

**M.Sc. Zoology
Courses Offered**

Semester	Subject Code	Title of the Paper	Hours / Week	Credits
I	PZ1711	Core I - Biochemistry	6	4
	PZ1712	Core II - Cell and Molecular Biology	6	4
	PZ1713	Core III - Culture and Capture Fisheries	6	4
	PZ1714 PZ1715	Elective I: (a) Biosystematics and Biodiversity (b) Cell Technology	6	5
	PZ17P1	Practical I (Biochemistry, Cell and Molecular Biology & Culture and Capture Fisheries)	6	-
II	PZ1721	Core IV - Biostatistics, Computer Applications and Bioinformatics	6	4
	PZ1722	Core V - Genetics and Evolution	6	4
	PZ1723	Core VI - Research Methodology	6	4
	PZ1724 PZ1725	Elective II: (a) Developmental Biology (b) Bioinformatics	6	5
	PZ17P1	Practical I (Biochemistry, Cell and Molecular Biology & Culture and Capture Fisheries)	-	5
	PZ17P2	Practical II (Biostatistics, Computer Applications and Bioinformatics, Genetics and Evolution & Research Methodology)	6	5
	LST172	Life Skill Training (LST) I	-	1
III	PZ1731	Core VII - Physiology	6	4
	PZ1732	Core VIII - Immunology	6	4
	PZ1733 PZ1734	Elective III: (a) General Endocrinology (b) Health Care	6	5
	PZ17P3	Practical III (Physiology & Immunology)	4	-
	PZ17PR	Project	8	4
	PZ1741	Core IX - Microbiology	6	4
	PZ1742	Core X - Ecobiology	6	4

IV	PZ1743	Core XI - Biotechnology and Nanobiology	6	4
	PZ1744 PZ1745	Elective IV: (a) Parasitology (b) Medical Entomology	6	5
	PZ17P3	Practical III (Physiology & Immunology)	-	4
	PZ17P4	Practical IV (Microbiology, Ecobiology & Biotechnology and Nanobiology)	6	5
	LST174	Life Skill Training (LST) II	-	1
	STP171	Summer Training Programme	-	1
		TOTAL	120	90

Semester I
Core I - Biochemistry
Sub. Code: PZ1711

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To create awareness among the students about the structure and functions of biomolecules.
2. To provide knowledge in tackling more advanced and specialized biochemical techniques.

Unit I

Atoms – Molecules – Chemical bonds – Primary bonds and secondary bonds – pH and Hydrogen ion concentration - Buffers – ‘Henderson-Hasselbalch’ equation – Buffer systems in blood - Mechanism of buffer action - Acid base balance – Regulation of acid base balance – Acidosis and Alkalosis. Water – Colligative properties - Water turnover and balance - Electrolyte balance – Dehydration and Water intoxication.

Unit II

Carbohydrates: Classification, structure, properties of mono, oligo and polysaccharides and biological role of carbohydrates - Carbohydrate metabolism - glycogenesis, glycogenolysis, glycolysis, Krebs cycle, Electron transport and Oxidative phosphorylation, Energetics of glucose metabolism - Pasteur effect–HMP shunt - gluconeogenesis – glyoxylate pathway – Cori cycle – Regulation and hormonal control of carbohydrate metabolism – glycogen storage diseases – blood sugar level – Glycosuria - Glucose tolerance test – Diabetes.

Unit III

Proteins: Classification, structure, Ramachandran plot, Properties and biological role. Amino acids - classification, structure and properties – Metabolism of proteins - deamination, transamination– transmethylation and decarboxylation of amino acids – glycogenic and ketogenic amino acids – Formation and transport of ammonia - glucose-alanine cycle - Ornithine cycle – Metabolism of Phenylalanine, Tyrosine and Tryptophan. Porphyrins.

Unit IV

Lipids: Classification, structure and Biological role - Chylomicrons, VLDL, LDL, HDL - Lipid metabolism – Theories of oxidation of fatty acids – Oxidation of any one fatty acid and its bioenergetics (palmitic acid) – Ketogenesis - Biosynthesis of palmitic acid – Metabolism of cholesterol - lipid storage diseases – Role of liver in fat metabolism. Prostaglandins. Integration of carbohydrate, protein and lipid metabolism.

Unit V

Nucleotide metabolism: Biosynthesis and degradation of purines and pyrimidines. **Enzymes:** classification, nomenclature, enzyme kinetics, Michaelis - Menten constant, enzyme inhibition, mechanism of enzyme action, factors affecting enzyme activity, isozymes, coenzymes. **Vitamins:** Classification (fat soluble and water soluble), occurrence and biochemical role. **Detoxification:** Mechanism of detoxification (oxidation, reduction, conjugation) - cytochrome P 450 system.

Reference Books

1. Satyanarayana, U. & Chakrapani, U. (2013). *Biochemistry* (4th ed). India: Elsevier.
2. Chatterjea, M.N. & Rana Shinde (2012). *Textbook of Medical Biochemistry* (8th ed.). New Delhi: Jaypee Brothers Medical Publishers Pvt. Limited.
3. Vasudevan, D. M., Sree Kumari, S. & Kannan Vaidyanathan (2013). *Textbook of Biochemistry for Medical Students* (7th ed.). New Delhi: Jaypee Brothers Medical

Publishers Pvt. Limited.

4. Nitin Jain, Jain, J.L. & Sunjay Jain (2014). *Fundamentals of Biochemistry*. S. Chand & Co. Ltd., New Delhi.
5. Jeremy M. Berg, John L. Tymoczko & Lubert Stryer (2006). *Biochemistry* (6th ed.). San Francisco: Freeman & Co. Publishers.
6. Ambika Shanmugam (2012). *Fundamentals of Biochemistry for Medical Students* (7th ed.). Published by Wolters Kluwer, India.
7. David L. Nelson & Michael M. Cox (2004). *Lehninger Principles of Biochemistry* (4th ed.). New York: W.H. Freeman and Company.

Semester I
Core II - Cell and Molecular Biology
Sub. Code: PZ1712

No. of Hours per Week	Credits	Total No. of Hours	Marks	Objectives
6	4	90	100	

1. To provide firm intellectual and basic knowledge on the structure and functions of biomembranes, cell organelles and molecules of eukaryotic cells.
2. Get employment in educational institutions and research laboratories.

Unit I

Cell Structure & Functions of cell organelles: prokaryotic cells – structure. Plasma membrane: Structure and function - active transport and pumps- transport by transporter proteins – membrane potential. Cell – cell and cell – matrix interaction: Cell adhesion molecules: Selectin – Integrin – Cadherins. Calcium dependent and Calcium independent homophilic cell–cell adhesion. Tight junction, Gap junction – connexin. Extracellular matrix – Collagen and non–collagen components.

Unit II

Cell Signaling: Extra cellular signaling – signaling molecules and their receptors - Functions of cell surface receptors. Pathways of intracellular signal transduction: G protein coupled receptors – Cyclic AMP pathways - Receptor Tyrosine Kinases (RTKs) – Ras, Raf and MAP kinase pathway – second messengers – signaling from plasma membrane to nucleus.

Unit III

Cell organelles and Nucleic acids: Structure and functions of Nucleus, Mitochondria, Endoplasmic reticulum - Golgi complex and lysosomes. Cytoskeleton – structure and functions. Ribosomes and translation of genetic information - Types, structure and functions of RNA.

Unit IV

Protein synthesis and transport: DNA template – – Transcription – Translation – Post translation detection. Protein – Protein trafficking - sorting: Secretory and endocytic pathway – transport from endoplasmic reticulum to Golgi – Anterograde and retrograde transport – transport to lysosome – exocytosis – endocytosis. Membrane protein and secretory proteins.

Unit V

Normal and abnormal cell growth and functions: Cell cycle – Mitosis - Meiosis - Cyclin and Cyclin dependent kinases – Regulation of cyclin dependent kinases (cdk) – Cyclin activity. Biology of ageing – role of anti-oxidants and free radicals. Apoptosis – definition – mechanism and significance. Neoplastic transformation: cancer – proto-oncogenes – tumour suppressor genes.

Reference Books

1. Lodish, H. & Berk, A. (2016). Molecular Cell Biology (8th ed.). New York: W.H. Freeman and Company Limited Publication.
2. Gupta, P.K. (2014). Cell and Molecular Biology (4th ed.). New Delhi: Rastogi Publication.
3. Geoffrey M. Cooper & Robert E. Hausman (2013). The cell: A Molecular Approach (6th ed.). Massachusetts, USA: Sinauer Associates Publication.
4. Alberts B., Johnson. A., Lewis, J., Raff, M., Roberts, K. and Watter, P. (2008). Molecular Biology of the Cell (5th ed.). New York: Garland Science Publication.
5. De Robertis, E.D.P. (2011). Cell and Molecular Biology (8th ed.). New York: Lippincott Williams & Wilkins Publication.

1. .Semester I
Core III - Culture and Capture Fisheries
Sub. Code: PZ1713

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To gain knowledge on the construction and maintenance of ponds for culture of different types of cultivable aquatic organisms and also to gain information on fishery management, fish processing, preservation techniques and parasites of fishes.
2. To raise aqua farming and extend it to the society.

Unit I

Purpose and importance of aquaculture - basic qualification of candidate species - cultivable freshwater and marine fishes - global and Indian scenario of aquaculture. Construction and maintenance of fish farm: selection of site - lay-out and types of ponds - aquatic plants and their control - control of fish predators - liming - fertilization of ponds. Kinds of aquaculture - Integrated fish farming - Sewage fed fish culture - Pen and cage culture.

