DHANAMANJURI UNIVERSITY, MANIPUR
SYLLABUS FOR TWO YEARS M.Sc. ZOOLOGY UNDER CHOICE BASED CREDIT SYSTEM

Programme Structure

1. The M.Sc. Programme in Zoology is of two-years duration consisting of 4 semesters with a total marks of 2500 (100 credits).
2. Semester I will have 4 Core theory papers and 2 Core practical papers. Each paper will carry 100 marks of 4 credits.
3. Semester II will have 4 Core theory papers, 2 Core practical papers and 1 Open Elective Paper. Each paper will carry 100 marks of 4 credits.
4. Each Semester III & IV will have 3 Core papers (2 theory & 1 practical) and 3 Elective papers (2 theory & 1 practical). Each paper will carry 100 marks of 4 credits.
5. Each core/elective theory paper of 100 marks will have 2 components: internal assessment (20 marks) and end-semester examination (80 marks).
6. Elective papers (2 theory and 1 practical) in each Semester III and IV shall be treated as Papers for Specialization.
7. Fields for specialization are Fishery, Entomology and Animal Physiology and Endocrinology.
8. The minimum marks for passing the examination for each theory and practical paper shall be 40% (for theory, 8 from internal assessment and 32 from end-semester examination).

Abbreviations: ZOO = Zoology, OPE = Open Elective

COURSE STRUCTURE

SEMESTER I

Course Code	Course Type	Course Title	Internal Assessment marks	End-Semester marks	Total marks	Class Hours per week	No. of Credits
ZOO-501	Core	Cell and Molecular Biology	20	80	100	6	4
ZOO-502	Core	Environmental Biology	20	80	100	6	4
ZOO-503	Core	Comparative Anatomy of vertebrates	20	80	100	6	4
ZOO-504	Core	Developmental Biology, Basic Histology and Histochemistry	20	80	100	6	4
ZOO-505	Core	General Lab-1 (based on ZOO-501 and ZOO-502)	-	100	100	6	4
ZOO-506	Core	Zoology Lab-1 (based on ZOO-503 and ZOO-504)	-	100	100	6	4
Total					**600**	**36**	**24**

SEMESTER II

Course Code	Course Type	Course Title	Internal Assessment marks	End-Semester marks	Total marks	Class Hours per week	No. of Credits
ZOO-507	Core	Biochemistry and Immunology	20	80	100	6	4
ZOO-508	Core	Applied Zoology and Animal behavior/Ethology	20	80	100	6	4
ZOO-509	Core	Animal Physiology and Endocrinology	20	80	100	6	4
ZOO-510	Core	Evolution, Biosystematics and Taxonomy	20	80	100	6	4
ZOO-511	Core	General Lab-2 (based on ZOO-507 and ZOO-508)	-	100	100	6	4
ZOO-512	Core	Zoology Lab-2 (based on ZOO-509 and ZOO-510)	-	100	100	6	4
OPE - X	Open Elective	Biodiversity and Climate change	20	80	100	6	4
Total					**700**	**42**	**28**

SEMESTER III

Course Code	Course Type	Course Title	Internal Assessment marks	End-Semester marks	Total marks	Class Hours per week	No. of Credits
ZOO-613	Core	Biotechnology and Genetic Engineering	20	80	100	6	4
ZOO-614	Core	Tools and Techniques in Biology	20	80	100	6	4
ZOO-615	Core	General Lab-3 (based on ZOO-613 & ZOO-614)	-	100	100	6	4
ZOO-621	Elective	Entomology I	20	80	100	6	4
ZOO-622	Elective	Entomology II	20	80	100	6	4
ZOO-623	Elective	Entomology Lab -I	-	100	100	6	4
ZOO-631	Elective	Fishery I	20	80	100	6	4
ZOO-632	Elective	Fishery II	20	80	100	6	4
ZOO-633	Elective	Fishery Lab - I	-	100	100	6	4
ZOO-641	Elective	Animal Physiology and Endocrinology I	20	80	100	6	4
ZOO-642	Elective	Animal Physiology and Endocrinology II	20	80	100	6	4
ZOO-643	Elective	Animal Physiology and Endocrinology Lab I	-	100	100	6	4
Total					**600**	**36**	**24**

