

ZOOLOGY

M.Sc. Syllabus

| Paper No | Title | Total Credits |
|--|--|---------------|
| SEMESTER-I | | |
| ZOO-PG-T101 | Functional biology of Non-chordates, Chordates | 4 |
| ZOO-PG-T102 | Biosystematics, Ecology, Biostatistics | 4 |
| ZOO-PG-T103 | Biochemistry, Endocrinology | 4 |
| ZOO-PG-P104 | Practicals –Non-Chordates, Chordates, Ecology, Biochemistry, Endocrinology | 4 |
| Total Credits | | 16 |
| SEMESTER-II | | |
| ZOO-PG-T201 | Molecular Biology, Biotechnology, Immunology | 4 |
| ZOO-PG-T202 | Genetics, Evolutionary Biology | 4 |
| ZOO-PG-T203 | Developmental Biology, Parasitology | 4 |
| ZOO-PG-P204 | Practicals - Immunology, Genetics, Developmental Biology, Parasitology | 4 |
| Total Credits | | 16 |
| SEMESTER-III | | |
| ZOO-PG-T301 | Cell Biology, Techniques in Biology, Bioinformatics | 4 |
| ZOO-PG-T302 | Animal Physiology | 4 |
| Elective Theory (Any One from Theory) | | |
| ZOO-PG-T303 | Applied Ecology, Climate Change Biology | 4 |
| ZOO-PG-T304 | Immunobiology and Parasitology-I | |
| ZOO-PG-P305 | Practicals – Cell Biology, Techniques in Biology, Animal Physiology | 4 |
| Total Credits | | 16 |
| SEMESTER-IV | | |
| Elective Theory and Practical (Any Two from Theory & One from Practical groups) | | |
| ZOO-PG-T401 | Biodiversity, Conservation Biology | 4 |
| ZOO-PG-T402 | Immunobiology and Parasitology-II | |
| ZOO-PG-T403 | Wildlife Biology, Animal Behaviour | 4 |
| ZOO-PG-T404 | Immunobiology and Parasitology-III | |
| ZOO-PG-P405 | Practicals – Biodiversity, Wildlife Biology, Animal Behaviour | 4 |
| ZOO-PG-P406 | Practical – Immunobiology and Parasitology | |
| ZOO-PG-D-407 | Dissertation and Viva-Voce | 4 |
| Total Credits | | 16 |

Abbreviations:

CT – Core Theory; CP- Core Practical; OT-Open Theory; ET-Elective Theory; EP-Elective Practical; DV- Dissertation and Viva Voce

SEMESTER - I

ZOOPG-CT-101: FUNCTIONAL BIOLOGY OF NON-CHORDATES, CHORDATES

Total Max. Marks-100

Total Credit-04

UNIT I – FUNCTIONAL BIOLOGY OF NON-CHORDATES

Hydrostatic movements in Cnidaria, Annelida and Echinodermata; Significance of segmentation with reference to locomotion in Annelids.

Excretory organs in mollusks and echinoderms.

Reproductive organs and life history of major crustaceans, decapods and echinoderms.

Origin of multicellularity, cephalization, trend of neural evolution in non-chordates.

Defence mechanism in Cnidaria and Mollusca.

UNIT II – ENTOMOLOGY

Insect classification upto orders with characters and examples.

Adaptive radiations in insects with reference to trophic relation.

Insect developmental hormones in cockroach and silkworm: sources, biosynthesis, transport, mode of action and regulation of their titers.

Life cycle strategies in social insects and aphids.

Communications in insects.

UNIT III – FUNCTIONAL BIOLOGY OF CHORDATES-I

Skull in vertebrates: structural and evolutionary approach.

Anatomical features of desert animals (camels, *Phrynosoma*).

Central Nervous System (CNS): cranial nerves, functional associations, information processing.

Sensory organs in mammals; Auditory system and its evolutionary changes.

Stomach in ruminants.

UNIT IV – FUNCTIONAL BIOLOGY OF CHORDATES-II

Aquatic adaptations in birds and mammals, cave adaptation, deep sea adaptation.

Aerodynamics in birds.

Echo location in bats.

Integuments in reptiles and mammals.

Circadian rhythm.

Suggested Reading

1. Anderson, D.T. (2001) *Invertebrate Zoology*. Oxford University Press.
2. Ruppert, E. E., Fox, R. S. & Barnes, R. D. (2004) *Invertebrate zoology: a functional evolutionary approach* (7th edition). Belmont, CA: Thomas-Brooks.
3. Chapman, R. F. (2012) *The Insects: Structure and Function*. Cambridge University Press.
4. Gullan, P. J & Crasston, P. S. (2010) *The Insects: An Outline of Entomology*. Wiley Blackwell Publisher
5. Klowden, M. J. (2013) *Physiological system in Insects*. Academic Press.
6. Price, P. W. (1997) *Insect Ecology*. Wiley Blackwell Publisher.
7. Pugh, Heifer & McFarland (1999) *Vertebrate life*. 4th End. Prentice-Hall of India, New Delhi.
8. R.F. Schmidt & Thaws (1989) *Human Physiology*, (Eds.), 2nd End. Springer-Vela, Berlin.
9. K. Kardong (2011) *Vertebrates: Comparative Anatomy, Functions, Evolution*, 6th Ed. McGraw-Hill Science.
10. Thangamani et al (2013) *A Text Book of Chordates*. Saras Publication

UNIT I - BIOSYSTEMATICS

Procedures of taxonomy: alpha, beta and gamma taxonomy.

Classification: species and supra and infra species categories, cryptic, polytypic and sibling species, apomictic and panmictic populations.

Rules of zoological nomenclature: nomenclature at species and higher categories, types, homonyms and synonyms.

Phenetics and cladistics classification.

Molecular taxonomy: DNA barcoding, use of genetic markers, determination of genetic distance.

UNIT II – ECOLOGY

Population ecology: population regulation - extrinsic and intrinsic mechanisms, oscillation, dispersal, competitive exclusion principle.

Concept of metapopulations: theories and applications.

Life history strategy: r-selection, k-selection.

Construction of life table, survivorship curves.

Plant-animal interactions, evolution of plant-pollinator relationships.

UNIT III – BIODIVERSITY AND WILDLIFE

Types of biodiversity: species, genetic and ecosystem.

Geographical level biodiversity: local and regional diversity, β -diversity.

Measurements of biodiversity: dominance indices, diversity indices (Shannon-Weiner, Brillouin index), similarity index.

Macroecological patterns: vertical zonation of vegetation with special reference to the Himalayas, faunal diversity patterns: altitudinal and latitudinal gradients.