Unit II

Nutrition and Breeding: Nutritional requirements - Culture of fish feed organisms - phytoplankton (diatom), zooplankton (rotifers, cladocerans), Artemia, Tubifex. Artificial feed and feed formulation. Seed collection: Sex identification – collection, rearing and selection of brooders - induced breeding by hypophysation - ovaprim - transportation of fish seed.

Unit III

Finfish culture: Culture of Indian major carps, Tilapia and murrel. Ornamental fish culture and its prospectus. **Shell fish culture:** Culture of freshwater and marine prawns, lobsters, crabs, edible and pearl oysters. **Fish pathology:** Ectoparasites, Endoparasites, Bacterial, Viral and Fungal diseases, nutritional deficiency diseases.

Unit IV

Fishery Genetics: Chromosomes in fishes - chromosome set manipulation - gynogenesis and androgenesis - induced polyploidy. Chromosomal abnormalities - Sex determination in fishes - sex patterns - intrinsic and extrinsic factors in sex control and sex reversal. Transgenic fishes.

Unit V

Capture Fisheries: Inland fisheries (riverine, lakesterine and cold water fisheries) - Estuarine fisheries - Marine fisheries. Crafts and fishing gears - Common fishes of Kanyakumari - Fish spoilage and methods of fish preservation – Fish Marketing and co-operative societies in aquaculture. **Economic importance of fishes:** Food value and fish by-products.

Reference Books

1. Pillay, T.V.R. (1990). *Aquaculture: Principles and Practices*. England: Fishing News Books Ltd.
2. Khanna, S.S. (2005). *An Introduction to fishes*. Allahabad: Silverline Publications.
3. Pandey & Shukla (2005). *Fish and Fisheries*. Meerut: Rastogi Publications.
4. Jai Singh, P. (2008). *Fishes of Kanyakumari – A Hand Book on the Study of Fishes* (2nd ed.). Nagercoil: Tower Graphics Printer.
5. Bardach, J. (1972). *Aquaculture*. New York: Wiley-Interscience Publication.
6. Jhingran, V.G. (1991). *Fish and Fisheries of India*. New Delhi: Hindustan Publishing Co.

7. Schaperclaus (2001). *Fish Diseases*, Vol. I and II. New Delhi: Oxonian Private Ltd.
8. Ghosh, R. (2007). *Fish Genetics and Endocrinology*. New Delhi: Swastik Publishers.
9. Santhanam, R. (1990). *Fisheries Science*. New Delhi: Daya Publishing House.
10. Rath, R.K. (1993). *Freshwater Aquaculture*. Jodhpur: Scientific Publishers.
11. Schonder. S.L. (1980). *Hypophysation in Indian Major Carp*. Agra: Satish Book Enterprises.
12. Reddy, P.V.G.K., Ayyappan, S., Thampy, D.M. & Gopal Krishna (2005). *Text book of Fish genetics and Biotechnology*. New Delhi: Indian Council of Agricultural Research.

Semester I
Elective I (a:) Biosystematics and Biodiversity
Sub. Code: PZ1714

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To enable the students to know about the diversified forms in nature and also to identify the relationships among different species.
2. Get employability in Zoological Survey of India, Museum and Biodiversity conservation organizations.

Unit I

Basic concepts of Biosystematics - Importance and applications of biosystematics - Stages of taxonomy – alpha, beta and gamma taxonomy. Newer trends in taxonomy: Morphological, embryological, ecological, behavioral, cytological, biochemical approaches, Numerical taxonomy and Molecular taxonomy.

Unit II

Zoological classification: Theories of classification, components of classification, Linnaean hierarchy. Outline classification of animal kingdom. Systematic position of Invertebrates (one example for each phylum) and Chordates (one example for each class). Concept of species: kinds of species concept, polytypic species, sub species and other infra specific groups. Super species.

Unit III

Taxonomic collection: Collecting ways, preservation of collected materials, curating, preparation of specimens and methods of identification. **Zoological Nomenclature:** International code of Zoological Nomenclature (ICZN) – rules of nomenclature. Typification, type and its kinds.

Unit IV

Biodiversity and its conservation: Importance of biodiversity. Human impact on biological diversity: habitat fragmentation – wild life and human conflict - loss of animal diversity - endangered wildlife species – special projects - IUCN red list - hot spots. Conservation of biodiversity: *In situ* and *Ex situ* conservation - management of germplasm. Conservation practices in India: Wildlife sanctuaries, national parks and biosphere reserves - Indian Board of Wildlife (IBWL) - wildlife protection laws – Trade laws (CITES).

Unit V

Biodiversity – Levels of diversity – species, genetic, ecosystem. Evaluation of Biodiversity indices: Shannon-Weiner index, Brillouin diversity index, Dominance index (Simpson and Margalef index), Evenness index, richness index, Similarity and dissimilarity index, Association index. Diversity and ecosystem process theory.

Reference Books

1. Kapoor, V.C. (2001). *Practice of Animal Taxonomy* (5th ed.). New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

2. Simpson, G.G. (1969). *Principles of Animal Taxonomy*. New Delhi: Oxford and IBH Publishing Co.
3. Supriyo Chakraborty (2004). *Biodiversity*. Jaipur: Pointer Publishers.
4. Jordan, E.L. & Verma, P.S. (2001). *Invertebrate Zoology*. New Delhi: S. Chand and Company Ltd.
5. Jordan, E.L. and Verma, P.S. (2014). *Chordate Zoology*. New Delhi: S. Chand and Company Ltd.
6. Trivedi, P.C. and Sharma, K.C. (2003). *Biodiversity Conservation*. Jaipur: Avishekar Publishers.
7. Kotpal, R.L. (2014). *Modern Text Book of Zoology, Invertebrates*. Meerut, New Delhi: Rastogi Publications,
8. Kotpal, R.L. (2005). *Modern Text Book of Zoology, Vertebrates* (3rd ed.). Meerut, New Delhi: Rastogi Publications.
9. Ekambaranatha Ayyar, M. & Anantha Krishnan, T.N. (1985). *Manual of Zoology, Volume I, Invertebrata*. Chennai: Viswanathan Printers and Publisher Pvt. Ltd.
10. Ekambaranatha Iyyar, M. (1995). *A Manual of Zoology, Volume II, Chordata*. Chennai: Viswanathan Printers and Publisher Pvt. Ltd.
11. Kato, M. (2012). *The biology of biodiversity*. Tokyo: Springer – Verlag Publications.

Semester I
Elective I (b): Cell Technology
Sub. Code: PZ1715

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To apply certain biological techniques to observe and analyze cells and their constituents in health and disease.
2. To impart skills to perform histological and histochemical techniques and identify the types of cells and their products.

Unit I

Cells as experimental models – microorganisms (*E. coli* and Yeast), invertebrates (*Caenorhabditis elegans* and *Drosophila melanogaster*), vertebrates (*Xenopus* and mice) - Isolation, culture, harvest and preservation of cells – cryopreservation of cells for later recovery- plasmolysis, hemolysis and cell fractionation.

Unit II

Tissue preparation for microtechnique – fixation – need, types and a good fixative – preparation of compound fixatives – physical and chemical effects of fixation – alternative methods of fixation- special treatment of mineralized tissue - processing – embedding and sectioning.

Unit III

Staining – definition of a stain – structure and classification of stains - principles and properties of staining – vital staining – metallic impregnation technique use of radiolabelled and Fluorescent dye. Stains: histological, acidophilic, basophilic and histochemical. Alizarin preparation. Significance of staining – Blood dyes.

Unit IV

Histochemistry – principles of commonly used histochemical techniques. Identification and demonstration of tissue components – proteins, carbohydrates, lipids, nucleic acids, enzymes, pigments, amyloids. Differential staining in identification of pathogens and diagnosis of disease.

Unit V

Stem cell technology – Stem cells - properties, applications and current standings of the stem cell technology. Embryonic stem cell – adult stem cell – applications – Stem-cell plasticity, Regulators of pluripotency and differentiation of stem cell. Regenerative medicine – Current stem cell therapies - stem cells and ageing - clinical applications of hematopoietic stem cells from cord blood - treatment of neural diseases such as Parkinson's disease, Huntington's disease and Alzheimer's disease. Repair of damaged organs (liver and pancreas).

Reference Books

1. John R. Baker (1966). *Principles of Biological microtechnique - A study of fixation and dyeing*. Great Britain: Richard Clay and Company Pvt. Ltd.
2. Ramnik Sood (1994). *Medical Laboratory Technology* (4th ed.). New Delhi: Jaypee Brothers Medical Publishers Pvt. Ltd.
3. Gretchen, L.H. (1979). *Animal tissue techniques*. San Francisco: W.H. Freeman and Company.
4. Lodish, Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. & Darnell, J. (2000). *Molecular Cell Biology*. San Francisco: W.H. Freeman and Company.
5. Joseph Panno (2006). *Stem cell research - Medical applications and ethical controversy*.

USA: Checkmark Books Publication.

6. Shyamsundari, K & Hanumantha Rao (2007). *Histochemistry in focus: A source book of techniques and research needs*. Chennai: MJP Publishers.
7. Prakash, M. & Arora, C.K. (1998). *Microscopical methods in Encyclopaedia of laboratory techniques series*. New Delhi: Anmol Publication Pvt. Ltd.

