B. Sc. Genetics and Genomics

(For the examination of 2006 and thereafter)

B. Sc. Part I Genetics and Genomics

There will be three written papers and one practical examination. The following courses are prescribed.

PAPER I Protozoa to Nemathelminthes

Unit I: Protozoa
Unit II: Porifera
Unit III: Coelenterata
Ctenophora
Unit IV: Platyhelminthes
Nemathelminthes

PAPER II Annelida to Echinodermata

Unit I: Annelida
Unit II: Arthropoda
Unit III: Mollusca
Unit IV: Echinodermata

PAPER III Basic Genetics

Unit I: Mendelian Genetics and Developmental Genetics
Unit II: Gene structure and function
Unit III: Regulation of gene expression
Unit IV: Structure and function of cell organelles

B. Sc. Part I

There will be three written papers and one practical examination. The following courses are prescribed.

PAPER I Protozoa to Nemathelminthes

The habits, morphology, physiology, reproduction, development (in outline) and classification of the following groups of animals including a detailed study of the types given in each:

Unit-I

- **Protozoa** - *Euglena*, *Monocystis* and *Paramecium.*

Unit-II

- **Porifera** - *Sycon*

Unit-III

- **Coelenterata** - *Obelia* and *Aurelia*
- **Ctenophora** - Salient features

Unit-IV

- **Platyhelminthes** - *Fasciola* (liver fluke) and *Taenia* (tape worm)
- **Nemathelminthes** - *Ancylostoma* (hook worm)

PAPER II Annelida to Echinodermata

The habits, morphology, physiology, reproduction, development (in outline) and classification of the following groups of animals including a detailed study of the types given in each:

Unit-I

- **Annelida** - *Nereis* and *Hirudinaria* (leech)

Unit-II

- **Arthropoda** - *Palaemon* (prawn) and *Apis* (honeybee)

Unit-III

- **Mollusca** - *Lamellidens* (fresh water mussel) and *Pila* (apple-snail)

Unit-IV

- **Echinodermata** -*Pentaceros* (excluding development)

PAPER III Basic Genetics

Unit-I

Mendelian Genetics and Developmental Genetics

- Mendelism: Mendel's laws, extensions of Mendelism---basis of dominant and recessive mutations, complementation test
- Sex-linked inheritance, linkage and crossing over, cytoplasmic inheritance, maternal effects
- Molecular basis of development, Developmental genes
- Genetic determination of sex in *Caenorhabditis elegans, Drosophila melanogaster* and mammals

Unit-II

Gene structure and function

- Chemical structure and base composition of DNA and RNA, DNA supercoiling, chromatin organization, chromosome structure, polytene and lampbrush chromosomes
- Gene structure, C-value paradox, repetitive sequences, clustered gene families, dosage compensation
- Cell division: mitosis and meiosis
- DNA replication, DNA repair and DNA recombination—homologous recombination, gene conversion, transpositional and meiotic recombination

Unit-III

Regulation of Gene Expression

- Structure and function of nucleus and ribosomes in eukaryotes
- Regulation of gene expression in prokaryotes: *lac* and *trp* operons in *E. coli*
  Regulation of gene expression in eukaryotes:
  - Transcription: regulation, post-transcriptional processing, RNA splicing, RNA editing, RNAi, RNA degradation
  - Translation: regulation, post-translational processing, protein folding, processing and degradation

Unit-IV

Structure and function of cell organelles

- Plasma membrane, Cell-cell interaction, Signal transduction
- Endomembrane system: protein targeting and sorting, endocytosis, exocytosis
- Cytoskeleton: microtubules, microfilaments, intermediate filaments
- Mitochondria: Structure, oxidative phosphorylation

B.Sc. Part I
Genetics and Genomics Practical Syllabus

1. Study of museum specimens and slides of invertebrates

2. Dissection- Pila, *Palaemon*

3. Temporary and Permanent preparations of-

- Spicules of sponges
- Gemmules of sponges
- Hastate plate
- Statocyst of Prawn
- Ovary of earthworm
- Septal nephridia of earthworm
- Setae *in situ*
- Parapodium of Nereis

4. Demonstration of working of different instruments: Microscopes, Centrifuge, Electronic balance, Colorimeter, pH Meter, Spectrophotometer, Manual Sequencer, Electrophoresis apparatus, Laminar Flow, Shaker incubator.