SEMESTER IV

Course Code	Course Type	Course Title	Internal Assessment marks	End-Semester marks	Total marks	Class Hours per week	No. of Credits
ZOO-616	Core	Genetics and Cytogenetics	20	80	100	6	4
ZOO-617	Core	Biostatistics, Computational Biology and Bioinformatics	20	80	100	6	4
ZOO-618	Core	General Lab-4 (based on ZOO-616 and ZOO-617)	-	100	100	6	4
ZOO-624	Elective	Entomology III	20	80	100	6	4
ZOO-625	Elective	Entomology IV	20	80	100	6	4
ZOO-626	Elective	Entomology Lab-II	-	100	100	6	4
ZOO-634	Elective	Fishery III	20	80	100	6	4
ZOO-635	Elective	Fishery IV	20	80	100	6	4
ZOO-636	Elective	Fishery Lab - II	-	100	100	6	4
ZOO-644	Elective	Animal Physiology and Endocrinology III	20	80	100	6	4
ZOO-645	Elective	Animal Physiology and Endocrinology IV	20	80	100	6	4
ZOO-646	Elective	Animal Physiology and Endocrinology Lab II	-	100	100	6	4
Total					**600**	**36**	**24**

SEMESTER I

ZOO-501: Cell and Molecular Biology 100 Marks (4 Credits); 100 contact hours

Unit 1:

1. Structure of model biological membrane, lipid bilayer and membrane proteins; Principles of membrane transport: diffusion, osmosis, ion channels and ion pumps.
2. Mechanism of transport of molecules through nuclear envelope; Structure and functions of endoplasmic reticulum, Golgi bodies and lysosome.
3. Cytoskeleton: microtubules, microfilaments and intermediate filaments; Mitochondria: Structure and functions, mitochondrial DNA, synthesis and localization of mitochondrial proteins.

Unit 2:

1. Cell cycle and its regulation including check points in the mammalian cell cycle; Regulation of mitosis and meiosis.
2. General principles of cell communication, cell adhesion, gap junctions, integrins and neurotransmitters in cell communication.

Unit 3:

1. Mechanism of DNA replication, proof reading in DNA replication.
2. Mechanism of transcription and translation, eukaryotic mRNA processing, translational proof reading and post-translational modification of proteins.

Unit 4:

1. Structure and regulation of Lactose and tryptophan operons.
2. Paradigm of gene regulation in phages and prokaryotes: anti-termination and attenuation.

Recommended Books

1. Bruce Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: In Molecular Biology of the cell, 6thEdn, 2015; Publisher: Garland Science, Taylor & Francis Group, New York
2. H. Lodish, D. Baltimore & others: In Molecular Cell Biology, 5th Edn, 2006, Publisher: W.H. Freeman and Company, New York
3. Stryer, L: *Biochemistry*, W.H. Freeman & Co, New York, 2012.
4. Michael M. Cox and David L. Nelson: In Lehninger Principles of Biochemistry, 5th Edn.2010; W.H. Freeman and Company, New York
5. Lewin, B: *Genes IX*, Oxford University Press, 2012.
6. Becker, Kleinsmith, Hardin: *The World of the Cell*, (6th Ed), Pearson Education, 2007.
7. Geoffrey, M. Cooper: *The Cell – A Molecular Approach*, (2nd Ed.) ASM Press, Wahsington, D.C.
8. Freifelder, D.: Molecular Biology, Jones & Bartleth Pub. Inc.
9. De Robertis, EMF & EDP De Robertis: *Cell and Molecular Biology*, BI Waverly Pvt. Ltd.1997.