Semester II
Core IV - Biostatistics, Computer Applications and Bioinformatics
Sub. Code: PZ1721

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To enable the students to get the insight into statistical analysis of biological data with mathematical principles in collection and calculations in various biological experiments.
2. To develop skill in handling useful tools for automation of complex computer jobs, and making these tools accessible on the network from a Web browser.

Unit I

Population and sample in biological studies - variables - sampling methods. Types of biological data. Measurement scales - ratio scale, interval scale, ordinal scale, nominal scale - parameters and statistics. Accuracy and precision. **Data collection and presentation:** Tabulation - graphs - diagrams. Frequency distribution - histogram - frequency curves and Ogives. Measures of central tendency: types of mean, median, mode.

Unit II

Measures of dispersion: Range – quartile and percentile - mean deviation - standard deviation - coefficient of variation – skewness and kurtosis - standard error. Distribution: Binomial, Poisson and Normal. Parametric and non parametric tests. Hypothesis testing – single and two population mean - types of error (Type I and Type II) – Chi-square analysis – test for goodness of fit and homogeneity.

Unit III

Student's t-distribution - Analysis of variance (ANOVA): one way classification and two way classification (Factorial design). Probability: Addition theorem, multiplication theorem and conditional theorem. Permutation and combination. Correlation – types, methods of study and testing the significance. Regression: equations – regression lines – simple linear regression and testing its significance. Mathematical modeling in biology: types and applications.

Unit IV

Computer applications: Computer memory and storage devices (Hard disc, floppy disc, CD-ROM, DVD, Pendrive). Microsoft office - M.S. Power point. MS Excel and statistical function: Descriptive statistics – t –test, ANOVA, correlation, regression, Chi-square test, table and charts. Internet and E-Mail - viruses and worms. SPSS Package - usage and application.

Unit V

Bioinformatics: Scope – Biological data bases – Data base retrieval tools (Locus link, ENTREZ, Pubmed and SRS) – Nucleotide sequence data base (NCBI, EMBL) - Protein data base (SWISS-PROT). Data base similarity research tools (BLAST, FASTA). Biological sequence analysis: sequence alignment, pair-wise alignment and multiple sequence alignment (CLUSTALW). Protein structure visualizing tools (RasMol, Swiss PDB Viewer). Applications of bioinformatics tools.

Reference books

1. Gurumani, N. (2005). *An Introduction to Biostatistics*. Chennai: MJP Publishers.
2. Khan, I. & Khanum, A. (2014). *Fundamentals of Biostatistics* (3rd ed.): Hyderabad. Ukaaz Publications.
3. Zar, J.H. (1984). *Biostatistical Analysis* (2nd ed.). London: Prentice-Hall International Inc.
4. Bailey, N.T.J. (1997). *Statistical methods in Biology* (3rd ed.). New York: Cam. University Press.
5. Sokal, R. & James, F. (1973). *Introduction to Biostatistics*. Tokyo, Japan: W.H. Freeman and Company Ltd.
6. Daniel, W.W. (1987). *Biostatistics: A foundations for Analysis in the Health Sciences*. New York: John Wiley & Sons.
7. Gupta, S.P. (1998). *Statistical Methods*. New Delhi: S. Chand and Company Ltd.
8. Banerjee, P.K. (2005). *Introduction to Biostatistics*. New Delhi: S. Chand and Company Ltd.
9. Attwood, T.K & Parry Smith, D.J. (2005). *Introduction to bioinformatics*. Delhi: Pearson Education Pvt. Ltd.
10. John De Britto, A. (2011). *Bioinformatics*. Sivakasi: Anto Art Craft Printers.
11. Kumaresan, V., Arumugam, N., Gopi, A., Meena, A. & Sundaralingam, R. (2008). *Biostatistics, Computer Application and Bioinformatics*. Nagercoil: Saras Publication.
12. Sundaralingam, R. & Kumaresan, V. (2008). *Bioinformatics*. Nagercoil: Saras Publication.

Semester II
Core V - Genetics and Evolution
Sub. Code: PZ1722

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To understand the principles of hereditary mechanisms at molecular level and to discern the evolutionary significance of animals.
2. To get employability in Genetic counseling units in hospitals and paleontological centers.

Unit I

Mendelian Genetics: Mendelian principles (Dominance, segregation, independent assortment). Allelic and non-allelic interactions. Penetrance, expressivity and pleiotropism. Linkage and crossing over – types – mechanism – theories. Chromosome mapping - linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids. LOD score linkage test. Polygenic inheritance. Heritability and its measurements. QTL mapping.

Unit II

Molecular and Human Genetics: Gene concept. Mutation – types and effects of gene mutation – mutagens – insertional mutagens. DNA damage and repair. Inter and Intra chromosomal aberrations. Ploidy - kinds – mechanism – significance. Human chromosomes, Karyotyping, Chromosomal banding and painting. Pedigree analysis. Inborn errors of metabolism: Disorders of amino acid metabolism (phenylketonuria, alkaptonuria, albinism), Disorders of nucleic acid metabolism (Gout, ADA deficiency), Disorders of carbohydrate metabolism (Pompe's, G₆PD deficiency), Disorders of lipid metabolism (Tay Sach's disease, Gaucher's disease), Hemoglobin disorders (sickle cell anemia, thalassemia).

Unit III

Population Genetics and Evolution: Mendelian populations - gene pool and gene frequencies - Hardy Weinberg law and genetic equilibrium. Calculation of gene frequencies for autosomal (dominant and recessive alleles, codominant alleles and multiple alleles) and sex-linked genes. Factors affecting Hardy Weinberg equilibrium – selection - heterozygous advantage – mutation – migration – random genetic drift – Founder's effect. Genetic load and death - neutralist hypothesis - genetic polymorphism.

Unit IV

Molecular evolution: Principle – methods of molecular evolution – nucleotide substitution (types and rates). Interpretation of variation in DNA sequence. Molecular clock. Origin of new gene functions – evolution of novel genes and proteins. Molecular phylogeny – phylogenetic tree – reconstruction of phylogenetic relationship – Distance Matrix approach and Parsimony based approach - kinds of molecular phylogenies – Universal Tree of Life. Phylogenetic and biological concept of species. Adaptive radiation. Isolating mechanisms. Modes of speciation (allopatry and sympatry).

Unit V

Origin of higher categories: Major trends in the origin of higher categories. Microevolution, macroevolution, megaevolution and co-evolution. Evolution rates, phyletic gradualism and punctuated equilibrium. Origin and Evolution of Primates: Evolution of

Anthropoid Primates - The first hominids and origin of modern man - Bipedalism – communication – speech – language - altruism and morality. Evolution of culture.

Reference Books

1. Peter Snustad, D. & Michael J. Simmons (2009). *Principles of Genetics* (5th ed.). USA: John Wiley & Sons, Inc.
2. Eldon John Gardner, Michael J. Simmons & D. Peter Snustad (2005). *Principles of Genetics* (8th ed.). New Delhi: Wiley (India) Pvt. Ltd.
3. Monroe W. Strickberger (2015). *Genetics* (3rd ed.). India: Pearson Education.
4. Robert F. Weaver and Philip W. Hedrick (1989). *Genetics*. New York: W. M. C. Brown Publishers.
5. Emmanuel. C., Rev. Fr. Ignacimuthu, S. & Vincent, S. (2006). *Applied Genetics*. Chennai: MJP Publishers.
6. Hickey, G. I., Fletcher, H. L. & Winter, P. (2010). *Genetics*. New York: Taylor and Francis Group Publications.
7. Sanjib Chattopadhyay (2008). *Evolution, Adaptation and Ethology*. Kolkatta: Books and Allied Pvt. Ltd.
8. Maynard Smith, J. (1999). *Evolutionary Genetics*. England: Oxford University Press.
9. Monroe W. Strickberger (2000). *Evolution* (3rd ed.). Sudbery, Massachusetts: Jones and Bartlett Publishers.
10. Mark Ridley (1996). *Evolution*. England: Blackwell Science Ltd.
11. Arora, M. P. (2000). *Organic Evolution*. Mumbai: Himalaya Publish House.
12. Tomar, B.S. & Singh, S.P. (2000). *Evolutionary Biology*. Meerut: Rastogi Publications.
13. Ahuja, N. (2008). *Evolution and Population Genetics*. New Delhi: Pearl Books.
14. Savage, J.M. (1969). *Evolution*. New Delhi: Amerind Publishing Co. Pvt. Ltd.

Semester II
Core VI - Research Methodology
Sub. Code: PZ1723

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To enable the students to understand the working principles of bioinstruments and methodologies used in biological investigations and report writing.
2. To create self employment opportunities using the knowledge acquired.

Unit I

Microscope: Principle – Instrumentation, Types– bright field, dark field, phase contrast, interference, fluorescence, polarization, confocal, electron microscopes – scanning tunneling microscope, atomic force microscope, near field scanning optical microscope, magnetic force microscope. Photography – light – film – camera types – photomicrography.

Unit II

Centrifugation: Principle - Factors affecting sedimentation rate – Types and applications of centrifuges. pH meter: principle – electrodes – applications. Cryotechniques – cryopreservation. Cytotechnique: Whole mounts. Microtome: Rotary and Freezing microtome. Microtomy: Fixation – Dehydration – Clearing - Embedding - Sectioning – staining – mounting.