Major threats to biodiversity of the world.

Introduction to biodiversity hotspot.

Importance of wildlife and rationale for their conservation.

In Situ and *Ex Situ* conservation: prospects and limitations

UNIT IV – BIOSTATISTICS

Probability distribution: concept, normal, binomial and Poisson's distribution.

Hypothesis testing.

Statistical tests: correlation and regression analyses (linear and non-linear, meanings of intercept, slope and intercept values), student's "t" test (paired and unpaired), Mann-Whitney 'U' Test, ANOVA.

Models: types of models, empirical, mechanistic, stochastic, deterministic.

Suggested Reading

1. Odum, E.P. (1983). Basic Ecology. Saunders, Philadelphia.
2. Smith, R.L. and T.M. Smith (2002) Ecology and Field Biology. Addison – Wesley Educational Publishers Inc.
3. Ricklefs, R.E. and G.L. Miller. (1999) Ecology. W.H. Freeman & Company.

4. M. Kato. (2000) *The Biology of Biodiversity*. Springer.
5. Kothari, A.S. & Chapgar. (2005) *Treasure of Indian Wildlife*, BNHS, Mumbai.
6. B. B. Hosetti. (2005) *Concepts in Wildlife Management*. 2nd Revised & Enlarged Edn, 2005. Daya Publishing House, Delhi.
7. Sharma, A.K. (2005). *Text Book of Biostatistics*. Vol. I. Discovery Publishing House.
8. Sokal, R.R. & Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W. H. Freeman.
9. Slater, P.J.B and Milinski, M. (1996) *Parental Care: Evolution, Mechanisms, And Adaptive Significance*. Academic Press.
10. Wells, K.D. (2007) *Ecology and Behaviour of Amphibians*. The University of Chicago Press.

ZOOPG-CT-103: BIOCHEMISTRY, ENDOCRINOLOGY

Total Max. Marks-100

Total Credit-04

UNIT I – BIOCHEMISTRY-I

Bioenergetics and metabolism: principles of glycolysis with regulation, citric acid cycle with regulation, glycogenolysis, gluconeogenesis, HMP-shunt pathway, amino acids: transamination and deamination reactions, oxidative phosphorylation in mitochondria, β -oxidation of fatty acids.

Protein structure: Ramachandran plot.

UNIT II – BIOCHEMISTRY-II

Enzymology: introduction to enzymes, classification, structure and properties, energetics of enzyme-catalyzed reaction, effects of different physico-chemical factors on enzyme activity. Enzyme kinetics: Michaelis-Menten equation and its derivation, Lineweaver-Burk plot, significance of K_m , simple calculation on enzyme kinetics; Inhibition of enzyme, allosteric enzyme, isoenzyme, ribozyme.

UNIT III – ENDOCRINOLOGY-I

Vertebrate endocrine system: concept of neurosecretion, neurosecretory centres; Hypothalamus, pineal and thymus and their hormones.

Hypophysis: neurohypophysis and adenohypophysis - structure, function and hormones.

Molecular mechanism of steroid and peptide hormone actions.

Chemistry and biosynthesis of steroid hormones, thyroid hormones and melatonin.

UNIT IV – ENDOCRINOLOGY-II

Hormone receptors: characteristics and types of receptors, membrane-bound and intra-cellular receptors; Receptor recycling.

Hormone-receptor complex and signal transduction mechanism.

Regulation of estrous and menstrual cycles by hormones.

Suggested Reading

1. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2002) Biochemistry. W.H.Freeman & Company.
2. Murray, R.K. et al (2012) Harpers Illustrated Biochemistry. McGraw-Hill Medical.
3. Nelson, D.L & Cox, M.M. (2008) Lehninger Principles of Biochemistry. W.H. Freeman & Company.
4. Zubay, G. (1999) Biochemistry. William C Brown Publishers.
5. Mathews, C.K., van Holde, K.E., Appling, D.R. & Anthony-Cahill, S.J. (2012) Biochemistry. Prentice Hall Publisher.
6. Murray et al. (2003) Harper's Illustrated Biochemistry (26th ed), Appleton and Lange.
7. Hadley, M. & Levine, J.E. (2006) Endocrinology. Benjamin Cummings.
8. Nussay, S.S. & Whitehead, S.A. (2001) Endocrinology: An Integrated Approach. CRC Press.
9. Bentley, P. J. (1998) Comparative Vertebrate Endocrinology, Cambridge University Press.
10. Brook, C.G.D. & Marshall, N.J. (2001) Essential Endocrinology, 4th edn. Wiley.

ZOOPG-CP-104: PRACTICAL
NON-CHORDATES, CHORDATES, ECOLOGY, BIOCHEMISTRY, ENDOCRINOLOGY

Total Max. Marks-100

Total Credit-04

UNIT I – NON-CHORDATES AND CHORDATES

Preparation of identification keys of insects.

Mounting of mouthparts of mosquitoes and houseflies.

Isolation and identification of soil nematodes.

Demonstration of endocrine glands in vertebrates.

Demonstration of cranial nerves in vertebrates.

UNIT II – ECOLOGY

Water Analysis: estimation of total hardness, salinity, chloride, calcium, magnesium, phosphate, TDS.

Demonstration of limnological apparatus: Secchi disk, Jacksons candle turbidometer, Ekman's dredge.

UNIT III – BIOCHEMISTRY AND ENDOCRINOLOGY

Estimation of protein using Folin's/Bradford reagent.

Estimation of sugar by anthrone reagent.

Estimation of DNA using diphenylamine reagent.

Estimation of RNA using orcinol reagent.

Assay of urease enzyme by titrimetric method.

Display of endocrine glands in laboratory bred animals.

Histological study of endocrine glands (thyroid, adrenal, testis and ovary).

UNIT IV – ECOLOGICAL EXCURSION, FIELD REPORTS AND SEMINAR

Students have to participate in ecological excursion organized by the department and prepare a field report based on observation in the field.

Students have to prepare a term paper on any topic related to the subject in consultation with faculty members. Every student has to present a 10 minutes duration seminar on the topics chosen.

SEMESTER - II

UNIT I – MOLECULAR BIOLOGY-I

Structure and properties of DNA and RNA.

DNA replication: semi-conservative, structural properties of DNA polymerases, mechanism of DNA replication.

Transcription: mechanism of transcription - initiation, elongation and termination, sense and antisense strands, structural properties of RNA polymerases, RNA processing.

UNIT II – MOLECULAR BIOLOGY-II

Protein synthesis: initiation, elongation and termination.