[***All the books shall be of latest editions***]

ZOO-502: Environmental Biology 100 Marks (4 Credits); 100 contact hours

Unit 1: Ecological principles

1. Concepts of ecosystem: structure and function of ecosystems
2. Primary production: methods of measurements
3. Global pattern and controlling factors
4. Trophic levels, Food chains and Food webs

Unit 2: Population dynamics

1. Demography
2. Population growth form
3. Population density and structure
4. r- and k- selections and carrying capacity

Unit 3: Environmental health and Toxicology

1. Agricultural wastes and management
2. Domestic waste: effects and management for purification and recirculation
3. Biodegradation and Bioremediation

Unit 4: Biodiversity, Conservation and management of natural resources

1. Biodiversity values and ecosystem services
2. Threats to biodiversity
3. Conventions: CITEC, CBD, Ramsar sites and IUCN
4. Endangered species management and biodiversity protection

Recommended Books

1. Ehrlich, Ehrlich & Holdren: Ecoscience, Freeman Publ.1997.
2. Freedman, B: Environmental ecology, Acad.Press, 1989.
3. Watt, K.E.F.: Principles of Environmental Sciences.
4. Odum, E.P.: Fundamentals of Ecology, Saunders International.
5. Kormondy, J: Concepts of Ecology, Oxford & IBH.1984
6. Ambasht, R.S.: A text book of Plant Ecology. Students Friends Publ. Varanasi 1990
7. Misra, K.C.:Manual of Plant Ecology, Oxford & IBH. New Delhi.
8. Remmert, H. : Ecology: A text book , Springer Verlag.1990
9. Harper, J.L.: Population Ecology of Plants. Acad. Press New York.
10. Colinvaux, P: Introduction to Ecology. John Willey & Sons, Inc.
11. Daubenmire, R.F.: Plants and Environment. Willey Eastern Pvt. Ltd. New Delhi (Edn.II).
12. Richards, P.W.: The tropical Rainforest. Cambridge University Press. 1996.
13. Putman,R.J. and Wrathen, S.D.: Principles of Ecology, Chapman and Halls. New York, 1988.
14. Grime, J.P.: Plant Strategies and Ecosystem Processes. John Welley and Sons, New York.
15. Misra, R: Ecology work book. Today and Tomorrow publ., Allahabad, 1974.
16. Richard Brewer: The Science of Ecology (2nd Ed.), Sounders Pub., 1994.
17. J.S. Singh, S.P. Singh,, S.R. Gupta: Ecology Environment and Research Conservation (Anamaya Publishers, New Delhi, 2006).

[***All the books shall be of latest editions***]

ZOO-503: Comparative Anatomy of Vertebrates 100 Marks (4 Credits); 100 contact hours

Unit 1:

1. Development, structure and functions of integument and its derivatives (glands, scales, feathers and hairs).
2. Comparative account of digestive and respiratory systems in vertebrates.

Unit 2:

1. Comparative study of heart anatomy in vertebrates; Evolution of aortic arches and portal systems.
2. Comparative account of jaw suspension, vertebral column, limbs and girdles.

Unit 3:

1. Evolution of urinogenital system in vertebrates including succession of kidneys.
2. Basic concepts of comparative muscular system in vertebrates.

Unit 4:

1. Comparative anatomy of brain and spinal cord, peripheral and autonomic nervous system of vertebrates.
2. Sense organs in vertebrates; Comparative account of endocrine glands (pituitary, thyroid, parathyroid, thymus, adrenal and pancreas).

Recommended Books

1. Weichert, C.K.: Anatomy of the Chordates-Vertebrates. McGraw-Willey International Book Co Tokyo.
2. George C. Kent and Robert K. Carr: Comparative anatomy of the vertebrates. McGraw Hill International Edition, 2001, Singapore.
3. Walter & Shakes: Biology of Vertebrates, Acad. Press.
4. Eaton: Comparative anatomy of vertebrates.
5. Romer A.S.: Anatomy of Vertebrates.
6. Kingsley, J.S. Outlines of Comparative Autonomy of Vertebrates, Central Book Depot. Allahabad.
7. Young J.Z. life of vertebrates. The oxford University Press, London

[***All the books shall be of latest editions***]

ZOO-504: Developmental Biology, Basic Histology and Histochemistry **100 Marks (4 Credits)**
100 contact hours

Unit 1:

1. Spermatogenesis and oogenesis; Fertilization: mechanism and biological significance.
2. Early embryonic development: pattern of cleavage and events during cleavage, blastula formation and gastrulation in mammals.
3. Gene expression and human disease: inborn errors of nuclear RNA processing, inborn errors of translation; Teratogenesis: environmental assaults on human development.