Unit III

Chromatography: Principle, types – paper, thin layer, column, gas and liquid chromatography – High Performance Liquid Chromatography – Ion exchange – Affinity chromatography. Electrophoresis: Principles, types – Paper and gel – Polyacrylamide gel, agarose gel, Iso electric focusing – Immunoelectrophoresis. Protein sequencing methods.

Unit IV

Spectrophotometer: principle, design and applications. Spectroscopy: principle- design- types- Atomic Absorption Spectroscopy, flame photometer, chemiluminometer, Nuclear Magnetic Resonance spectroscopy, FTIR spectrometry - Electron Spin Resonance, Magnetic Resonance Imaging – applications. Radio activity counters.

Unit V

Experimental design and Report writing: Essential steps in research – Literature collection – Review of literature – Research and discriminative reading – Bibliography- Index card – Literature citation – Plagiarism - Alphabet number system – Research report - Tables – Figures – Formatting and typing – Online literature collection – open access journals - Impact factor and Copy Right - Laboratory safety.

Reference Books

1. Veerakumari, L. (2006). *Bioinstrumentation*. Chennai: MJP Publishers.
2. Gurumani. N. (2006). *Research Methodology for Biological Sciences*. Chennai: MJP Publishers.
3. Robert L. Dryer & Gene F. Lata (1989). *Experimental Biochemistry*. New York: Oxford University Press.
4. Rana, S.V.S. (2002). *Biotechniques*. Meerut: Rastogi Publications.
5. Keith Wilson & John Walker (2000). *Principles and Techniques of Practical Biochemistry* (5th ed.). United Kingdom: Cambridge University Press.
6. Marimuthu, R. (2008). *Microscopy and Microtechnique*. Chennai: MJP Publishers.
7. Ramnik Sood (2006). *Medical Laboratory Technology*. New Delhi: Jaypee Brothers Medical Publishers Pvt. Ltd.

Semester II
Elective II (a): Developmental Biology
Sub. Code: PZ1724

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To enable the students to gain knowledge on the process by which a single cell, the zygote, multiply, differentiate and develop into an adult.
2. To gain employment at fertility centers in hospitals, health centers and cryopreservation units.

Unit I

Historical perspectives and theories of embryology. Male reproductive system of a mammal, spermatogenesis, structure and function of sperm, factors influencing spermatogenesis, semen and seminal fluid. Female reproductive system of a mammal, female gonad, Oogenesis, ovulation, Regulation of ovulation. Vitellogenesis, types of eggs.

Unit II

Fertilization and molecular aspects: Mechanism of fertilization, theories of fertilization and post fertilization changes. Cleavage: Laws of cleavage, planes – patterns – chemical changes during cleavage. Cleavage and blastulation in chick and mammal. Cell lineage, Fate map of chick and mammal. Gradient theory. Morphogenetic pattern and fields.

Unit III

Morphogenetic movements: Gastrulation in chick and mammal. Germinal layers and their derivatives in vertebrates. Neurogenesis, Notogenesis, Development of mesoderm and coelom. **Organogenesis in vertebrates:** Central nervous system, eye, skin and its derivatives, heart, kidney, limbs, alimentary canal and its derivatives.

Unit IV

Development of reproductive organs in man: development and differentiation of testis, development of male genital ducts and accessory glands. Development and differentiation of ovary, development of female genital ducts and accessory glands. Infertility – causes and treatment, Assisted Reproductive Technology (ART), Family planning. Development of extra embryonic membranes. Placentation in mammals.

Unit V

Embryonic induction in vertebrates – types –exogenous and endogenous. Theories of organizer or inductor, competence. Differentiation - characteristics and types, selective action of genes in differentiation. Teratogenesis and teratogens. Metamorphosis in insects and amphibians. Neoteny. Regeneration – regenerative ability in animals and mechanism. Asexual reproduction, Parthenogenesis and types.

Reference books

1. Balinsky, B. I. (1981). *An Introduction to Embryology* (5th ed.). Philadelphia: Holt-Saunders.
2. Wolpert, L. (2010). *Principles of Development* (4th ed.). United Kingdom: Oxford University Press.
3. Ronald W. Dudek & James D. Fix (2005). *Embryology* (3rd ed.). Philadelphia, USA: Lippincott Williams and Wilkins Publication.
4. Twyman, R. M. (2004). *Developmental Biology*. New Delhi: BIOS Scientific Publishers.
5. Verma, P. S. & Agarwal, V. K. (2014). *Chordate Embryology: Developmental Biology*. New Delhi: S. Chand & Company Ltd.
6. Gayatri Prakash (2007). *Reproductive Biology*. United Kingdom: Alpha Science International Ltd.

Semester II
Elective II (b): Bioinformatics
Sub. Code: PZ1725

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To understand the application of computer technology, to study and process the biological data.
2. To develop skills to use bioinformatics tools.

Unit I

Introduction to Bioinformatics. Basics of computer and Information Technology – parts of a computer, memory and operating system, Internet, search engines. Genomics – structural, comparative and functional. Proteomics – expression, structural and functional. Types of sequences used in Bioinformatics – DNA sequences, RNA sequences, Protein sequences. Applications of Bioinformatics.

Unit II

Bioinformatics Databases: Types of databases. Biological databases: nucleotide sequence databases - GenBank, DDBJ, EMBL, NCBI; Protein sequence databases – SWISS-PROT, Uniprot, TrEMBL; Structure databases – PDB, NDB, PubChem, ChemBank, CSD; Bibliographic databases- MEDLINE, PUBMED. Database programs –DBMS and RDBMS. Data retrieval systems – SRS, ENTREZ and DBGET.

Unit III

Sequence Analysis: Sequence alignment and alignment programs; Comparison of two sequences – Dot Matrix analysis; Scoring schemes – PAM Matrices and BLOSUM Matrices; Dynamic programming – Needleman-Wunch algorithm, Smith-Waterman algorithm, BLAST and FASTA; Multiple Sequence Alignment, ClustalW; Storing alignments.

Unit IV

Drug Designing: Drug discovery process – drug target identification, target validation, Lead compound identification, Lead optimization, Docking (importance, mechanics of docking, docking sites), Quantitative structure-activity relationship. Preclinical and clinical development. Medical informatics: Hospital management and information system, computer based patient records, computer assisted surgical techniques, searching and retrieval of medical literature.

Unit V

Phylogenetic analysis: Molecular phylogenetic analysis; methods of phylogenetic analysis - phenetic and cladistic; phylogenetic trees, methods for determining evolutionary trees – maximum parsimony, distance and maximum likelihood; phylogenetic software resources. Programming for bioinformatics: IT fundamentals, operating systems, programming concepts, HTML, web technologies, common gateway interface.

Reference Books

1. Gladis Helen Hepsyba, S. & Hemalatha, C.R. (2009). *Basic Bioinformatics*. Chennai: MJP Publishers.
2. John De Britto, A. (2011). *Bioinformatics*. Sivakasi; Anto Art Craft Printers.
3. Sundaralingam, R. & Kumaresan, V. (2008). *Bioinformatics*. Nagercoil: Saras Publication.
4. Jin Xiong (2006). *Essential Bioinformatics*. USA: Cambridge University Press.
5. Hooman H. Rashidi & Lukas K. Buehler (2000). *Bioinformatics Basics: Application in Biological Science and Medicine*. New York: CRC Press.
6. Mohan Bansal, A.S. (2003). *Medical informatics – A primer*. New Delhi: Tata McGraw-Hill Publishing Company Ltd.

Semester I
Practical I (Biochemistry, Cell and Molecular Biology and Culture and Capture Fisheries)
Sub. Code: PZ17P1

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To design and perform biochemical and cell biological experiments.
2. To provide laboratory skills to identify the aquatic organisms and the physico-chemical parameters for sustainable aquaculture.

Biochemistry

1. Colorimetry- verification of Beer-Lambert's law.
2. Determination of pH of the given sample using pH paper and pH meter.
3. Quantitative estimation of glucose (Blood/Tissue).
4. Quantitative estimation of protein.
5. Quantitative estimation of Total lipid (Blood/Tissue).
6. Quantitative estimation of ascorbic acid.
7. Quantitative estimation of blood urea.
8. Determination of salivary amylase activity in relation to temperature, pH and enzyme activity.
9. Determination of salivary amylase activity in relation to temperature, pH and enzyme activity Electrophoresis - SDS - PAGE (Demonstration).

Instruments/ Charts/ Models

Colorimeter, pH Meter, Centrifuge, Chromatogram, Electrophoretic unit

Cell and Molecular Biology

1. Isolation and observation of sub cellular organelles.
2. Observation of mitosis from onion root tip.
3. Observation of meiosis from grasshopper testis.
4. Observation of polytene chromosome from the salivary gland of Chironomous larva.
5. Barr-body identification.
6. Observation of striated muscle fibre from the coxal muscle of cockroach.
7. Observation of adipocytes from the fat body of cockroach.
8. Haemolymph smear (Cockroach).
9. Blood smear (Human).

Spotters/ Slides:

Fluid mosaic model, Golgi complex, Cancer cell, Cadherins, Karyotype, Haemocytometer.