Genetic code: triplet codon concept, features of genetic code.

Prokaryotic gene expression: positive and negative control, lac operon in *E. coli*, tryptophan operon in *E. coli*, repression and attenuation.

UNIT III - BIOTECHNOLOGY

Genomic and cDNA libraries: construction and screening; Expression of vectors and expression of fusion proteins; Transgenic Animals: production, prospects, advantages and disadvantages; Site directed mutagenesis: strategies and prospects.

Recombinant DNA technology and its application in human gene therapy, vaccine development, environmental bioremediation and protein engineering; Reverse transcriptase.

Microbial synthesis of commercial products: restriction endonucleases, antibiotics and vitamins.

UNIT IV – GENERAL IMMUNOLOGY

Overview of the immune system: components of the immune system; Innate and adaptive immune system.

Barriers of immune system: mechanical barriers, chemical barriers.

Cells of immune system: lymphoid and myeloid lineages.

Concept of antigen: physical and chemical nature, general properties of antigens, superantigens, haptens, adjuvants.

Immunoglobulin structure: CDR/hypervariable region, framework region, biological and physical properties; Antibody subclass, isotype, allotype, idiotype; Antibody engineering.

Antibody-mediated effector functions: complement activation, cell mediated cytotoxicity, opsonization.

Suggested Reading

1. Cooper, G.M. (2009) *The Cell: A Molecular Approach*. Sinauer Associates, Inc.
2. Karp, G. (2009) *Cell & Molecular Biology Concepts and Experiment*. Willey Blackwell Publisher.
3. Lewin, B. (2007) *Genes IX*. Jones & Bartlett Publishers.
4. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010) *Molecular Biotechnology: principles and applications of recombinant DNA*. 4th Edition. ASM Press.
5. Balasubramanian, D, Dharmalingam, K., Bryce, C. F. A., Green, J. & Jayaraman, K. *Concepts in Biotechnology*. Revised edition. University Press (India).
6. Abbas, A.K. (2011). *Cellular and Molecular Immunology* (7th Ed). Saunders.
7. Chakravarty, A.K. (2003) *Immunology II*. N.L. Publishers.
8. Kindt, T.J et. al. (2006) *Kuby: Immunology*, 6th Ed. W.H. Freeman & Company.
9. Roitt, I. (2001) *Immunology*. Mosby Publ. London.
10. Tizard I.R. (1995). *Immunology: an introduction*, 4th edn. Saunders College Publishing.

UNIT I – GENETICS-I

Extra chromosomal inheritance: inheritance of mitochondrial and chloroplast genes, maternal inheritance.

Microbial Genetics: methods of gene transfers - transformation, transduction, conjugation, sexduction.

Transposable genetic elements in prokaryotes and eukaryotes: IS element, composite transposons, Tn3 element, mechanism of transposition, P element and hybrid dysgenesis in *Drosophila*, retrotransposons.

Somatic cell genetics: concept and applications, transfection of cells - principles and methods, cell fusion, hybridoma, applications of embryonic stem cells.

UNIT II – GENETICS-II

Destabilizing forces influencing allele frequencies: mutation and estimation of mutation rates; Natural Selection: gametic selection, selection against recessive and recessive lethal, selection against dominant, heterozyote advantage.

Genetic structure of population: optimum phenotype, selection pressure, Fisher's theorem of natural selection, canalization, genetic homeostasis, genetic load and genetic death.

Inbreeding: measure of inbreeding, inbreeding depression, heterosis.

UNIT III - EVOLUTIONARY BIOLOGY-I

Isolation mechanisms and their role in evolution; Implication of geographical distribution for modes of speciation.

Concept of molecular evolution: molecular clock and molecular drive; human evolution.

Macro evolution: concept, phylogenetic gradualism, punctuated equilibrium, major trends in the origin of higher categories.

UNIT IV - EVOLUTIONARY BIOLOGY-II

Genome Evolution: evolution of multigene family, acquisition of new genes - mechanisms and exon theory.

Concerted evolution.

Emergence of Non-Darwinism: neutral hypothesis.

Genetic variations, genetic polymorphism, determination of average heterozygosity.

Founder principle, bottleneck effect and genetic drift as factors in speciation.

Suggested readings

1. Karp, G. (2009) Cell & Molecular Biology Concepts and Experiment. Willey Blackwell Publisher.
2. Pierce, B.A. (2010) Genetics: A Conceptual Approach. W. H. Freeman Publisher.
3. Griffiths, A.J.F. et al. (2010) Introduction to Genetic Analysis. W. H. Freeman Publisher.

4. Hartwell, L. et al. (2010) Genetics: From Genes to Genomes. McGraw-Hill Science/Engineering/Math.
5. Cooper, G.M. (2009) The Cell: A Molecular Approach. Sinauer Associates, Inc.
6. Gardner, E.J., Simmons, M.J. & Snustad, D.P. (2000) Principles of Genetics. John Wiley & Sons.
7. Futuyama, D.J. (2005) Evolutionary Biology, Sinauer Associates INC Publishers, Dunderland.
8. Strikberger, M.W. Evolution. Jones and Bartlett Publishers, Boston London
9. Rastogi, V.B. (2014) Organic Evolution. Medtec.
10. Graur, D. & Li, W-H., Fundamentals of Molecular Evolution, 2nd Ed., Sinauer Associates.

ZOOPG-CT-203: DEVELOPMENTAL BIOLOGY, PARASITOLOGY

Total Max. Marks-100

Total Credit-04

UNIT I - DEVELOPMENTAL BIOLOGY- I

Gametogenesis: spermatogenesis, formation of spermatids and spermeiogenesis, sperm function, composition of semen; Oogenesis: oocyte growth, maturation, vitellogenesis, types of eggs; Hormonal control of gametogenesis.

Fertilization: fertilization in sea urchin, recognition of sperm and egg, polyspermy, activation of egg metabolism, fusion of genetic material.

UNIT II - DEVELOPMENTAL BIOLOGY - II

Cleavage: characteristics, plane and patterns of cleavage; Mechanism and products of cleavage; types of blastulae; Axis pattern in *Drosophila*.

Gastrulation and formation of germinal layers; Gastrulation in amphibians; Concept of organizer, induction and competence.

Nuclear transplantation experiments and genomic equivalence.

UNIT III – PROTOZOAN PARASITOLOGY

Host-parasite interactions.

General characters and classification of parasitic protozoans.

Distribution, life cycle and pathogenicity of *Acanthamoeba*, *Naegleria*, *Giardia*, *Toxoplasma*, *Cryptosporidium*.