Unit 2:

1. Elementary concepts of: transplantation, determination, competence, embryonic induction and organizers.
2. Hormonal control of ovulation and pregnancy; Histomorphology and physiology of Placenta.

Unit 3:

1. Organogenesis: tissue interaction during the development of brain; Differentiation: chemical and molecular basis of differentiation.
2. Regeneration: factors affecting regeneration, histo-physiological processes during regeneration.
3. Senescence and apoptosis; Embryonic stem cells and their applications.

Unit 4:

1. Characteristics and basics of epithelial tissue; Ultrastructure of skeletal muscle; Histology of mammalian bone tissue.
2. Histochemistry: General principles and techniques of histochemistry; Identification of: proteins, carbohydrates, lipids, nucleic acids (in sections).

Recommended Books

1. Balinsky, B.I.: An introduction to Embryology,W.B. Saunders-Toppan Co. Japan.
2. Waddington, C.H.: Principles of Development and differentiation.
3. Berril and Carp: Developmental Biology.
4. Rastogi, V. B. and M.S. Jayaraj: Developmental Biology, Kedarnath Ramnath, Meerut.
5. Berril, N.J.: Developmental Biology T.M.H.
6. John W. Saunders Jr: Developmental Biology, Macmillan Publishing Co.Inc.N.Y.
8. Verma, P.S. and Agarwal, V.K.: Chordate Embryology, S. Chand & Co. Ltd., New Delhi.
9. T.W. Sadler: Langman"s Medical Embryology, 11th Edn. 2010. Lippincott, Williams & Wilkins
10. Michael H. Ross: Histology: A Text and Atlas, 3rd Edn.1995, Lippincott, Williams & Wilkins
11. Drury R.A.B. and E.A.: Wallington - Carlton's Histological Techniques, Oxford University Press.

[***All the books shall be of latest editions***]

ZOO-505: General Lab-1 (based on ZOO-501 and ZOO-502) 100 Marks (4 Credits)

Cell and Molecular Biology 40 marks

1. Study of mitotic and meiotic cell divisions in grasshopper/silkworm/fish/rat
2. Demonstration of salivary gland chromosomes of *Drosophila*/*Chironomous* larva
3. Demonstration of sex-chromatin (Barr body) in buccal smear and hair bud cells.
4. Isolation of genomic DNA from a bacterial cell/human blood
5. Polymerase chain reaction (PCR) [Demonstration]

Environmental Biology 40 marks

1. Study of pH of different types of soil.
2. Study of bioindicators in different water samples.
3. Estimation of minerals (Na, Ca, K, Mg, Fe, etc.) in water.
4. Studies on the population density of insect communities in a grassland ecosystem.
5. Determination of density of different species in a grassland ecosystem.

Laboratory Record Book 10 marks
Viva voce 10 marks

ZOO-506: Zoology Lab-1 (based on ZOO-503 and ZOO-504) 100 Marks (4 Credits)

Comparative Anatomy 25 marks

1. Dissection and display of aortic arches of fish.
2. Comparative osteological study: lower jaw, vertebral column and limbs of birds and mammals.
3. Dissection and display of endocrine glands of fish.
4. Mounting: Fish scales, Ampulla of Lorenzini, Chromatophores, Salivary gland & mouth parts of cockroach.

Developmental Biology 25marks

1. Study of different types of eggs (of fish, frog, lizard and bird).
2. Study of permanent slides of different developmental stages of frog.
3. Study of chick embryo of different hours of incubation (24, 36, 40, 48, 55 and 72 hours).

Histology 12 marks

1. Study of mammalian permanent slides of simple squamous, cuboidal and columnar epithelia.
2. Study of mammalian permanent slides of skeletal muscle fibers and bone tissues.

Histochemistry 18 marks

1. Preparation of sections for histochemical tests for lipids, carbohydrates, amino acids, and nucleic acids.
2. Demonstration of lipids using Sudan dyes.
3. Demonstration of proteins by Sakaguchi and Millon's Reactions.
4. Demonstration of glycogen by PAS.
5. Demonstration of nucleic acids by using Methyl green and pyronin.