Culture and Capture Fisheries

1. Morphometry of a pond.
2. Estimation of fish population by Mark and Recapture method using beads.
3. Length- weight relationship of fish *Oreochromis mossambicus*.
4. Morphological features of penaeids and nonpenaeids.
5. Identification of aquatic weeds, insects and predators.
6. Sex identification in fishes and prawn.
7. Determination of age and growth in fishes (scales).
8. Fish pathology – White spot- Tail rot – Costiasis - Anchor worm- Saprolegnia
9. Taxonomic description of the following - Indian major carps: *Catla catla*, *Labeo rohita*, *Cirrihinus mrigala*. Exotic carp: *Cyprinus carpio*, Silver carp: *Hypophthalmichthys molitrix*. Grass carp: *Ctenopharyngodon idella*. Cat fishes: *Clarius batrachus*, *Heteropneustes fossilis*. Other cultivable fishes: *Channa punctatus*, *Channa morulius*. Prawns, lobsters, crabs and oysters.
10. Visit to a coastal / aquaculture research centre (report).

Semester II
Practical II (Biostatistics, Computer applications and Bioinformatics, Genetics and Evolution & Research Methodology)
Subject code: PZ17P2

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To design an experimental problem and evaluate critically with inferential biostatistics and necessary computer skills.
2. To understand the mechanism of heredity, evolution and population genetics.

Biostatistics, Computer applications and Bioinformatics

1. Collection of data - insect population in the campus.
2. Graphical representation of collected data.
3. Diagrammatic representation of collected data.
4. Measures of central tendency: mean, median and mode.
5. Measures of dispersion- Standard deviation and standard error.
6. Correlation co-efficient – height - weight relationship, length and width of molluscan shells.
7. Study of probability using coin tossing with 2 and 3 coins and chi square test
8. Regression Analysis.
9. Test of significance (student's *t*-test).
10. Preparation of graph using M.S. Excel.

Charts/ Models

NCBI, SWISS-PROT and PubMed

Genetics and Evolution

1. Demonstration of monohybrid and dihybrid cross using beads.
2. Identification of sex and mutant forms of *Drosophila*.
3. Calculation of gene frequencies using Hardy-Weinberg equilibrium - ABO blood group.
4. Demonstration of natural selection using beads.
5. Demonstration of genetic drift using beads.
6. Analysis of variation in finger print patterns.
7. Study of homologous organs (fore limbs and hind limbs of vertebrates).
8. Study of analogous organs (wings of animals).
9. Adaptive radiation - beaks in Birds.

Specimens / Charts / Models / Photographs

Karyotype of syndromes, Pedigree chart, Fossils (Ammonite, Trilobite, Nautiloid fossil), Living fossil (*Limulus*, *Peripatus*), Connecting link (*Archaeopteryx*), leaf insect, stick insect.

Research Methodology

1. Whole mount preparation of five specimens.
2. Separation of amino acids using thin layer chromatography.
3. Sectioning and staining of a tissue.
4. Separation of pigments by column chromatography using plant extract (Demonstration).
5. Gel electrophoresis (Demonstration).

Instruments/ Charts/ Models

Phase contrast microscope, fluorescent microscope, pH meter, centrifuge, spectrophotometer, flame photometer, microtome, Chromatography column, electrophoretic apparatus, Index card.

Semester III
Core VII - Physiology
Sub. Code: PZ1731

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To impart knowledge on the structure and functions of various organs, organ systems and also to know about the associated disorders.
2. To get job in diagnostic centers, research and academic institutions.

Unit I

Nutrition: types of nutrition and feeding mechanisms in animals. Digestion - Functional anatomy of the digestive system (human), Movements of gastrointestinal tract, Secretory functions of the alimentary tract and glands, Digestion and absorption. Metabolism of protein, carbohydrate and lipid. Balanced diet – Malnutrition - Energy balance – BMR. Gastrointestinal disorders: Gall stones, liver cirrhosis, gastritis, peptic ulcer and appendicitis.

Unit II

Respiration and Homeostasis: Respiratory organs and respiratory pigment in animals, Physiological anatomy of the respiratory system (human), Transport of respiratory gases, Regulation of respiration, Respiratory problems - bronchial asthma, pneumonia and pulmonary tuberculosis. Homeostasis: Osmoregulation - types and mechanism. Thermoregulation – classification, thermoregulatory mechanism in animals, aestivation and hibernation, Deep sea physiology, High altitude and space physiology, Effects of exposure to cold and heat. Bioluminescence – physiology and functions.

Unit III

Circulation: Components and functions of blood, Blood clotting. Haemopoiesis. Myogenic and neurogenic heart. Functional anatomy of human heart, Cardiac cycle, pacemaker, heart rate, Bradycardia and tachycardia, Regulation of cardio-vascular system. Blood pressure, sphygmomanometer, Electrocardiogram (ECG), Heart diseases (Atherosclerosis, coronary thrombosis and angina pectoris). Lymphatic system - organization, composition of lymph and functions.

Unit IV

Neuro-muscular system: Structure of the brain and neuron, Neurotransmitters, Synapse, Nerve impulse conduction, Reflex activity, Inborn and conditioned reflex actions, Electroencephalogram. Neural disorders - Meningitis and epilepsy. Types of muscle, structure and properties of skeletal muscle, Mechanism of muscle contraction, Neuromuscular junction. Sense organs - Structure and functions of skin, eye and ear.

Unit V

Excretion and Reproduction: Excretory organs in different groups of animals, Patterns of excretion, Structure and function of kidney (human), Nephron, Formation of urine, Micturition, Renal disorders – nephritis, renal calculi, Dialysis. Structure of testis and ovary (human), oestrus and menstrual cycle, ovulation, pregnancy, parturition and lactation, hormonal regulation of reproduction.

Reference Books

1. Sembulingam, K. and Prema Sembulingam (2013). *Essentials of Medical Physiology* (6th

- ed.). Bangalore: Jaypee Brothers Medical Publishers Pvt. Ltd.
2. Guyton and Hall (2010). *Textbook of Medical Physiology* (12th ed.). Philadelphia: John E. Hall, Saunders Elsevier.
 3. Elaine N. Marieb (2003). *Human Anatomy and Physiology* (6th ed.). San Francisco: Daryl Fox publisher.
 4. Sawant, K.C. (2011). *Human Physiology*. New Delhi: Wisdom Press/ Dominant Publishers and Distributors Pvt Ltd.
 5. Sarada Subrahmanyam and Madhavankutty, K. (2001). *Text Book of Human Physiology* (6th ed.). New Delhi: S. Chand and Company Ltd.
 6. William. S. Hoar (1984). *General and Comparative Animal Physiology* (2th ed.). Prentice Hall of India.
 7. Prosser, C. L. (1991). *Comparative Animal Physiology* (4th ed.). United States: John Wiley and Sons Ltd.
 8. Nielsen Knut Schmid (2007). *Animal Physiology, Adaptation and Environment* (5th ed.). New Delhi: Cambridge University Press.
 9. Nagabushnam, R., Kadarkar, M.S. and Sarojini, R. (2002). *Textbook of Animal Physiology*. New Delhi: Oxford and IBH Publishing Company.
 10. Sobti, R.C. (2008). *Animal Physiology*. New Delhi: Narosa Publishing House Pvt. Ltd.
 11. Rastogi, S.C. (2007). *Essentials of Animal Physiology* (6th ed.). New Delhi: JBA Publishers.

Semester III
Core VIII - Immunology
Sub. Code: PZ1732

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To facilitate the students to understand and appreciate the defense functions of the immune system.
2. To develop the skill to determine the immunomodulatory strategies used to enhance or suppress the immune response.

Unit I

Immune System in Invertebrates and Vertebrates: Immunity - Innate and acquired, II, III and IV line of defense. Types – natural and artificial - active and passive immunity; Lymphoid organs and cells involved in immune response. Antigens and Immunoglobulins – characteristics, haptens, types. Immune Response: Humoral and Cell mediated immune response - primary and secondary immune response, importance of B cells in humoral immune response (antibody formation), factors influencing antibody formation. Immunological memory (Anamnesis). Immunization: immunization schedule and vaccines.

Unit II

Major and Minor Histocompatibility Complex: MHC class I and II molecules, cellular distribution and regulation of MHC expression, MHC in immune responsiveness, MHC and susceptibility to infectious diseases. Minor histocompatibility (H) antigens. Immune effector mechanisms: Cytokines and their functions, Complement system – classical and alternate pathways, biological functions.

Unit III

B and T Cell: B cells - Maturation, activation and differentiation - B cell receptor (BCR) - B cell co-receptor complex - signal transduction from B cell antigen receptor, major pathways of BCR signaling. T cells - maturation, activation and differentiation, T cell receptor (TCR), T cell co-receptor complex - formation of T and B cell conjugates, Co-stimulation in T cell response and signal transduction. Clonal anergy. Antigen processing and presentation – role of antigen presenting cells – cytosolic pathway and endocytic pathway.

Unit IV

Immune System in Health and Diseases: Tumour immunology - properties of tumour cells, causes of tumours, tumour antigens, immune response to tumour, immune surveillance, immunodiagnosis of tumour antigens, immuno therapy of tumour. Hypersensitivity: factors causing hypersensitivity, Type I, II, III, and IV reactions. Immunodeficiency - primary and secondary. Autoimmune diseases - characteristics, causes, classification, localized (Diabetes mellitus, Addison's disease) and systemic (systemic lupus erythematosus, rheumatoid arthritis). Immune response to infectious diseases and treatment - Protozoan disease (Malaria), Bacterial disease (Tuberculosis), Viral disease (AIDS).

