asia).
Mathematical Statistics and Data Analysis, J.A. Rice, 3rd Edition, Duxbury Press.

B1203- Advanced Microbiology

(Credits-4)

- **Prokaryotic and Eukaryotic Microorganisms:** Classification of prokaryotes, General characteristics of various groups of prokaryotes, Ultrastructure of a bacterial cell, General characteristic, structure, classification, life cycles, economic importance of important yeasts, moulds and algae.
- **Molecular Microbiology & Genetics:** Genome organization in bacteria and eukaryotic microorganisms and nucleic acid replication, Gene transfer - transformation, conjugation, transduction and methods of gene mapping, Extra-chromosomal genetic elements and their inheritance, mobile genetic elements and their effect on chromosome structure and gene expression, alternate sigma factors; protein modification and degradation; bacterial two component signaling systems; RNA structure, processing and decay; and DNA modification and rearrangement in gene control, emerging knowledge of sequence databases available and ongoing projects
- **Environmental Microbiology:** Interactions between microorganisms and their environment, methods of sampling various environments, methods for monitoring microbial activities, microbial degradation of petroleum & hydrocarbon, bioremediation, survival of airborne microorganisms, microbial metabolism of selected pollutants such as pesticides & xenobiotics

- **Molecular basis of pathogenesis & infectious diseases:** The molecular mechanisms, by which microorganisms invade hosts & mechanisms available for genetic variability in different intracellular pathogens to defy host immune system, express their genomes, interact with macromolecular pathways in the infected host, and induce disease, bacterial virulence factors, protein and DNA secreting systems and pathogenicity island, Molecular basis of antimicrobial resistance and its detections, Molecular approaches in clinical microbiology, Air and water-borne diseases; sources of environmental pathogens, mode of transmission and disinfection, Molecular diagnostics
- **Industrial microbiology:** Suitability of microbes in industrial processes and their source, types of fermentation's and bioreactors, substrates for industrial fermentations, growth kinetics in batch and continuous fermentation processes, strain improvement, and recent developments in industrial microbiology, production aspects of important industrial products such as alcohols & alcoholic beverages, organic acids, enzymes, SCP, rDNA products etc.

B1204 – Infectious Disease Biology

(Credits- 4)

- Evolutionary Biology of Infectious Diseases
- Host pathogen interactions
- Viral infections
- Bacterial infections
- Parasitic infections
- Host defense & Immunopathology
- Molecular Epidemiology and control of infectious diseases in developing countries

B1205 Evolutionary Biology (B503)

(Credits-4)

- Introduction to evolutionary Biology
- Classification, Phylogeny & the tree of life
- Patterns of evolution
- Evolution & fossil record
- History of life on earth
- Geography of evolution
- Evolution of biodiversity
- Genetic variation
- Phenotypic variation
- Genetic drift
- Natural selection and adaptation
- Genetic theory of natural selection
- Evolution of phenotypic traits
- Conflict and cooperation
- Species and speciation

- Reproductive success
- Co-evolution- interactions amongst species
- Evolution of genes and genomics
- Evolution and development
- Macroevolution
- Evolution & society
- Human evolution

Recommended Books:-

“**Evolution**” by *D. J. Futuyma*.

B1206 Ecology (B303)

(Credits-4)

- Overview of ecology
- Ecological setting: The biogeography of the earth & the climatic zones of the earth
- The individual
- Autecology-single species ecology
- Population and population dynamics
- Regulation of population
- Ecological genetics
- Behavioral ecology
- Sociobiology
- The environment
- Habitats and niches
- Trophic levels
- Energy transfer
- Nutrient cycling and pollution
- Communities
- Ecosystems
- Succession
- Biomes
- Co-evolution
- Conservation
- Human ecology
- Evolution ecology, mass extinction & their reasons
- Climate change
- Ecological studies of Chilka lake, Bhitarkanika biosphere reserves
- Olive Ridley turtle, their nestling ground and their preservation
- Biodiversity and its maintenance

Recommended Books:-

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

“**Fundamentals of Ecology**” by *M. C. Dash*

“**Essentials of Ecology**” by *Townsend C, Begun M and Harper*

B1209 Cell Biology

(Credits-4)