Laboratory Record Book 10 marks

Viva voce 10 marks

SEMESTER II

ZOO-507: Biochemistry and Immunology 100 marks [4 credits]; 100 contact hours

Biochemistry

Unit 1:

1. Fundamental non-covalent bond types: electrostatic interactions, hydrogen bonds, van der Waals interactions, and hydrophobic interactions.
2. Structure and classification of amino acids; Concepts of peptides and proteins; Primary, Secondary, Tertiary and Quaternary structure of proteins; Ramachandran plot.
3. Enzymes: General account, Classification, Enzyme kinetics, Enzyme inhibition, Isozymes and Coenzymes.
4. Biological energy transformations and Laws of Thermodynamics; Standard Free-Energy Change and Actual Free-Energy Change; ATP as Universal Currency of free energy.

Unit 2:

1. Carbohydrate metabolism: Glycolysis and its regulation in liver and muscle, Oxidative decarboxylation, Citric acid cycle and its regulation, Glycogenesis and Glycogenolysis and their regulation, Gluconeogenesis and its regulation, Hexose monophosphate shunt.
2. Metabolism of amino acids: Transamination, deamination and Urea cycle.
3. Metabolism of fats: Oxidation of fatty acids, formation and utilization of ketone bodies, biosynthesis of fatty acids.
4. Electron transport chain and oxidative phosphorylation.

Immunology

Unit 3:

1. Introduction to cells and organs of Immunity; Types of Immunity: cell mediated immunity and humoral immunity.
2. Antibody: fine structure, classes, allotypes and idiotypes; Functional properties of antibodies; Generation of antibody diversity: molecular mechanism.
3. Antigen: classes, epitopes and paratopes; Acquired immunological tolerance; Major histocompatibility complex: MHC genes and molecules, role of MHC in immune response; Complement system: pathways, biological activities of complement components; Concepts of cytokines; Hypersensitivity reactions.

Unit 4:

1. Immuno-hematology: ABO blood group, Rh blood group & HDN, and Clinical aspects of blood transfusion; Transplantation immunology: immunologic basis of graft rejection, clinical manifestation of graft rejection, tissue typing, immune suppressive drugs.
2. Tumor immunology: tumor antigen, immunity against cancer, cancer immunotherapy; Immunodeficiency diseases: primary, severe combined immunodeficiency disease, secondary immunodeficiency disease, acquired immunodeficiency disease.
3. Recent development in antibody and immunotherapy; Immunization: active and passive, recent approaches to vaccine production.

Recommended Books:

1. Stryer, L: *Biochemistry*, W.H. Freeman & Co, New York, 2012.
2. Michael M. Cox and David L. Nelson: *In Lehninger Principles of Biochemistry*, 5th Edn.2010; W.H. Freeman and Company, New York
3. Victor W. Rodwell, David A. Bender, Kathleen M Botham, Peter J. Kennelly, P. Anthony Weil: Harper's Illustrated Biochemistry, 30th Edn. 2015; Mc Graw Hill Education.
4. Satyanaraya, U: Biochemistry, 3rd Edn. 2006; Books and Allied (P) Ltd., Kolkata
5. Vasudevan DM, Sreekumari S: Text Book of Biochemistry, 5th Edn.2007; Jaypee Brothers, New Delhi
6. A.C. Dev: Text Book of Biochemistry
7. Bruce Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: In *Molecular Biology of the cell*, 6thEdn, 2015; Publisher: Garland Science, Taylor & Francis Group, New York
8. Roitt, I.M. : *Essential Immunology*, ELBS Edition
9. Paul, W.E.: *Fundamentals of Immunology*, Lippincott-Raven Pub., Philadelphia, New York.
10. Kuby: *Immunology* , W.H. Freeman, USA
11. Lal, S.S.: *Immunology*, Rastogi Pub., Meerut, India (3rd ed., 2012).
12. Tizzard, I: Immunology

[***All the books shall be of latest editions***]

ZOO-508: Applied Zoology and Animal behavior/Ethology **100 marks [4 credits]**
100 contact hours

Unit 1:

1. Sericulture: scope and prospects of sericulture
2. Life cycle and rearing methods of mulberry and tasar silk worms.
3. Apiculture: prospects and problems of apiculture in India.
4. Species diversity of honey bees, indigenous and modern methods of apiculture.