Unit V

Antigen-antibody Interaction: strength, affinity, avidity and cross reactivity. Complement fixation test - precipitation reaction in fluids and precipitin curve. Radial

immunodiffusion and double immunodiffusion. Immuno-electrophoresis – counter and rocket electrophoresis. Agglutination reaction - hemagglutination, bacterial agglutination, coated particle agglutination, agglutination inhibition. Radio immuno assay - ELISA – Western blotting - Immunofluorescence - Flow cytometry. Transplantation: classification of grafts, mechanism of graft rejection, graft versus host reaction, immuno suppressive therapy during transplantation.

Reference Books

1. Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2007). *Kuby's Immunology* (6th ed.). New York: W.H. Freeman and Company.
2. Delves, P., Martin, S., Burton, D., Roitt I.M. (2006). *Roitt's Essential Immunology* (11th ed.). Oxford: Wiley-Blackwell Scientific Publication.
3. Ashim, K., Chakravarthy (2007). *Immunology and Immunotechnology* (2th ed.). Delhi: Saurabh Printers Pvt. Ltd.
4. Dasgupta, A. (1992). *Modern Immunology* (2th ed.). New Delhi: Jaypee Brothers Medical Publications Pvt. Ltd.
5. Gupta, S.K. (1991). *Immunology perspectives in Reproduction and Infection*. New Delhi: Oxford and IBH publication Co. Pvt. Ltd.
6. Hannigan, B.M., Moore, C.B.T. and Quinn, D.G. (2010). *Immunology* (2th ed.). India: Viva Book Pvt. Ltd.
7. Rao, C.V. (2006). *Immunology* (2th ed.). Chennai: Narosa Publishing House.
8. Murphy, K., Travers, P. and Walport, M. Garland (2008). *Janeway's Immunobiology* (7th ed.). New York: Science Publishers.

Semester III
Elective III (a): General Endocrinology
Sub. Code: PZ1733

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To learn how the endocrine system functions under normal circumstances, as well as the pathologies that arise when homeostasis fails.
2. To get job in clinical laboratory and endocrine research institutes.

Unit I

Introduction: Historical perspective and scope of endocrinology. Endocrine methodologies - assay of hormones, surgical methods, radioisotope studies, pharmacological methods, and replacement therapy and animal models for research. Chemical messengers - neurocrine, paracrine, autocrine, endocrine, pheromones and chalone.

Unit II

Neurosecretion and Neuroendocrine mechanisms: Neuroendocrine integration-evolution of regulatory mechanisms and endocrine control of neural function. Neuroendocrine mechanisms and functions in insects, crustaceans and non-arthropod invertebrates. Analogous neurosecretory systems of invertebrates and vertebrates.

Unit III

Endocrine glands and hormones: Organization of the endocrine system - classification of hormones - structure, functions and patho-physiology of hypothalamus, pituitary, thyroid, parathyroid, adrenal, pancreas, gonads. Gastro-intestinal hormones.

Unit IV

Hormone synthesis and mechanism of Hormone action: Biosynthesis, storage and release of amine (catecholamines and thyroxine), protein (growth hormone and insulin) and steroid hormones (sex hormones). Mechanism of hormone action - receptors (membrane and cytosolic) - second messengers, signal transduction, termination of hormone activity. Pathophysiological correlates of hormone action. Endocrine disorders due to receptor number and function. Hormonal therapy.

Unit V

Endocrine Integration: Diffuse effect of hormones - Hormonal regulation of growth, development and metabolism, reproductive cycle and pregnancy, parturition and lactation, migration (birds and fishes), behavior and hibernation, neoplastic growth, colour change in vertebrates.

Reference Books

1. Mac E. Hadley and Jonathan Levine (2009). *Endocrinology*. India: Pearson Education (Singapore) Pvt. Ltd.
2. Aubrey Gorbman and Howard A. Bern (1974). *A textbook of Comparative Endocrinology*. Bombay: John Wiley and Sons, Inc. Wiley Eastern Pvt. Ltd.
3. Barrington, E.J.W (1975). *An Introduction to General and Comparative Endocrinology*, 5th Ed. London: Oxford University Press.
4. Donnell Turner, C. and Joseph T. Bagnara, W.B. (1976). *General Endocrinology* (6th ed.). Philadelphia: Saunders Company.
5. James Griffin and Sergio R. Ojeda (1988). *Textbook of Endocrine Physiology*. London: Oxford University Press.
6. Prakash S. Lohar (2005). *Endocrinology: Hormones and Human Health*. Chennai: MJP Publishers.

Semester III
Elective III (b): Health Care
Sub. Code: PZ1734

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To make the students realize the importance of the health of the body, develop a healthy personality so as to live a healthy and successful life.
2. To acquire independent employable skills in voluntary organizations or in health sectors.

Unit I

Concept of health and well-being: Definition – Physical, mental, social and positive health – Quality of life. Determinants of health: Heredity – Environment – Lifestyle – Socio-economic conditions – Health services. Nutrition and Health: Nutrients that provide energy – Carbohydrates – Lipids – Proteins. Nutrients that regulate: Vitamins – Minerals – Water. Healthy diet – Food guide Pyramid – Snacking – Vegetarian diet – Fast food.

Unit II

Personal Health Care: Protecting skin – common skin problems – Dry Skin, Acne, Dermatitis, Psoriasis, skin infections – skin cancer - caring for the skin. Hair – General care, cleaning tips, preventing hair loss, Anti dandruff strategies. Teeth – Common dental problems – General care of teeth – Dental check up. Eye – Common eye problems – Eye diseases – General care of eyes – Vision check up. Ear – general care – do's and don'ts.

Unit III

Maternal and Child Health: Motherhood – pregnancy confirmation test – Prenatal care – Intra natal care – problems during pregnancy – Miscarriage and stillbirth – premature birth – labor and delivery - Family planning. Child health: Care of the newborn – Feeding – Nutritional guidelines - Care of the under-five (Toddler and Preschool).

Unit IV

Environmental and Mental Health: Mental health: Characteristics – Types: Schizophrenia – Manic depressive psychoses – Paranoia – Neurosis – Personality and character disorders. Environmental health: health in the home environment – pollution at home – diseases. Safety at home: Fall – Fires – Poisoning – Electrical hazards - Safety in road (Auto mobile – Pedestrian) - Disaster management (Severe weather condition – Flood- Lightning – Cyclone – Earthquake - Landslides- Tsunami).

Unit V

Alternative medicine and First aid: Naturopathy – Homeopathy- Ayurveda – Unani – Siddha. First aid: First aid procedures for dehydration – heart attack – fractures and dislocation, burns – bleeding – poisoning – electric shocks – drowning.

Reference Books

1. Park, K. (1995). *Park's Textbook of preventive and social medicine*. Jabalpur: M/S Banarsidas Bhanot Publishers.
2. Getchell, Pippin and Varnes (2006). *Perspectives on Health*. USA: D C Heath & Co.
3. Lakshmana Sarma and Swami Nathan. S. (1960). *Speaking of nature cure – Regain, retain and improve health the drugless way*. New Delhi: Sterling Publications Pvt. Ltd.
4. Tom Sanders and Peter (2004). *Emergy Molecular basis of human nutrition*. London: Taylor and Francis Publishers.

Semester IV
Core IX - Microbiology
Sub. Code: PZ1741

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To know about the microbes in and around us and recognize their role in industrial production of valuable products, environmental management, biomining and also about the diseases caused by them.
2. To provide careers in industries, clinical laboratories, agricultural establishments, research institutes and Universities.

Unit I

Introduction: History and scope, classification of microorganisms, Whittaker's five kingdom classification, three domain classification. Virus - General properties, structure of viruses, viral taxonomy, bacteriophages, reproduction of DNA and RNA phages, temperate bacteriophages and lysogeny, cytocidal infections and cell damage, persistent, latent and slow virus infections. Cultivation of viruses and purification assays. Viruses and cancer. Viroids and prions.

Unit II

Bacteria: Classification, Bergey's system of bacterial classification, Bacterial morphology and fine structure of *Escherichia coli*. Bacterial nutrition - Common nutrient requirements, Nutritional classes, Uptake of nutrients. Bacterial growth and measurement of growth - Influence of environmental factors on growth, Synchronous growth, Continuous culture, Chemostat and turbidostat. Types of culture media - Pure culture and methods of isolating pure cultures (streak plate technique and pour-plate technique).

Unit III

Industrial Microbiology: Fermentation and microbes - fermenter and types of fermenters (air-lift fermenter and stirred tank fermenter). Production of microbial products - alcohol (ethanol), antibiotics (penicillin), vitamin B₂ and Vitamin B₁₂. Biofertilizers - steps for preparing bacterial biofertilizers, mass cultivation of Cyanobacteria and *Azolla*, production of mycorrhizal fungi and VAM fungi. Bacterial insecticides - *Pseudomonas* species and *Bacillus* species. Food spoilage and food preservation.

Unit IV

Environmental Microbiology: Drinking water and microbiological analysis of water purity - Coliform test, Most Probable Number (MPN) test, and Membrane Filter (MF) test. Purification of water. Sewage treatment - small scale, large scale (primary, secondary and tertiary) treatment. Biogas production - solubilization, acetogenesis and methanogenesis. Microbial leaching - copper and uranium leaching. Biodegradation of petroleum and xenobiotics.