5. Molecular modeling- Nitrogenous bases, Nucleosides, Nucleotides using bead and stick method.

6. Microscopic study of different cell types: Buccal epithelial cells, Neurons, Striated muscle cells.

7. Preparation and study of different components of human blood.

8. Permeability study of plasma membrane-Effect of isotonic, hypotonic and hypertonic solutions on mammalian RBCs.

9. Chromosomal preparation

- Temporary squash preparation of giant chromosomes
- Mitosis in root tip of onion

10. Preparation of different buffers and solutions: 1 M Tris-HCl (pH 8), 10 N NaOH, 1 N HCl, 20% KOH, 5 M NaCl etc.

11. *Drosophila* Genetics -Culture, handling of flies, preparation of food and setting up of genetic crosses.

12. Class Record and *Viva-voce*

B.Sc. Part I

Reference Books				
1.	Strickberger	Genetics	Mcmillan	1985
2.	Gardner *et al*	Principles of Genetics	John Wiley	1991
3.	Hartl and Jones	Genetics-Principles and Analysis	Jones & Bartlett	1998
4.	Hartwell *et al*	Genetics: From Genes to Genomes	McGraw-Hill	2004
5.	Pierce	Genetics	Freeman	2004
6.	Watson *et al*	Molecular Biology of the Gene	Pearson	2004
7.	Gilbert	Developmental Biology	Sinauer	2003
8.	Griffiths et al	An Introduction to Genetic Analysis	Freeman	2004
9.	Alberts *et al*	Molecular Biology of the Cell	Garland	2002
10.	Lewin	Genes VIII	Pearson	2004
11.	Lodish *et al*	Molecular Cell Biology	Freeman	2004
12.	Cooper	Cell: A Molecular Approach	ASM Press	2000
13.	Karp	Cell and Molecular Biology	Wiley	2002

List of Books of Indian Authors

S. No.	Name of the Book	Name of the author/s	Name of the Publisher
1.	Biology of Animals Vols I, II	Sinha,,Adhikari, Ganguly, Goswami	New Central Book Agency
2.	Modern Textbook of Zoology-Invertebrates & Vertebrates	Kotpal	NCBA
3.	Introduction to General Zoology	Chaki, Kundu & Sarkar	NCBA
4.	Fundamentals of Zoology	Ghosh, Manna	NCBA
5.	Invertebrate Zoology	Ramesh Gupta	
6.	Vertebrate Zoology	Ramesh Gupta	
7.	Invertebrate Zoology	R.L. Kotpal	Rastogi Publications
8.	Vertebrate Zoology	R.L. Kotpal	Rastogi Publications
9.	Cell Biology	Satyesh C. Roy, Kalyan Kumar De	New Central Book Agency
10.	Biology of Vertebrate	H.C. Nigam	Vishal Publishers
11.	Biology of Chordate	H.C. Nigam	Vishal Publishers
12.	Fundamentals of Human Genetics	S. Mandal	NCBA
13.	Fundamentals of Microbiology & Immunology	Ajit Kr Banerjee & Nirmalya Banerjee	NCBA
14.	Modern trends in Biology	H.C. Nigam	Vishal Publications Jalandhar

B. Sc. Part II Genetics and Genomics

There will be three written papers and one practical examination. The following courses are prescribed.

PAPER I Chordata

Unit I: Hemichordata
Cephalochordata
Unit II: Urochordata
Unit III: Classification of different classes of vertebrates (Pisces, Amphibia, Reptilia, Aves and Mammalia)
Unit IV: Comparative anatomy of vertebrates

PAPER II Advanced Genetics

Unit I: Immunogenetics
Unit II: Cancer genetics
Unit III: Microbial genetics
Unit IV: Clinical genetics

PAPER III Physiology and Biochemistry

Unit I: Physiology of digestion, respiration, and blood and circulation
Unit II: Physiology of excretion and osmoregulation, neural transmission and muscles
Unit III: Physiology of endocrine system, including insect endocrine glands, homeostasis, thermoregulation
Unit IV: General chemistry and classification of carbohydrates, lipids and proteins; Enzymes

B.Sc. Part II

There will be three written papers and one practical examination. The following courses are prescribed.

PAPER I Chordata

Unit-1

- **Hemichordata**: Classification and detailed study (habit, morphology, anatomy, physiology and development) of *Balanoglossus*

- **Cephalochordata**: Classification and detailed study (habit, morphology, anatomy and physiology) of *Branchiostoma* (*Amphioxus).*

Unit-II

- **Urochordata**: Classification and detailed study (habit, morphology, anatomy, physiology and post embryonic development) of *Herdmania*

Unit-III

- **Classification of different classes of vertebrates** (Pisces, Amphibia, Reptilia, Aves and Mammalia) up to order with characters and examples.