Mechanism of strain formation in *Plasmodium*.

UNIT IV – HELMINTH PARASITOLOGY

Parasitic adaptations in helminthes.

Distribution, life cycle and pathogenicity of medically important helminth parasites of man: Trematodes – *Paragonimus*, *Clonorchis*; Cestodes – *Diphyllobothrium*; Nematodes – soil-transmitted helminthes, filarial worms; Plant parasitic nematodes: diversity and host-parasite relationship.

Suggested readings

1. Balinsky, B.I. (1970) *An Introduction to Embryology*, Saunders, New York.
2. Berrill, N.J. (1974) *Developmental Biology*. Tata McGraw-Hill.
3. Gilbert, S.F. (2013) *Developmental Biology*, 10th edn. Sinauer Associates Inc.
4. Wolpert, L. (2011) *Principles of Development*. Oxford University Press.
5. Subramoniam, T. (2011) *Molecular Developmental Biology*. Alpha Science International.
6. Roberts, L.S., Janovy, J. & Nadler, S. (2013) *Foundations of Parasitology*, 9th edn. McGraw-Hill.
7. Cox, F. E. G. (2009) *Modern Parasitology: A Text Book of Parasitology*, 2nd edn. John Wiley & Sons.
8. Cheng, T.C. (2012). *General Parasitology*, 2nd edn. Elsevier.
9. Smyth, J.D. and Wakelin, D. (1994) *Introduction to Animal Parasitology*, 3rd edn. Cambridge University Press, London.
10. Soulsby, E.J.L. (2004) *Helminths, Arthropods and Protozoa of Domesticated Animals*, 7th edn. Elsevier.

**ZOOPG-CP-204: PRACTICAL
IMMUNOLOGY, GENETICS, DEVELOPMENTAL BIOLOGY, PARASITOLOGY**

Total Max. Marks-100

Total Credit-04

UNIT I – IMMUNOLOGY

Collection of plasma and serum, separation and preparation of lymphocytes from the whole blood sample by ammonium chloride method, viability test of separated lymphocytes.

UNIT II – GENETICS

Determination of allelic frequency and genotype frequency of ABO blood group.

Meiotic cell division from grasshopper testis and calculation of chiasma frequency and coefficient of terminalisation.

Preparation of human karyotypes: normal male and female; analysis of some common chromosomal aberrations.

Drosophila genetics: preparation of culture medium, study of wild type and mutants.

UNIT III – DEVELOPMENTAL BIOLOGY AND PARASITOLOGY

Preparation of developmental stages of chick embryo.

Study of regeneration in Hydra/ Planaria.

Identification: spot and with reasons of permanent mounts of protozoans, trematodes and cestodes viz.

Plasmodium, Leishmania, Polystoma, Paramphistomum, Gastrothylax, Fasciola, Fasciolopsis,

Schistosoma, Clonorchis, Paragonimus, Taenia, Railletina, Cotugnia, Echinococcus,

Diphyllobothrium, Dipylidium, Hymenoplepis, Gyrocotyle.

UNIT IV – TERM PAPER PREPARATION AND PRESENTATION

Students have to prepare a term paper on any topic related to the subject in consultation with faculty members. Every student has to present a 10 minutes duration seminar on the topics chosen.

SEMESTER – III

UNIT I – CELL BIOLOGY

Chromatin: types, chemical compositions, histones, molecular organization of nucleosomes, nucleoplasmin, chromatin to chromosomes, histone modifications, chromatin remodeling complex.

Cell cycle: features and phases, cyclins and cyclin dependent kinases, cell cycle checkpoints.

Targeting and sorting of proteins.

Cancer biology: oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis.

Cancer therapeutics: surgery, radiation and chemotherapy.

UNIT II – TECHNIQUES IN BIOLOGY-I

Microscopy: General concept, fluorescent and electron microscopy.

Chromatography: principles and applications of absorption, ion exchange, gel filtration, affinity, gas liquid chromatography (GLC), high performance liquid chromatography (HPLC)

Spectroscopy: colorimeter, spectrophotometer, spectrofluorometer, nuclear magnetic resonance (NMR) spectroscopy, mass spectrometry.

UNIT III – TECHNIQUES IN BIOLOGY-II

Electrophoresis: basic principles, polyacrylamide gel electrophoresis, isoelectrofocussing, agarose gel electrophoresis.

Crystallography and X-ray diffraction.

Nucleic acid amplification: polymerase chain reaction (PCR), real-time PCR.

Radioisotope techniques: radioactivity and half life, radioisotopes, units of radioactivity, G-M counter, solid and liquid scintillation counter, applications of radioisotopes.

UNIT IV – BIOINFORMATICS

Introduction to Bioinformatics resources and databases: tools and databases.

Sequence Analysis: basic concepts of sequence similarity, identity and homology, homologues, orthologues, paralogues; Sequence-based Database Searches: BLAST and FASTA.

Pairwise and multiple sequence alignments: basic concepts of sequence alignment.

Phylogeny: phylogenetic analysis, definition, description and method of construction of phylogenetic trees.

Current Advancements in Bioinformatics.

Suggested Reading

1. Cooper, G.M. (2009) *The Cell: A Molecular Approach*. Sinauer Associates, Inc.
2. De Robertis, E.D.P. (2006) *Cell & Molecular Biology*. Lippincott Williams and Wilkins.
3. Narayanan, P. (2007) *Essentials of Biophysics*. New Age International Publishers,
4. Boyer, R.F. (2001) *Modern Experimental Biochemistry*, 3rd Edition. Pearson Education
5. Primrose, S. B. & Twyman, R. M. (2006) *Principles of Gene Manipulation and Genomics*. Seventh Edition. Blackwell Publishing.
6. Pranav Kumar (2016) *Fundamentals and Techniques of Biophysics and Molecular Biology*. Pathfinder Publication.
7. Moganty R. Rejeswari (2013) *An Introduction to Biophysics*. Rastogai Publications.
8. Xiong, J. (2006) *Essential Bioinformatics*. Cambridge University Press.
9. Attwood, T.K. (1999) *Introduction to Bioinformatics*. Pearson Education.
10. Higgs, P.G. & Attwood, T.K. (2013) *Bioinformatics and Molecular Evolution*. John Wiley & Sons.

UNIT I – PHYSIOLOGY-I

Physiology of digestion: digestive enzymes in vertebrates, secretion and regulation in mammals, mechanism of digestion and absorption of different components of food materials.

Circulation: circulatory system in invertebrates and vertebrates, types of hearts, cardiac cycle and its regulation, functions of blood and its components, haemopoiesis, blood pressure and its regulation, blood group types.