Unit 2:

1. Lac culture: cultivation and extraction of lac, uses of lac.
2. Fishery and aquaculture: types of fish culture, induced and natural breeding; Integrated fish farming; Transgenic fishes.
3. Preservation and processing of fish food, freshwater prawn culture.

Unit 3:

1. General Introduction of clinical parasitology: Historical perspectives, parasites and parasitism.
2. Morphology, life cycle, epidemiology, pathogenicity and prophylaxis of *Cryptosporidium parvum*, *Enterobius vermicularis* and *Echinococcus granulosus*.
3. General account on medically important arthropods (mosquitoes, lice, fleas, bed bugs, ticks and mites).

Unit 4:

1. Types of animal behaviour: stereotyped and acquired behaviour
2. Communication in insects, fishes and birds.
3. Adaptive functional significance of biological clocks.
4. Migration in fishes and birds; Role of hormones in animal behaviour.

Recommended Books:

1. Cheng, T.C.: *General Parasitology*, Academic Press College Division, Harcourt Brace Javanovich, Publishers Orlando, Florida (2nd Edition, 1986).
2. Smyth, J.D.: *Animal Parasitology*, Cambridge University Press (3rd Edition, 1993).
3. Ichhpujani R.L. and R. Bhatia: *Medical Parasitology*, Jaypee Brother Medical Publishers (P) Ltd. New Delhi.
4. Jhingran, V.G.: *Fish & Fisheries of India,* 3rd. En. Today & Tomorrow Book Agency, New Delhi.
5. G.S. Shukla and V.B. Upadhyay : *Economic Zoology*, Rastogi Publications, Shivaji Road, Meerut
6. David, B.V. and Anantha Kiishnan, T.N.: *General and Applied Entomology*, Tata-Mcgraw-Hill, New Delhi.
7. B.K. Tyagi: *Medical Entomology – A handbook of Medically important insects and other arthropods,* Scientific Publishers, India
8. Alcock John: Animal Behaviour, Sinauer Associate Inc., USA
9. Goodenough, McGuire and Wallace: Perspective on Animal Behaviour, , John Wiley & Sons, USA
10. A. Manning and M.S Dawkins: An Introduction to Animal Behaviour, , Cambridge University Press, UK.

[***All the books shall be of latest editions***]

ZOO-509: Animal Physiology and Endocrinology **100 marks [4 credits]**

100 contact hours

(*Physiology should be with special reference to mammal/man*)

Unit 1:

1. Digestion and absorption of food; Regulation of gastrointestinal functions.
2. Mechanism of Inspiration and Expiration; Mechanism of O_2 and CO_2 transport in blood; Regulation of respiration.
3. Mechanism of blood coagulation; Cardiac conducting system and Cardiac cycle; Regulation of blood pressure.

Unit 2:

1. Physiology of urine formation and its regulation; Micturition.
2. Mechanism of skeletal muscle contraction; Sources of energy during muscle contraction; Fate of muscle lactate (Cori cycle).
3. Resting membrane potential and action potential of nerves; Propagation of nerve action potential/impulse; Transmission of nerve impulse through synapse.

Unit 3:

1. Fine structure of retina; Photochemistry of vision; Nocturnal and diurnal adaptations; Colour vision.
2. Physiology of hearing, olfaction and taste.
3. General concept of bioluminescence; Illustration of bioluminescence in invertebrates and vertebrates.

Unit 4:

1. Mechanism of hormone (steroid, amine and peptide/protein hormone) action.
2. Hypothalamo-hypophysial axis and physiological functions of hypothalamic and pituitary hormones; Physiological functions of hormones of thyroid, parathyroid, and thymus.
3. Physiological functions of hormones of adrenal, pancreas, testis, ovary, heart, kidney and placenta.