Unit-IV

- **Comparative anatomy of vertebrates**: Histology (types of tissues). Comparative study of the following systems- integument, skeleton, digestive, respiratory, circulatory, nervous, receptor and urinogenital.

PAPER II Advanced Genetics

Unit-I

Immunogenetics

- Immune system: innate and adaptive immunity, clonal selection, complement system
- Humoral immunity and cell mediated immunity
- Immunoglobulin and T-cell receptor genes: organization of Ig gene loci, molecular mechanism of generation of antibody diversity
- HLA complex: organization, class I and II HLA molecules, expression of HLA genes

Unit-II

Cancer Genetics

- Cell cycle and its regulation, Apoptosis, Characteristics of cancer cells, histopathology, types of cancer and their symptoms.
- Cell transformation and tumorigenesis: oncogenes, tumour suppressor genes, DNA repair defects, genomic instability
- Metastasis, tumour specific markers, DNA markers, SNPs, cancer therapy
- Cancer and environment: physical, chemical, biological carcinogens

Unit-III

Microbial Genetics

- Methods of gene transfer in bacteria: conjugation, transformation, transduction
- Genetic analysis of mutants: recombination and genetic mapping
- Microbial technology: fermentation technology, synthesis of microbial and recombinant products
- Life cycles and advantages of organisms commonly used in genetic studies. Genes and gene products in different model systems: T4 and λ phages, *Escherechia coli, Saccharomyces cerevisae*

Unit-IV

Clinical Genetics

- Human karyotype, Chromosomal anomalies and diseases, Inborn errors of metabolism
- Pedigree analysis, monogenic disorders: autosomal dominant, autosomal recessive, X-linked, multifactorial diseases
- Genome imprinting syndromes & mitochondrial syndromes
- Management of genetic disorders: calculation of genetic risk, prenatal diagnosis and genetic counseling

PAPER III Physiology and Biochemistry

General physiology (in outline) with special reference to mammals

Unit-I

- Physiology of digestion, respiration, and blood and circulation

Unit-II

- Physiology of excretion and osmoregulation, neural transmission and muscles

Unit-III

- Physiology of endocrine system, including insect endocrine glands, homeostasis, thermoregulation

Unit-IV

- General chemistry and classification of carbohydrates, lipids and proteins; Enzymes

B.Sc. Part II
Genetics and Genomics Practical Syllabus

1. Study of museum specimens and slides of vertebrates

2. Dissection- Afferent and Efferent arterial system, cranial nerves of *Scoliodon*

3. Temporary and Permanent preparations of-

- Placoid scales
- Striated and non-striated muscles of frog

4. Biochemistry

- Ninhydrin test for α-amino acids.
- Benedict's test for reducing sugar and iodine test for starch.
- Test for sugar and acetone in urine.
- Study of (a) the activity of enzyme catalase from rat liver (b) effect of heat denaturation on activity of catalase enzyme.
- Determination of acid value of oil.

5. Molecular modeling- Amino acids, dipeptides, polypeptides using bead and stick method.

6. Physiology

- Determination of blood groups and counting of WBC/RBC in human blood.
- Preparation of haemin crystals.
- Determination of Hb% in blood sample.
- Estimation of proteins by colorimetric method.

7. Bacterial Culture

- Preparation of media and plates, Autoclaving
- Growing bacteria in liquid medium and on agar plates,
- Bacterial growth curve.

8. Cytogenetics

- Preparation of karyotype and study of structural and numerical chromosomal aberrations (using models).
- Pedigree drawing.
- Analysis of pedigree charts.

9. Class Record and *Viva-voce*

B.Sc . Part II

Reference Books				
1.	Roitt	Essential Immunology	Blackwell	2003
2.	Benjamin *et al*	Immunology-A short Course	Wiley	2000
3.	Lewin	Genes VIII	Pearson	2004
4.	Lodish *et al*	Molecular Cell Biology	Freeman	2004
5.	Streips & Yasbin	Modern Microbial Genetics	Wiley	2002
6.	Trun & Trempy	Fundamentals of Bacterial Genetics	Blackwell	2004
7.	Black	Microbiology: Principles & Explorations	Wiley	2002
8.	Sudbery	Human Molecular Genetics	Prentice-Hall	2002
9.	Wilson	Clinical Genetics-A Short Course	Wiley	2000
10.	Pasternak	An Introduction to Molecular Human Genetics	Fritzgerald	2000
11.	Eckert & Randall	Animal Physiology	Freeman	2005
12.	Marieb	Human Anatomy & Physiology	Freeman	
13.	Ganong	Review of Medical Physiology	Lang Medical	2003
14.	Guyton and Hall	Text Book of Medical Physiology	Saunders	2001
15.	Hadley ME	Endocrinology	Prentice-Hall	