UNIT II – PHYSIOLOGY-II

Nervous system: ultrastructure of neuron, resting and action potential, neuronal conduction through an axon, nernst equation, simple calculation for RP and AP, neurotransmitters and synaptic transmission.

Musculature: types of muscles, chemical composition of skeletal muscles, molecular mechanism of skeletal muscle contraction.

UNIT III – PHYSIOLOGY-III

Respiration: respiratory organs in vertebrates, mechanism of respiration through gills in fish and through lungs in mammals.

Respiratory pigments: types, chemistry and functions.

Mechanism of transport of O₂ and CO₂, oxygen dissociation curve, Bohr effect and Root effect.

UNIT IV – PHYSIOLOGY-IV

Excretion: mechanism of urine formation through counter current mechanism in higher vertebrates, acid-base balance.

Osmoregulation: control of osmoregulation via ADH; Osmoregulation in aquatic and terrestrial animals.

Stress physiology: basic concepts of stress and strain, stress avoidance, stress tolerance, stress resistance.

Adaptation to cold and heat stress.

Physiological response to oxygen deficient stress, physiological response to body exercise, meditation, yoga and their effects.

Suggested readings

1. Hughes, G. M. Comparative Physiology of Vertebrate Respiration (1963) Cambridge, Mass., Harvard University Press.
2. Barrett, K.E. et al (2012). Ganong: Review of Medical Physiology (24th Ed.), McGraw-Hill Medical.
3. Guyton and Hall (2001) Text Book of Medical Physiology (10th Ed.), W.B. Saunders.
4. Keel et al (1989) Samson Wright's Applied Physiology (13th Ed.), Oxford Press.
5. West, J B (Ed) (1985) Best and Taylor's Physiological Basis of Medical Practice (11th Ed), Williams and Wilkins.
6. Webster, R. (2001) Neurotransmitters, Drugs and Brain Function (Ist Ed). Wiley.
7. Hill, R. W., Wyse, G. A. and Anderson, M. (2012). Animal Physiology, 3rd Edition, Sinauer Associates Inc.
8. Schmidt-Nielsen, K. (2002). Animal Physiology: Adaptation and Environment. Cambridge University Press.

UNIT I – ECOLOGICAL NICHE, RESTORATION ECOLOGY, BIOLOGICAL INVASION

Development of niche concept, niche width, niche overlap, diffuse competition, niche dynamics, ecological equivalents, character displacement, sympatry and allopatry; Concept of ecological niche modelling.

Restoration ecology: historical perspectives, strategies; Plan and rehabilitation measures; Successes and effectiveness.

Biological invasion: nature and status; Invasion process and hypothesis, characteristics of invasive species; Impact, prevention and mitigation of invasion.

UNIT II – SYSTEMS ECOLOGY AND SUSTAINABLE DEVELOPMENT

Energy in ecological systems; Measuring ecosystem productivity, patterns in primary production.

Ecosystem services: overview, valuation, laws and policies.

Millennium Ecosystem Assessment: framework and synthesis.

Role of geographical information system (GIS) and remote sensing in ecology.

Sustainable Development: principles, sustainability indicators, sustainable development. goals;

Millennium development goals; Green economy; Environmental performance index.

UNIT III – CLIMATE CHANGE: CAUSES AND INITIATIVES

Greenhouse gases and green house effect, ozone layer depletion.

Global patterns of temperature and precipitation, carbon trading, carbon foot print, concept of REDD (reducing emission through destruction and deforestation); Introduction to UNFCCC and its protocols.

Introduction to Intergovernmental Panel on Climate Change (IPCC) and their reports.

Vulnerability assessment, resilience and adaptation of species.

El niño, La niña, southern oscillation and their ecological impact.

UNIT IV – IMPACT OF CLIMATE CHANGE

Impact on the physical environment: glacial melt including glacial retreat in the Himalayas, sea level rise, glacial lake outburst flood (GLOF), changes in rainfall patterns, snow fall events, coral reef bleaching, etc.

Impact on the faunal characteristics: species range shift, species migration, species extinction, changes in phenology and altered breeding pattern of animals (herpetofauna, birds and mammals), changes in insect emergence pattern and effect on food chain, infestations of diseases and crop pests.

UNIT I – ANTIBODY DIVERSITY, CYTOKINES

Generation of antibody diversity: genetic organization of immunoglobulin genes, rearrangement of genes, allelic exclusion.

Antibody diversity: junctional diversity, gene conversion, somatic hypermutation, association of light and heavy chain; Membrane bound and secreted immunoglobulins, assembly and secretion of immunoglobulins, antibody class switching.

Binding forces of antigen and antibody: hydrogen bond, ionic bond, hydrophobic interaction, Van der Waals interaction.

Cytokines: classification of cytokines, properties of cytokine, cytokine receptors, cytokine secretion by TH1 and TH2 subsets, mechanism of cytokine action, cytokine-related diseases, therapeutic uses of cytokines and their receptors.

UNIT II – COMPLEMENT HYPERSENSITIVITY, INFLAMMATION

Complement: characteristic features, methods of complement activation - classical, alternative and MBL pathways.

Hypersensitivity: Gell and Coombs classification, process of immediate hypersensitivity, cytotoxic hypersensitivity, immune-complex and delayed hypersensitivity.

Inflammation: chemical mediators of inflammation, cell surface adhesion molecules, chemotaxis during inflammation, process of inflammation - localized and systemic inflammation, anti-inflammatory agents.

UNIT III - GENERAL PARASITOLOGY

Emerging infectious diseases, re-emerging infectious diseases, neglected tropical diseases, zoonoses: general concept.

Host-parasite interactions: molecular, cellular and physiological basis.

Epidemiology and control: principles and concepts; parasite control strategies.

Impact of climate change on parasitic diseases.

UNIT IV - VECTOR BIOLOGY

Vectors and its importance in transmission of parasites; Vector biology: special reference to blackflies, sandflies, tsetse flies and mollusks.

Major malaria vectors of India: distribution, bioecology, potentiality and present sustainability status, form and function.

Symbiotic association of microbes with vectors; Role of microbes as controlling agents of vectors.

ZOOPG-CP-305: PRACTICAL
CELL BIOLOGY, TECHNIQUES IN BIOLOGY, ANIMAL PHYSIOLOGY

Total Max. Marks-100

Total Credit-04

UNIT I – CELL BIOLOGY

Preparation and staining of polytene chromosomes from chironomous larva.
Barr body preparation from human buccal swab.