Unit V

Antimicrobial Agents: classification, Drug administration, determination of antimicrobial activity, mechanism of antimicrobial agents, effectiveness of antimicrobial drugs, drug resistance, drug dosage, antibacterial drug (penicillin), antifungal drug (nystatin), antiviral

drug (amantadine). Current problems of antibiotic resistance in man. Microbes and diseases - Gnotobiotic animals, distribution of normal micro biota of the human body, Mechanism of microbial pathogenesis, Nosocomial infections. Protozoan diseases - Malaria and Amoebiasis. Fungal diseases - Mycotoxicosis and Aspergillosis. Bacterial diseases - Air borne diseases – Meningitis and Streptococcal pneumonia. Food and water borne diseases - Cholera and Typhoid. Soil borne diseases - Tetanus and Anthrax. Sexually transmitted and contact diseases – Gonorrhoea and Syphilis. Viral diseases - Ebola, Hepatitis-B, Rabies and AIDS.

Reference Books

1. Dubey R.C. and Maheswari, D.K. (2010). *A textbook of Microbiology* (3rd ed.). 3rd Ed. New Delhi: S. Chand and Co.
2. John L. Ingraham and Catherine A. (2004). *Introduction to Microbiology*. UK: Inghram Thomson Books / Cole.
3. Pelzar, Chan and Krieg (2006). *Microbiology*. New Delhi: Tata McGraw Hill Publishing Company Ltd.
4. Joanne Willey, Linda Sherwood, Chris Woolverton (2013). *Prescott's Microbiology* (9th ed.). New York: WCB McGraw Hill Co.
5. Vijaya Ramesh, K. (2004). *Environmental Microbiology*. Chennai: MJP Publishers.
6. Powar, C.B. and Dagainawala, H.F. (2008). *General Microbiology*, Vol. 2. Chennai: Himalaya Publishing House.
7. Singh, R.P. (2007). *General Microbiology*. New Delhi: Kalyani Publishers.

Semester IV
Core X - Ecobiology
Sub. Code: PZ1742

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To provide the opportunity for students to develop a deep understanding of various aspects of the environment and apply that knowledge to current environmental issues and for wise environmental management.
2. To work productively with those within and beyond the academy on interdisciplinary collaborative projects.

Unit I

Introduction: Scope of Ecobiology and need for public awareness. **Ecosystem:** Concepts of ecosystem – structure and functions. Energy flows – single channel energy model, Y - shaped energy flow models. Productivity - Primary production, secondary production, measurement of primary productivity. Habitat ecology: freshwater, marine, estuarine, mangrove and terrestrial.

Unit II:

Population: Structure and regulation, growth form, population fluctuations, population processes. Life table - diagrammatic and conventional life tables, Life history strategies. **Community:** Concept, basic terms, community structure, composition and stratification. Ecological niche, Ecotone and Edge effect, Ecotype. **Ecological succession:** types, general process, Concept of climax.

Unit III

Environment in action: Climatic factors (climate, precipitation, temperature, light, oxygen, carbon dioxide and pH), topographic factors, edaphic factors (soil formation, soil profile, soil organisms), biotic factors (symbiosis, commensalism, parasitism and competition). **Biological clock:** biological rhythms and mechanism of biological clock. **Natural resource ecology:** Concept and classification of resource, mineral resource, land resource, forest resource, water resource, energy resource (conventional and non-conventional).

Unit IV

Biogeochemical cycles: water cycle, carbon cycle, nitrogen cycle, sulphur cycle and phosphorous cycle. **Biogeography:** patterns of distribution (continuous, discontinuous, endemic), descriptive zoogeography, zoogeographical regions of the world. Dynamic biogeography (dispersal dynamics, dispersal pathways, migration, ecesis). **Natural Disasters:** Floods, earthquakes, cyclones, landslides, Tsunami, Mitigation and Disaster Management. **Urbanization:** Possible advantages of urbanization – problems, solutions. Remote sensing and its applications.

Unit V

Pollution ecology: Causes, effects and control measures of air pollution, water pollution, soil pollution, noise pollution, thermal pollution, nuclear hazards. Green House Gas emission and climate change. **Waste management:** solid, liquid and gaseous wastes. e-wastes. **Toxicology:** Biomagnification and bioaccumulation, toxicants, classification, toxicity (LC₅₀ and LD₅₀), mode of action.

Reference Books

1. Eugene P. Odum, Murray Barrick, Gary W. Barret (2005). *Fundamentals of Ecology* (5th ed.). UK: Brooks/Cole Publishers.
2. Begon and Mortimer (1992). *Population Ecology*. Delhi: UBS Publishers.
3. Kormondy, Edward, J. (1994). *Concept of Ecology*. Delhi: Prentice Hall of India Pvt. Ltd.
4. Sharma, P.D. (1999). *Ecology and Environment*. Meerut: Rastogi Publications.
5. Dash, M.L. (1996). *Fundamentals of Ecology*. New Delhi: Tata McGraw Hill Publishing Company Ltd.
6. Trivedi, P.C. and Sharma, K.C. (2003). *Biodiversity Conservation*. Jaipur: Avishekar Publishers.
7. Trivedi, R.N. (1993). *Textbook of Environmental Sciences*. New Delhi: Anmol Publications Pvt. Ltd.
8. Shukla, S.K. and Srivastava, P.R. (1992). *Water Pollution and Toxicology*. New Delhi: Common-Wealth Publishers.
9. Subramanian, M.A. (2004). *Toxicology: Principles and methods*. Chennai: MJP Publishers.
10. Verma, P.S. and Agarwal V. K. (1986). *Principles of Ecology*. New Delhi: S. Chand & Co. Pvt. Ltd.

Semester IV
Core XI - Biotechnology and Nanobiology
Sub. Code: PZ1743

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To enable the students to understand the essence of biotechnology and become aware of the advances in Nanobiology.
2. To develop skill of technical proficiency in genetic manipulation to try to improve agricultural production, pharmaceutical products, medical treatment, or mitigation of environmental pollution.

Unit I

Gene Cloning: Basic steps of gene cloning, restriction and modifying enzymes, linkers and adaptors, cloning and expression vectors, construction of chimeric DNA, nucleic acid probes, DNA libraries, polymerase chain reaction, molecular markers, DNA sequencing, synthesis of oligonucleotides. Human Genome Project.

Unit II

Animal Biotechnology: Primary culture and cell lines, pluripotent stem cell lines, tissue engineering. *In vitro* fertilization and embryo transfer in animals; gene transfer methods. Primary explantation techniques – organ and embryo culture – transgenic animals and the knockouts. Biotechnology and aquaculture - ploidy induction, gynogenesis and androgenesis.

Unit III

Medical Biotechnology: Hybridoma technology and Monoclonal antibodies – Applications of biotechnology in medicine, Vaccines, diagnostics and forensics. Gene therapy – Pharmacogenomics. **Enzyme biotechnology:** Isolation and purification of enzymes, uses of enzymes in industries, immobilization of enzymes and their uses, Biosensors. Terminator and traitor technology. Intellectual Property Rights.

Unit IV

Industrial and Environmental Biotechnology: Production of metabolites - Downstream processing and *in situ* recovery of products, microbial biotransformation, microbial biomass production (SCP). Bioremediation and phytoremediation - Genetically engineered microorganisms (GEMs) - treating oil spills, detection of pesticide in soil and their degradation, sequestering heavy metals. Biomining and Biofuels.

Unit V

Nanomaterials: Types and properties, DNA and protein nanoarrays, biosystems (microbes) as nanofactories. Application of nanotechnology - medical diagnostics, imaging and drug delivery, agro-practices and food related nanoproducts, cosmetics, contact lenses and dental implants. Nanotechnological approaches for environmental remediation, prevention of contamination, environment maintenance and quality enhancement. Risks and threats of nanoparticles in environment.

Reference Books

1. Gupta P.K. (2009). *Elements of Biotechnology*. Meerut: Rastogi Publications.
2. Singh B.D. (2003). *Biotechnology - Expanding Horizons*. Chennai: Kalyani Publishers.
3. Satyanarayana V. (2004). *Biotechnology*. Kolkata: Books and Allied (P) Ltd.
4. Dubey R.C. (2006). *A Text Book of Biotechnology* (4th ed.). New Delhi: S. Chand and Co. Ltd.,
5. Rema L.P. (2006). *Applied Biotechnology*. Chennai: MJP publishers.
6. Prakash S. Lohar, (2012). *Biotechnology*. Chennai: MJP publishers.
7. Madhuri Sharon, Maheshwar Sharon, Sunil Pandey and Goldie Oza (2012). *Bio-Nanotechnology: Concepts and Applications*. New Delhi: Ane Books Pvt. Ltd.
8. Vinod Labhasetwar and Diandra. L. Leslie-Pelecky (2007). *Biomedical applications of Nanotechnology*. New Jersey: Wiley Publications.
9. Jo Anne Shatkins (2008). *Nanotechnology: Health and Environmental Risks*. New York: CRC Press.
10. Y.S. Raghavan (2010). *Nanostructures and Nanomaterials: Synthesis properties and applications*. New Delhi: Arise Publishers and distributors.
11. Parthasarathy, B.K. (2007). *Nanotechnology in Life Science*. New Delhi: Isha Books.
12. Rakesh K. Yadav (2009). *Investing in Nanotechnology*. New Delhi: Mangalam Publications.

Semester IV
Elective IV (a): Parasitology
Sub. Code: PZ1744

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To enable the students to be aware of the cosmopolitan distribution of parasites and vectors and their control measures.
2. To obtain job in clinical laboratories and health departments.