List of Books of Indian Authors

S. No.	Name of the Book	Name of the author/s	Name of the Publishers
1.	Biochemistry	Jain, Jain and Jain	S. Chand & Company Ltd.
2.	An introduction to Animal Physiology and related Biochemistry	Dr. H. R. Singh	Shoban Lal Nagin Chand & Co. Jalandhar City
3.	Fundamentals of Biochemistry	A. C. Deb	New Central Book Agency
4.	Animal Physiology	H.C. Nigam	Vishal Publishers
5.	Concepts of Toxicology	Omkar	Vishal Publishers
6.	Experimental animal physiology and biochemistry	Omkar and S.C. Nigam	New Age International (P) Limited, New Delhi
7.	Fundamentals of Human Genetics	S. Mandal	NCBA
8.	Fundamentals of Microbiology & Immunology	Ajit Kr Banerjee & Nirmalya Banerjee	NCBA
9.	Modern trends in Biology	H.C. Nigam	Vishal Publications Jalandhar

B.Sc. Part III

There will be three written papers and one practical examination. The following courses are prescribed.

PAPER I Biostatistics, Bioinformatics and Bioinstrumentation

Unit-I

Basics of Biostatistics

- Calculations of mean, median, mode, variance, standard deviation
- Concepts of coefficient of variation, Skewness, Kurtosis
- Elementary idea of probability and application
- Data summarizing: frequency distribution, graphical presentation—bar, pie diagram, histogram
- Tests of significance: one and two sample tests, Z-test, t-test, F-test and Chi-square test

Unit-II

Basics of Computers

- Basics (CPU, I/O units) and operating systems
- Computer networking, internet and e-mail
- Concept of homepages and websites, World Wide Web, URLs, using search engines
- Databases: nucleic acids, genomes, protein sequences and structures, SNP db Bibliography

Unit-III

Basics of Bioinformatics

- Information retrieval from biological databases, Entrez system, SRS
- Sequence analysis (homology): pairwise and multiple sequence alignments-BLAST, CLUSTALW
- Protein structure prediction---visualizing 3D-structures of proteins
- Phylogenetic analysis

Unit-IV

Bioinstrumentation

- Microscopy: principles and application--light microscopy, dark field microscopy, phase-contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy, Photography-- digital imaging and image processing
- Centrifugation: principle, types of rotors, high speed and ultracentrifuge
- Colorimetry and spectrophotometry: Beer-Lambert law, absorption spectrum
- Chromatography: paper, thin layer, column---ion-exchange, gel filtration, HPLC, affinity
- Measurement, applications and safety measures of radio-tracer techniques

PAPER II Population Genetics, Behavioural Genetics and Applied Molecular Genetics

Unit-I

Population and Evolutionary Genetics

- Microevolution in Mendelian population: allele frequencies, genotype frequencies, Hardy-Weinberg equilibrium and conditions for its maintenance
- Forces of evolution: mutation, selection, genetic drift
- DNA polymorphism in natural population

Unit-II

Genes and Environment

- Genotype to phenotype: effect of environment, penetrance, expressivity, phenocopy, gene interactions and modifying genes
- Inheritance of quantitative traits—continuous and discontinuous variation
- Polygenic inheritance, genetic variance, heritability

Unit-III

Behavioural Genetics

- Genetics of animal and human behaviour—selection studies, inbred strain studies, twin and adoption studies, linkage and association studies
- Learning and memory
- Psychological disorders---mental retardation, learning disorders, mood disorders, anxiety disorders, personality disorders

Unit-IV

Applied Molecular Genetics

- Nucleic acid fractionation, detection by electrophoresis, DNA sequencing, polymerase Chain Reaction (PCR), primer designing, DNA fingerprinting, site directed mutagenesis, RFLP
- Molecular cloning, genomic libraries, Gene transfer techniques: electroporation, microinjection
- Oligonucleotide synthesis, preparation of probes, hybridization, Southern, Northern and south-western blotting
- Detection of proteins, PAGE, ELISA, western blotting, hybridoma technology
- Applications of recombinant DNA technology: crop and live stock improvement, development of transgenics, Gene therapy, Development of DNA drugs and vaccines
- DNA diagnostics--genetic analysis of human diseases, detection of known and unknown mutations

PAPER III Genomics

Unit-I

Organization of genomes

- Overview of prokaryotic and eukaryotic genomes
- Human genome project: mapping strategies
- Mitochondrial genome, nuclear genome, gene density, CpG islands, Gene families and superfamilies: gene duplication, pseudogenes, repetitive DNA and transposable elements