UNIT II –TECHNIQUES IN BIOLOGY

Demonstration of polyacrylamide gel electrophoresis (PAGE) and polymerase chain reaction (PCR).
Demonstration of ELISA.

UNIT III – ANIMAL PHYSIOLOGY

Estimation of O₂ consumption by fish.
Absorption of glucose by chicken gut.
Estimation of ascorbic acid in an unknown solution.
Estimation of casein content in milk.
Estimation of Amino-N by Sorenson's Formol Titration method.
Estimation of ESR.
Enumeration of blood platelets using haemocytometer.
Estimation of blood glucose during fasting and PP.

UNIT IV – TERM PAPER PREPARATION AND PRESENTATION

Students have to prepare a term paper on any topic related to the subject in consultation with faculty members. Every student has to present a 10 minutes duration seminar on the topics chosen.

SEMESTER - IV

ZOOPG-ET-401: BIODIVERSITY AND CONSERVATION BIOLOGY

Total Max. Marks-100

Total Credit-04

UNIT I – BIODIVERSITY: CONCEPTS, COMPONENTS AND PATTERNS

Conceptual framework of biodiversity; Patterns and process of local and regional biodiversity: niche assembly theories, unified Neutral theory, island biogeography model. Global Hotspots of biodiversity; Biodiversity with reference to Eastern Himalayas; Biogeography of India, restricted range species and endemism, key stone species, flagship species, indicator species, surrogate Species; Plate tectonics and continental drift.

UNIT II – THREATS TO BIODIVERSITY

Biodiversity losses: past and present, natural and human induced threats and vulnerability of species to extinctions; Mass extinction, zero extinction, extinction vortex; Problem of genetic diversity loss over time: bottlenecks, genetic drifts, inbreeding depression.

UNIT III – CONSERVATION OF BIODIVERSITY

Identification and prioritization of ecologically sensitive area (ESA); Coarse filter and fine filter approaches of biodiversity conservation; Population viability analysis-conceptual foundation; Minimum viable populations and recovery strategies for threatened species.

Conservation genetics: genetic variation and its significance, measure of genetic variability.

Traditional knowledge and biodiversity conservation: world heritage convention, Satoyama concept, Tani cultural landscape, Demazong sacred landscape.

UNIT IV – LEGAL FRAMEWORK OF BIODIVERSITY CONSERVATION

Introduction to laws and policies for biodiversity conservation: convention on biological diversity and important protocols; Aichi targets; Indian Biodiversity laws and rules, national biodiversity authority, state biodiversity boards, Sikkim state biodiversity rules; Biodiversity management committees and peoples biodiversity register.

Ramsar convention on conservation of wetlands, Forest (Conservation) Act of India 1980, Environment (Protection) Act of India 1986.

UNIT I - MAJOR HISTOCOMPATIBILITY COMPLEX (MHC)

MHC: genetic organization, classical and non classical HLA genes; Molecular organization of HLA molecule; Polymorphism of HLA; Haplotype and Linkage disequilibrium, antigen presentation and MHC restriction; HLA and disease association; HLA (Human Leukocyte Antigen) typing: microlymphocytotoxicity assay, molecular HLA typing; HLA-G and reproductive immunology.

UNIT II - CYTOTOXIC RESPONSE, TOLERANCE AND AUTOIMMUNITY

Cell mediated cytotoxic responses: effector mechanisms, leukocyte activation and migration.

Tolerance: factors causing tolerance, types of tolerance, mechanism of tolerance.

Autoimmunity: characteristics, causes of autoimmune disease, pathogenesis, classification, common autoimmune disorder, therapeutic approaches to autoimmune disease.

UNIT III – TLR, TUMOUR IMMUNOLOGY, VACCINES, IMMUNODEFICIENCY DISEASES

Toll-like receptors: structure, ligands, mechanism of action.

Tumour immunology: tumours of the immune system, immune response to tumours, evasion of immune response by tumours, immunotherapy for cancer.

Vaccines: requirements and aims of a successful vaccine, types of vaccines, advantages and disadvantages, new vaccine strategies, concept of immunization.

Immunodeficiency diseases: combined immunodeficiency, acquired immunodeficiency syndrome (AIDS).

UNIT IV – IMMUNOLOGICAL TECHNIQUES

Techniques and technologies for quantitation of immunologically relevant molecules, substances and the cells and their uses for diagnostic purposes.

Agglutination reaction, precipitation reaction, immunodiffusion, immunoelectrophoresis, radioimmunoassay, hybridoma technology and monoclonal antibody synthesis and usage, flow cytometry and fluorescence-activated cell sorting (FACS), immunohistochemistry.

UNIT I – WILDLIFE AND THEIR MANAGEMENT

Wildlife wealth of India and threatened wildlife; Management of rare and endangered species; Control and management of over abundant wildlife populations.

Ecology and conservation of red panda, musk deer, great Indian bustard, olive ridley turtle.

Conservation approaches of important wildlife of India: project tiger, elephant and snow Leopard.

Applications of cloning in wildlife conservation and management.

UNIT II - WILDLIFE MONITORING, TRADE AND LEGISLATION

Wildlife census technique: objectives, direct and indirect methods with reference to herpetofauna, birds and mammals.

Wildlife conservation approaches and limitations.

Human animal conflict: type and nature of conflict, causes of conflict, measures of conflict mitigation.

Assessment, documentation, and prevention of wildlife trade; Concept of wildlife forensics. Wildlife laws and ethics: wildlife protection act of India and its schedules.

Introduction to organizations: International Union for Conservation of Nature and Natural Resources (IUCN), Convention on International Trade on Endangered Species of Flora and Fauna (CITES), Indian Board for Wildlife (IBWL).

UNIT III – ANIMAL BEHAVIOUR- I

Four propositions of Tinbergen.

Innate and learned behaviour; Classical conditioning; Instrumental learning, habituation and extinction.

Optimal foraging theory: patch choice, diet choice, pre-selectivity, group and solitary feeding.

Conflict: Male-male competition; Sexual selection: contribution of Darwin, the Healthy Male theory, the Good Gene theory.

Elaborate ornaments: Fisher's hypothesis (runaway selection), Handicap hypothesis of Zahavi.

Survival value of behaviour: experimental studies, Darwinian and inclusive fitness.

Altruism: Kin-selection, reciprocal altruism, parental care, cooperation.

UNIT IV – ANIMAL BEHAVIOUR-II

Communications and signaling; Territoriality, home range and courtship display.

Mating systems: monogamy, polyandry and polygyny.

Social systems of mammals: primates; Contemporary theories in insect socio-biology.