- Universal features of cells
- Diversity of genomes
- Overview of cell chemistry
- Visualization of cell, its fine structure and molecules
- The cell membrane and its structure
- Transport across membrane
- Ion channels
- Cellular compartments and function, protein sorting
- Vesicular traffic inside the cells
- Mitochondria and chloroplast and its genetic system
- Cell signaling, receptor, ligands, signaling pathways
- Cytoskeleton of cells, cytoskeleton filaments, molecular motors
- Cell cycle
- Cell division- Mitosis, meiosis and the mechanism of cell division
- Germ cells
- Stem cells
- Cancer cells
- Necrotic & Apoptotic cell death

Recommended Books:-

“Molecular biology of the Cell” by *Albert et.al*

B1211 Advanced Immunology

(Credits-4)

- Molecular basis of antibody and TCR diversity
- B cell and T cell development and differentiation
- Signal transduction in immune system
- Innate immunity and TLRs
- Autoimmunity and autoimmune disorders
- Biochemistry of complement cascade
- Antigen presentation
- Histocompatibility antigen and genetic basis of its polymorphism
- Cell adhesion molecules
- Regulatory T cells and Immunoregulation
- Antibody engineering
- Analytical methods in immunology
- Immunoinformatics
- Immunodeficiency disorders

Recommended Books: -

1. **“Fundamentals of Immunology”** by *William E. Paul*
2. **Journals:** *Trends in Immunology and Nature Review Immunology*

B1212 Enzymology

(Credits-4)

- General properties of enzymes
- Enzyme nomenclature
- Activation energy and reaction coordinates
- Denaturation of Enzyme
- Enzyme purification
- Enzyme kinetics: Michaelis Menten Equation, Line-Weaver Burk plot
- Enzyme catalytic mechanisms
- Enzymes in food technology
- Immobilization of enzyme, biosensor, Bioreactor
- Structure and function of specific enzymes: Lysozyme, serine protease
- Enzyme inhibition: Competitive inhibition, non-competitive inhibition, uncompetitive inhibition
- Allosteric regulation of enzyme activity: Carbonic anhydrase, Chymotrypsin, ATCase
- Allosteric enzyme inhibition

Recommended Books: -

- 1. “Fundamentals of Biochemistry”** *by Voet and Voet*
- 2. “Biochemistry”** *by JM Berg, JL Tymoczko, L Stryer*

B1213 Virology

(Credits-4)

- Introduction and history of viruses,
- General properties of viruses,
- Replication mechanism of viruses,
- Genetics of viruses,
- Virus-cell interaction,
- Cell transformation by viruses,
- Resistance of virus infection,
- Pathogenesis of virus infection,
- Evolution of viruses,
- Epidemiology of virus infection,
- Antiviral chemotherapy,
- Immunization against viral diseases,
- Virus vector and their replication,
- Resurgent and emergence of viral diseases,
- Viral diagnosis,
- Plant viruses,
- Insect viruses,
- Bacterial viruses,
- Specific viruses
 - i) Orthomyxoviruses & Influenza viruses,
 - ii) Gastroenteritis viruses,
 - iii) Aphanizygotes,
 - iv) Hepatitisviruses,
 - v) HIV and AIDS,
 - vi) Tumor viruses,
 - vii) Arthropod borne viruses,
 - viii) Exotic viruses.

Recommended Text Book:

- 1) **Human virology** by Leslie Collier & John Oxford, 3rd Edn. Oxford University Press, 2006
- 2) **Basic Virology** by EK Wagner & MJ Hewitt 2nd Edn. Blackwell Scientific Inc, 2005.

Reference Book:

1. **Field's Virology**, Edited by David M. Knipe et al., 5th Edition, Lippincott, Williams & Wilkins. 2007.

B1217 Vaccinology

(Credits-4)

- Innate Immunity, Activation in of the Innate Immunity through TLR mediated signaling
- Adaptive Immunity, T and B cells in adaptive immunity
- Immune response in infection, Protective immune response in bacterial, viral and parasitic infections, Correlates of protection
- Vaccination and immune response
- Appropriate and inappropriate immune response during infection
- CD4+ and CD8+ memory T cells, Memory B cells, Generation and Maintenance of memory T and B cells, Dendritic cells in immune response
- Adjuvants in Vaccination, Microbial, Liposomal and Microparticles as adjuvant
- Induction of Th1 and Th2 responses by using appropriate adjuvants
- Chemokines and cytokines, Role of soluble mediators in vaccination
- Oral immunization and mucosal Immunity
- Conventional vaccines, Bacterial vaccines, Live attenuated and inactivated vaccine, Subunit Vaccines and Toxoids, Peptide Vaccine
- New Vaccine Technologies, Rationally designed Vaccines
- DNA Vaccination, Mucosal vaccination
- New approaches for vaccine delivery
- Engineering virus vectors for vaccination
- Vaccines for specific targets: Tuberculosis Vaccine, Malaria Vaccine, HIV vaccine