Unit-II

Comparative Genomics

Conservation and diversity of genomes

- Genome size and organizations of genes
- C-value, number of genes and complexity of genomes
- Comparative genomics as an aid to gene mapping and study of human disease genes

Unit-III

Functional Genomics

- Concepts of transcriptome and proteome
- Microarray technology, and Proteomics
- Prediction, diversity and multiplicity of protein functions
- Sequence homology and prediction of gene functions

Unit-IV

Pharmacogenomics and Human Health

- Concept of pharmacogenomics and pharmacogenetics
- Genetic polymorphisms in drug metabolizing enzymes, drug targets, effects on drug response
- Personalized medicine—optimizing drug therapy
- Gene chips: applications in disease profiles, drug target discovery, drug action and toxicity

B.Sc. Part III
Genetics and Genomics Practical Syllabus

1. Application of different statistical tools to genetic studies.

2. Use of different computer programmes- MS Word, MS Powerpoint, MS Excel, Adobe Photoshop, INTERNET, Search engines, Homepages etc.

3. Genomics through Bioinformatics tools

- NCBI, Entrez, PubMed, Gene, Genomes
- BLAST, PSI-BLAST, homology searching
- Multiple alignment, CLUSTAL W
- Gene families
- Protein structure prediction (ExPasy, PROSITE).
- Phylogenetic analysis (PHYLIP).
- Primer designing

4. Molecular Genetics Techniques

- **Protein Chemistry:** Fractionation by differential centrifugation, Spectrophotometric estimation, Detection of proteins by Polyacrylamide Gel Electrophoresis (PAGE), Purification of proteins by paper and Gel filtration chromatography.

- **Nucleic Acid Chemistry:** DNA extraction from blood and flies, Quantitation by spectrophotometry, Detection of DNA on gel by Agarose gel electrophoresis, Southern hybridization and Comet Assay.

- **DNA Fingerprinting and Diagnostics:** Manual DNA sequencing (Demonstration), Polymerase Chain Reaction (PCR).

- **Molecular cloning:** Preparation of competent bacterial cells, Inserting a fragment of DNA in a suitable vector, Transformation using the recombinant plasmid.

5. Seminar

6. Class Record and *Viva-voce*

B.Sc. Part III

PAPER I

Reference Books				
1.	Sambrook *et al*	Molecular Cloning vols I, II, III	CSHL	2001
2.	Primrose	Molecular Biotechnology	Panima	2001
3.	Clark & Switzer	Experimental Biochemistry	Freeman	2000
4.	Westhead *et al*	Bioinformatics: Instant Notes	Viva Books	2003

PAPER II

Reference Books				
1.	Zar	Biostatistical Analysis	Pearson	2003
2.	Daniel	Biostatistics: A Foundationfor Analysis in Health Sciences	Wiley	2000
3.	Quin & Keough	Experimental Design & Data Analysis for Biologists	Canbridge Univ Press	2002
4.	Strickberger	Evolution	Jones & Barlett	2000
5.	Hartl & Clark	Principles of Population Genetics	Sinauer	1997
6.	Jobling *et al*	Human Evolutionary Genetics	Garland	2004
7.	Plomin *et al*	Behavioural Genetics	Freeman	2001
8.	Lynch & Walsh	Genetics & Analysis of Quantitative Traits	Sinauer	2000

PAPER III

Reference Books				
1.	Primrose & Twyman	Principles of Genome Analysis and Genomics	Blackwell	2003
2.	Brown	Genomes	Bios	1999
3.	Gibson & Muse	A Primer of Genome Science	Sinauer	2002
4.	Hartl & Jones	Genetics: principles & Analsysis of Genes & Genomes	Jones & Bartlett	1998
5.	Hartl	Essential Genetics: A Genomic Perspective	Wiley	2002

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S. No.	Name of the Book	Name of the author/s	Name of the Publisher
1.	Fundamentals of Human Genetics	S. Mandal	NCBA
2.	Problems on Genetics, Molecular Genetics & Evolutionary Genetics	Pranab kr Banerjee	NCBA
3.	Fundamentals of Biology of animals	Sinha, Adhikari	New Central Book Agency
4.	Fundamental of Biochemistry	A. C. Deb	New Central Book Agency
5.	Fundamentals of Microbiology & Immunology	Ajit Kr Banerjee & Nirmalya Banerjee	NCBA
6.	Ecology and Environmental Science	H.R. Singh & Neeraj Kumar	Vishal Publishers
7.	Environmental biology and Toxicology	P. D. Sharma	Rastogi publications