Human behaviour: genetic differences and human behaviour, IQ differences.

Behavioural genetics: single and multiple gene effect.

UNIT I - PROTOZOOLOGY

Parasitic protozoa: origin and evolution; energy metabolism.

Plasmodium: immunopathology, treatment (drug targets, mechanism of drug resistance) and vaccine strategies.

Leishmania: immunopathology, treatment (drug targets, drug resistance) and vaccine strategies.

Trypanosoma (Human African Trypanosomiasis): immunopathology, evasion of host immune system, treatment.

UNIT II - HELMINTHOLOGY

Origin and evolution of parasitic helminthes; Larval form of helminthes; Ultra structure of important helminthes tegument/cuticle; Structure of scolex in cestodes.

Energy metabolism in parasitic helminthes.

Immunopathology, treatment and control of *Schistosoma*, *Echinococcus*, *Wuchereria*.

UNIT III – PARASITOLOGY TECHNIQUES-I

Laboratory diagnosis of parasitic infections: blood and stool examination and examination of biopsy material for parasitic infection; Identification and diagnostics: morphological, serological, DNA-based and *in silico* methods.

In vitro cultivation of parasites: *Plasmodium*, *Leishmania*, *Schistosoma*.

UNIT IV – PARASITOLOGY TECHNIQUES-II

Isolation of DNA and RNA, polymerase chain reaction, primer designing, DNA sequencing nucleic acid hybridization, blotting techniques, ELISA.

Proteomics: 2D-Gel electrophoresis, liquid chromatography, mass spectrometry.

Introduction to drug designing.

**ZOOPG-EP-405: PRACTICAL
ECOLOGY, PAEDODOLOGY AND ANIMAL BEHAVIOUR**

Total Max. Marks-100

Total Credit-04

UNIT I – COMMUNITY ECOLOGY

Ecological sampling and census techniques: butterflies, amphibians, reptiles, birds and mammals.

Study of vegetation using quadrat method.

Calculation of species richness, diversity, equitability, similarity and generation of species accumulation curves based on study of any animal community.

Inter-specific association.

UNIT II – APPLICATION OF ECOLOGICAL TOOLS

Preparation of GIS Maps using Q-GIS/Map Info/Arc GIS.

Estimation of species using appropriate statistical package.

Study of the traditional knowledge of biodiversity conservation of any local communities.

UNIT III – PEDODOLOGY AND PRIMARY PRODUCTIVITY

Pedology: estimation of phosphorus, zinc and magnesium from soil samples; Estimation of percentage of calcium carbonate in soil by rapid titration method; Estimation of Organic-carbon in soil by wet oxidation method; Analysis of pH, specific conductivity and moisture content of soil samples; Qualitative analysis of soil micro-arthropods.

Estimation of Primary productivity of water bodies.

UNIT IV – ANIMAL BEHAVIOUR

Field study of behaviour of any one species of mammal/birds.

Flocking behaviour in pigeons.

Foraging behaviour in ants: orientation and cues.

Aggressive and predatory behaviour in fish.

Behavioral comments: a) Imprinting in Greylag Goose, b) Flank marking by golden Hamster, c)

Mobbing behaviour of colonial ground squirrel, d) Cooperation among Scrub Jay relatives, e) Alarm

call of Belding's Ground Squirrel, f) Sibling aggression in Great Egret, g) Parental care in male

stickleback, h) Resource defense polygyny in African Chichlid fish, i) Female defense polygyny in

marine amphipod, j) Resource defense polyandry in Spotted Sandpiper, k) Polyandry without

polygyny in Red Phalarope, l) Egg shell removing behaviour in Black-headed Gull.

Film shows on Animal behaviour.

**ZOOPG-EP-406: PRACTICAL
IMMUNOBIOLOGY AND PARASITOLOGY**

Total Max. Marks-100

Total Credit-04

UNIT I – IMMUNOBIOLOGY-I

Haemagglutinin Assay.

Precipitation and quantitation of immunoglobulins from the immunized mouse serum by ammonium sulphate preparation; Characterization of purified immunoglobulin by SDS-PAGE.

Agglutination test for antigen and antibody.

UNIT II – IMMUNOBIOLOGY-II

Raising of antiserum (ALS) and test of specificity of the serum in lysis of target; Immunodiffusion and immunoelectrophoresis.

Plaque forming cell (PFC) Assay and rosette forming cell (RFC) assay.

Peritoneal lavage / Macrophage activity.

FITC conjugation of antibody.

HLA typing demonstration.

UNIT III – PARASITOLOGY-I

Preparation of stains: haematoxylin, acetocarmine, borax carmine, bouins fluid.

Collection, fixation, mounting of different helminth parasites from vertebrates (nematode, trematode and cestode).

Preparation, staining and identification (with reasons) of blood parasites from *Clarias batrachus*.

Submission of prepared slides.

UNIT IV – PARASITOLOGY-II

Faecal examination: qualitative analysis - simple floatation and sedimentation methods; Quantitative analysis: McMaster counting technique.

Studying the infection of tomato plant by root knot nematode.

Histochemical demonstration of alkaline phosphatase activity in tissues of parasitic helminthes.