Unit I

Introduction: Historical perspectives - taxonomy and classification of parasites – origin and evolution of parasitism - host parasite relationship, classification of parasites and hosts– transmission of parasites – Parasitic zoonoses – pathogenesis - clinical manifestations of parasitic diseases.

Unit II

Protozoan parasites: Introduction and classification. Intestinal Amoeba - Pathogenic free living amoeba – Intestinal flagellates – Trypanosomiasis, Leishmaniasis, Balantoidiasis, Malaria, Isosporiasis, Toxoplasmosis, Cryptosporidiosis, Pneumocytosis. Protozoans of minor medical importance.

Unit III

Helminth parasites: Trichiuriasis, Trichinellosis, Strongyloidosis, Ascariasis, Enterobiosis, Filariasis, hook worm diseases, Dracunculiasis, Onchocerciasis, Loiosis – Larva migrants. Nematodes of lesser medical importance - Diphyllbothriasis, Taeniasis,

Echinococcosis, Sparganosis, Schistosomiasis, Fascioliasis, Fasciolopsiasis, Paragonimiasis, Clonorchiasis, Trematodes of minor medical importance.

Unit IV

Parasitic Insects: Prevalence, transmission and control of parasitic infections. Parasitic infection in compromised host. Applied Parasitology: Eosinophilia in parasitic infections, Nosocomial parasitic infections. Evasion and parasitic mode of life – morphological, biochemical and ethological adaptations. Quality assurance and laboratory safety.

Unit V

Diagnostic methods in parasitology: Microscopical examination of blood, stool, urine, sputum and biopsy material for parasites – general rules for microscopical examination. Cultural examination - preparation of media – techniques for cultivation of *E. histolytica*, Leishmania, Plasmodium. Immunodiagnostic methods – ELISA, AGD, IHA, IFAT, CFT, DAT, IB, WB, BF, DFAT. Molecular characterization of stage specific antigen nucleotide probes for diagnosis of protozoan diseases.

Reference Books

1. Cheng, C.T. (1964). *The Biology of Animal Parasites*. Tokyo: Toppan Company Ltd.
2. Chatterjee, K.D. (1981). *Parasitology*. Calcutta: Chatterjee Medical Publishers.
3. Rajesh Karyakarte and Ajit Damle (2008). *Medical Parasitology* (2nd ed.). Kolkata: Books and Allied (P) Ltd.
4. Ichhpujani R.L. and Rajesh Bhatia (2002). *Medical Parasitology*. New Delhi: Jaypee printers.
5. Patvaik, B.D. (2001). *Parasitic Insects*. Delhi: Dominant Publishers and Distributors.
6. Jones, A.W. (1976). *Introduction to Parasitology*. Boston, USA: Addison-Wesley Publishing Company.

Semester IV
Elective IV (b): Medical Entomology
Sub. Code: PZ1745

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To identify medically important arthropods by their general morphology and important characteristics, to describe their biology, ecology and geographical distribution, their roles in transmission of diseases and nuisance to public health and to describe and apply control methods for arthropod vectors.
2. To propose effective control measures to eradicate vector borne diseases and seek employment opportunities in health centers.

Unit I

Introduction: Fundamentals and scope of medical entomology - insects of medical importance: filth breeding insects, venomous insects, parasites of vertebrates, blood sucking insects, insects affecting physiology.

Unit II

Life Cycle of Human Parasitic Insects: Lice, fleas, mosquitoes, house flies and tsetse fly. Immunity to human parasites - host-parasitic relationships - ecological adaptive features among human parasitic insects.

Unit III

Vector Entomology: Scope - vector borne diseases - mechanism of transmission in human beings - mechanical, biological and myiasis - common vector insects and their identification: mosquitoes, sand flies, black flies, house fly, tsetse fly, human flea and human louse. Hard and soft tick, trombiculid mite, itch mite and Cyclops.

Unit IV

Medical Importance and Management: Lice - body, head and pubic louse; fleas - flea nuisance, plague, flea-borne endemic typhus; mosquitoes - nuisance, malaria, filariasis, yellow fever, dengue; house flies - common and greater house fly - typhoid, dysentery, diarrhea, cholera, amoebiasis, gastroenteritis; tsetse fly - Gambian and Rhodesian sleeping sickness.

Unit V

Vector Control: Insecticides - use and consequences. Use of bio-control agents and bio-pesticides - bacillus and predatory fishes. National programmes related to vector borne diseases - malaria - N.M.E.P., N.M.C.P – filarial - N.F.C.P. - N.F.E.P.

Reference Books

1. Bruce F. Eldridge and John D. Edman (2004). *Medical Entomology - A textbook of public health and veterinary probes caused by Arthropods*. Netherlands: Kluwer Academic Publishers.
2. Lance A. Durden (2002). *Medical and Veterinary Entomology* (3rd ed.). Cambridge: Academic Press.
3. Service, M.W. (2004). *Medical Entomology for Students* (3rd ed.). United Kingdom: Cambridge University Press.
4. Walter Scott Patton and Francis William Cragg (2008). *A textbook of Medical Entomology*. Montana, USA: Kessinger Publishing Pvt. Ltd.

Semester IV
Practical III (Physiology and Immunology)
Sub. Code: PZ17P3

No. of Hours per Week	Credits	Total No. of Hours	Marks
4	4	60	100

Objectives

1. To design experiments and apply it in physiological research.
2. To understand the various immune-techniques and apply in immunological experiments.

Physiology

1. Effect of temperature on heartbeat of Freshwater Mussel and calculation of Q_{10} .
2. Effect of temperature on salivary amylase activity and calculation of Q_{10} .
3. Effect of pH on salivary amylase activity.
4. Salt loss and salt gain in a freshwater fish.
5. Examination of excretory products of fish, bird and mammals.
6. Survey of digestive enzymes in Cockroach.
7. Counting of blood cells using haemocytometer.
8. Haemolysis of blood – Demonstration.
9. Observation of haemin crystals in blood.
10. Estimation of haemoglobin (any method).

Charts/ Slides/ Models/ Bookplates/ Instruments: EEG, ECG, Conditional reflex, Skeletal muscle, Kymograph, Sphygmomanometer, Intestine, Nervous tissue, Liver, Lungs, Heart, Kidney.

Immunology

1. Dissection of Lymphoid organs of a vertebrate (Demonstration).
2. Histology of lymphoid organs (Chart / CD).
3. Identification of various types of immune cells in peripheral blood smear.
4. Separation and preparation of cellular antigen (RBC and bacteria).
5. Methods of immunization- Intravenous, intraperitoneal and subcutaneous routes.
6. Methods of blood collection and serum preparation.
7. Antigen antibody interaction: Blood typing and Haemagglutination.
8. ELISA test (Demonstration).
9. Radial immunodiffusion.
10. Double immunodiffusion.

Spotters

Immuno-electrophoretic apparatus, Semi dry blotting apparatus, Counter current immuno-electrophoresis (chart), Rocket immuno-electrophoresis (chart).

Semester IV
Practical IV (Microbiology, Ecobiology & Biotechnology and Nanobiology)
Sub. Code: PZ17P4

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To acquire and demonstrate competency in laboratory safety and in routine microbiological and biotechnological techniques.
2. To recognize and apply methodological approaches of Ecobiology.

Microbiology

1. Sterilization of glassware.
2. Preparation of culture media.
3. Isolation of bacteria from soil, air and water.
4. Serial dilution – pure culture of soil bacteria.
5. Observation of bacterial motility - hanging drop method.
6. Simple staining of bacteria.
7. Gram's staining of bacteria.
8. Negative staining of bacteria.
9. Methylene blue reductase test for testing the quality of milk.
10. Test for antibiotic sensitivity.

Slides/ Charts/ Models:

Streptococcus, Salmonella, Corynebacterium, Clostridium, Influenza virus, Rabies virus, Hepatitis-B, HIV, *Entamoeba, Aspergillus*, root nodules (*Rhizobium*), *Azolla*, Ocular and stage micrometer, Autoclave, Laminar air flow.

Ecobiology

1. Measurement of primary productivity (O_2 measurement method).
2. Sampling of animal population using the quadrat method.
3. Observation of life table in an insect.
4. Collection and identification of freshwater planktons.
5. Measurement of turbidity using Secchidisc.
6. Determination of LC_{50} of a pesticide.
7. Estimation of H_2S in water sample.
8. Estimation of salinity in water sample.
9. Estimation of CO_2 in water sample.
10. Study report of a pond ecosystem.

Specimen/ Chart/ Models

Commensalisms (Shark and *Echeneis*), Mutualism (Sea anemone and Hermit crab), Food chain, Food web, Conventional energy source (coal) and non-conventional energy source (wind mill).

Biotechnology and Nanobiology

1. Extraction of genomic DNA.
2. Estimation of DNA (DPA method).
3. Agarose gel electrophoresis in separation of DNA (démonstration only).
4. Polymerase chain reaction (démonstration only).

5. Bacterial culture and antibiotic selection media.
6. Immobilization of yeast cells.
7. Préparation of wine.
8. Estimation of éthanol content in wine.
9. Production of amylase by bacteria.

Flow charts/ Instruments/ Figures

Plasmid DNA isolation, Insulin production by rDNA Technology, Hybridoma production, Synthesis of DNA nanoarray, Southern blotting, Biosensor (glucometer), Air-lift bioreactor, Bucky balls, Dendrimers.