Recommended Books: -

1. **“Immunology”** by *Goldsby, Kindt, and Osborne*
2. **“Novel Vaccination Strategies”** Edited by Stefan H.E. Kaufmann
3. **Topley & Wilson’s Microbiology and Microbial Infections Immunology.** Edited by Stefan H.E. Kaufmann and Michael W Steward Holder Arnold
4. **Immuno Biology, The Immune system in health and Disease,** 6th Edition, Charles A Janeway. Jr, Paul Travers, Mark Walport and Mark J Shlomchik, Garland Science, New York, 2005

B1218 Protein Chemistry (Common & same as MSc course EB 804)

(Credits 4)

- Peptides and Proteins
- Covalent structure of protein
- Protein secondary structure
- Protein tertiary and quaternary structure
- Protein denaturation
- Protein purification
- Protein Folding
- Reversible binding of protein to a ligand
- Complementary interactions between protein and ligand
- Protein interactions modulated by chemical energy: Actin, Myosin
- Molecular motors
- Glycoprotein
- Lipoprotein
- Amino acid sequencing
- Peptide synthesis
- Three dimensional protein structure: X-ray crystallography and NMR spectroscopy
- Nucleoprotein complex
- Membrane protein
- Protein stability
- 2-D gel electrophoresis and protein analysis

Recommended Books: -

1. **“Fundamentals of Biochemistry”** by Voet and Voet
2. **“Biochemistry”** by JM Berg, JL Tymoczko, L Stryer

B1220 Endocrinology

(Credits-4)

- Introduction to endocrine glands, hormones and their classification.
- Hormone biochemistry, mechanism of hormone synthesis and their transport to target organs or tissues.
- Hormone receptors and mechanism of hormone action.
- Methods of measurement of hormones.
- Neuroendocrinology: Neurohormones and Neurotransmitters.
- Hypothalamus and its hormones.
- Structure, function, hormones and clinical disorders of following mammalian endocrine glands. Pituitary, Pineal, Adrenal, Thyroid, Parathyroid, Pancreas, Gonads, Gastro intestinal tract, Thymus
- Endocrine control of sexual differentiation.
- Endocrine control of appetite and feeding.
- Calcium homeostasis: role of PTH, Vitamin D and calcitonin.
- Growth hormone and Insulin like growth factor (IGF)
- Important facts of vertebrate endocrinology.
- Invertebrate endocrinology.
- Environmental endocrinology: endocrine disrupting chemicals.

Recommended Books: -

1. **“Text book of endocrinology”** by *Turner and Bangnara*
2. **“Text book of endocrinology”** by *R.H. Williams*
3. **“General and Comparative Endocrinology”** by *E.J.W. Barrington*
4. **“Comparative vertebrate endocrinology”** by *P.J. Bentley.*

B1222- Molecular Medicine:**(Credits 4)**

- Genetic diseases
- Disease related to defective translation apparatus, proteins expression, degradation and mutations
- Hereditary neurodegenerative diseases
- Genetics of different cancers, telomeres in the development of cancer
- Genomic instability and damage response
- Protein engineering, incorporation of unnatural amino acid and rational drug design
- Use of antibiotics and mechanism of their action
- Gene and stem cell therapies

“Principles of Molecular Medicine” by *Marschall S. Runge, Cam Patterson*

B1223 Molecular Genetics**(Credits 4)**

- Properties and evolution of genetic material, flow of genetic information
- Organization of viral and bacterial genomes
- Eukaryotic genome
- Replication in bacterial and eukaryotic chromosomes
- Transcription, Translation, Regulation of gene expression
- Gene mapping in bacteria: Transformation, Conjugation, Transduction,
- Sexduction Recombination, deletion and complementation mapping in T4 phage, Mutagenesis & DNA repair: origins and types of DNA damage, DNA repair pathways, Error-prone repair and mutagenesis, Damage signaling and checkpoint arrest
- Types of mutations and nomenclature, Detection and isolation of mutations
Recombination: Homologous recombination, Gene conversion, Site specific recombination, Transposons and transposition mechanisms
- Concepts of Human and Developmental genetics

Recommended Books:-

“Genetics: A Conceptual Approach” by *Benjamin*

“Essential Genetics” by *Hartl et. al.*