Suggested readings

Ecology

1. Odum, E.P. Fundamentals of Ecology. W.B. Saunders Co. Philadelphia.
2. Clarke, G.L. Elements of Ecology. John Wiley & Sons, Inc. New York.
3. Giller, P.S. Community Structure and the Niche. Chapman & Hall.
4. Mc Naughton, S.J. & L.L. Wolf. General Ecology. Holt, Rinehartx, Winston New York.
5. Saunders, D.S. An Introduction to Biological Rhythms. Blackie, Glasgow & London.
6. Miller, R.W. & R. L. Donahue. Soils in our environment. Prentice Hall India Pvt. Ltd., New Delhi.
7. Bailey, J.A. Principles of Wild Life Management. John Wiley & Sons, New York.
8. Smith, R.L. Ecology and Field Biology. Addison – Wesley Educational Publishers. Inc.
9. Ricklefs, R.E. and G.L. Miller. Ecology W.H. Freeman & Company
10. Truk and Turk: Environmental Science (W.B. Saunders).
11. Chapman Jr., W.B. Natural Ecosystems. Macmilan Pub. Co. Inc.
12. Alcock, J. Animal Behaviour: An evolutionary approach. Sinauer Assoc., Sunderland, Mass. USA.
13. Bradbury, J, W., and S.L. Vehrencamp. Principles of animal communication. Sinauer Assoc., Sunderland, Mass, USA.
14. Clutton-Brock T.H. The evolution of parental care. Princeton Univ. Press, Princeton, NJ USA.
15. Eibl- Eibesfeldt, I. Ethology; The biology of behavior. Holt, Rinehart & Winston, New York.
16. Drickamer, L.C., S.H. Vessey and E.M. Jakob. Animal Behavior, McGraw Hill.
17. Dewsbur, D.A. Comparative animal behavior McGraw Hill Book Company.
18. Hunting ford, F. The Study of Animal Behavior, Chapman and Hall.
19. Mc Farland, D. Animal Behavior: Psychobiology, Ethology and Evolution.
20. Krebs, J.R. and N.B. Davies. Behavioral Ecology: An Evolutionary Approach.
21. IPCC (2007) Fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, United Kingdom.
22. Wormworth, J. and Sekercioglu, Ç.H. (2011) Winged Sentinels: Birds and Climate Change. Cambridge University Press.
23. Ramasamy, B. (2013) General Issues on Environmental Ecology, Bio diversity and Climate change. Pragn Publication.
24. Hussain, M. (2013) Environment and Ecology: Biodiversity, Climate Change and Disaster Management. Access Publishing House.
25. The Little Data Book on Climate Change (2011) World Bank Publications.
26. Negi, S. S. (2010) Hand Book of Climate Change Science. Bishen Singh Mahendra Pal Singh.
27. Henson, R. (2011) The Rough Guide to Climate Change. Rough Guides Publisher.
28. Kaur, R. (2014) General Issues on Environment, Biodiversity and Climate Change. New Vishal Publication.
29. Kondratyev, K.Y. and Krapivin, V. F. (2014) Global Carbon Cycle and Climate Change. Springer publications.
30. Seidel, K. and Martinec, J. (2014) Remote Sensing in Snow Hydrology: Runoff Modelling, Effect of Climate Change. Springer publications.
31. Mastrandrea, M.D. and Schneider, S.H. (2010) Preparing for Climate Change. MIT Press.
32. Novacek, M.J. (2010) The Biodiversity Crisis: Losing What Counts. The New Press.

33. Biodiversity: Convention on Biological Diversity, Abiotic Stress, International Treaty on Plant Genetic Resources for Food and Agriculture Books LLC, Wiki Series (2011).
34. Wilson, E. O. (1988) Biodiversity. National Academy Press
35. Krihnamurthy (2008) An Advanced Textbook On Biodiversity: Principles And Practice. Oxford & Ibh Pub. Co. Pvt. Ltd.
36. Pyers, G. (2010) Biodiversity of Rain Forests. Benchmark Books.
37. Anderson, A.B. (2006) Applying Nature's Design - Corridors as a Strategy for Biodiversity Conservation (Issues, Cases, and Methods in Biodiversity Conservation). Columbia University Press.
38. de Boef et al. ed (2013) Community Biodiversity Management: Promoting resilience and the conservation of plant genetic resources (Issues in Agricultural Biodiversity). Routledge.
39. Lanzerath, D. and Friele, M. (2014) Concepts and Values in Biodiversity (Routledge Studies in Biodiversity Politics and Management). Routledge

Immunology and Parasitology

1. Kuby Immunology, Richard, Thomas, Barbara, Janis, (5th Ed., 2003), W. H. Freeman and company, New York, USA.
2. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, (6th Ed., 2005), Garland Science Publishing, New York, USA.
3. Immunology, David, Brostoff and Roitt, (7th Ed., 2006), Mosby & Elsevier Publishing, Canada, USA.
5. Abbas, A. K., Lichtman, A. H. & Pillai, S. (2006). Cellular and molecular Immunology. 6th ed. Saunders.
6. Abbas, A. K. & Lichtman, A. H. (2006). Basic Immunology. 2nd ed. Elsevier.
7. Coico R, Sunshine, G., Benjamini, E. (2003). Immunology: A short Course. 5th ed. Wiley-Liss: New Jersey.
8. English, L. S. (1994). Technological Applications of Immunochemicals (BIOTOL).
9. Butterworth- Heinemann, Oxford Freeman & Co.
10. Goldsby, R. A., Kindt, T. J., Kuby, J. & Osborne, B. A. (2003). Immunology. 5th ed. W. H. Freeman & Co.
11. Khan F. H. (2009) The Elements of Immunology. Pearson.
12. Kindt, T., Goldsby, R. Osborne, B. (2007). Kuby Immunology. 6th ed. W.H. Freeman & Co.
13. Male, D., Brostoff, J., Roth, D. & Roitt, I. (2006). Immunology. 7th ed. Mosby.
14. Rao, C. V. (2002). Immunology. Narosa Publishing House, New Delhi.
15. Roitt, I. M. & Delves, P. J. (2001). Roitt's Essential Immunology. 10th ed. Blackwell Science. Ltd.
17. Chandler, A. C. & Read. C. P. (1961). Introduction to Parasitology, 10th ed. John Wiley & Sons Inc.
18. Chandra, G. (2000). Mosquito. Sree Bhumi Publication Co. Kolkata.
19. Bogitsch, B.J. & Cheng, T.C. (2000) Human Parasitology, 2nd edn. Academic Press.
20. Hati, A. K. (2001) Medical Entomology. Allied Book Agency, Kolkata.
21. Hati, A. K. (2001) Medical Parasitology. Allied Book Agency, Kolkata.
22. Noble, E. R. & Noble G. A. (1982) Parasitology. The Biology of animal Parasites, 6th ed. Lippincott Williams and Wilkins.
23. Roberts, L.S., Janovy, J. & Nadler, S. (2013) Foundations of Parasitology, 9th edn. McGraw-Hill.
24. Cox, F. E. G. (2009) Modern Parasitology: A Text Book of Parasitology, 2nd edn. John Wiley & Sons.
25. Cheng, T.C. (2012). General Parasitology, 2nd edn. Elsevier.

26. Smyth, J.D. and Wakelin, D. (1994) *Introduction to Animal Parasitology*, 3rd edn. Cambridge University Press, London.
27. Soulsby, E.J.L. (2004) *Helminths, Arthropods and Protozoa of Domesticated Animals*, 7th edn. Elsevier.

ZOOPG-DV-407: DISSERTATION AND VIVA-VOCE

Total Max. Marks-100

Total Credit-04

Students have to undertake short term research work in the field of their special paper (elective subject). Topics are to be decided in consultation with the course teacher(s). Dissertation should be prepared following standard format i.e. Introduction, Materials and Methods, Results, Discussion and Conclusions. Every student has to present a seminar on their research in the presence of faculty members of Zoology and external examiner(s) appointed by the University followed by viva-voce.