Recommended books:

1. Arthur C. Guyton and John E. Hall: *Text book of Medical Physiology*, 12th Edn. Elsevier Saunders.
2. Kim E. Barrett, Scott Boitano, Susan M. Barman and Heddwen L. Brooks: *Ganong's Review of Medical Physiology*, 23rd Edn. 2010. Tata McGraw Hill Education Private Limited, New Delhi.
3. Henry M. Kronenberg, S. Melmed, K.S. Polonsky and P. Reed Larsen: *Williams Text book of Endocrinology*, 12th Edn. 2011. Saunders Elsevier.
4. Mac E. Hadley: *Endocrinology*, 5th Edn. 2004. Pearson Education, Delhi.
5. A.K. Jain: *Text book of Physiology, Vol. I & II*, 4th Edn. 2011. Avichal Publishing Company, New Delhi.
6. William S. Hoar: *General and Comparative Physiology*, 3rd Edn. 1983. Prentice Hall of India, New Delhi.
7. Prosser, C.L. and Brown: *Comparative Animal Physiology*, Acad. Press.

[***All the books shall be of latest editions***]

ZOO-510: Evolution, Biosystematics and Taxonomy **100 marks [4 credits]**

100 contact hours

Evolution

Unit 1:

1. Modern synthetic concepts of organic evolution.
2. Speciation: Types of speciation, role of hybridization, genetic drift, variation, Hardy-Weinberg Equilibrium.
3. Role of Isolation in speciation.

Unit 2:

1. Reproductive isolation and origin of species.
2. Implications of geographical distribution for mode of speciation.
3. Isolating mechanisms in evolution; Theory of Orthogenesis.

Biosystematics and Taxonomy

Unit 3:

1. Principles of Taxonomy: Concept of Species, Difficulties in the application of the Biological concept of Species.
2. International Code of Zoological Nomenclature.
3. Recent trends in Modern Taxonomy: morphological, cytological, biochemical and numerical

Unit 4:

1. Taxonomic terms, Taxonomic characters, Taxonomic publication and Linnaean Hierarchy.
2. Taxonomic collection, Techniques of preservation and processes of identification of specimens.

Recommended books:

1. Richard S Lull: *Organic Evolution*, Light & Life Publisher.
2. Veer Bala Rastogi: Organic Evolution, 13th Edn. 2018, Meditech
3. Futuyama, D.J.: *Evolutionary Biology*, Sinaver Associates .Inc.
4. Mayr, E. & P.D. Ashlock: *Principles of Systematic Zoology*, Mc-Graw Hill Inc.
5. Kapoor , V.C. : *Theory and Practice of Animal Taxonomy* – Oxford & IBH, New Delhi
6. Black Welder, R.E.: *Taxonomy: A text and reference book*, New York.
7. Quicke DL J: *Principles & Techniques of Contemporary Taxonomy*. Blackies Academic and Professional

[***All the books shall be of latest editions***]

ZOO-511: General Lab-2 (based on ZOO-507 & ZOO-508)

100 marks [4 credits]

100 contact hours

Biochemistry **25 marks**

1. Determination of blood glucose concentration by Anthrone/Somogi method
2. Estimation of protein by Lowry's /Bradford's method
3. Estimation of cholesterol
4. Determination of enzyme activity of acid phosphatase
5. Detection of free amino acids by Paper Chromatography

Immunology **25 marks**

1. Study of permanent slides of sections of mammalian spleen, thymus, lymph node and tonsil
2. Assay of antibodies by ELISA/Chemiluminescence (demonstration)
3. ABO and Rh blood grouping
4. Minor and major Cross matching for blood transfusion

Applied Zoology **20 marks**

1. Study of different stages of life cycle of mulberry and tasar silk worms
2. Preservation and processing of some common fish fauna of Manipur
3. Identification of permanent slides of human protozoan parasites

Animal behavior/Ethology **10 marks**

1. Study of parental care in insects/fishes/birds

Laboratory Record Book **10 marks**

Viva voce **10 marks**

ZOO-512: Zoology Lab-2 (based on ZOO-509 & ZOO-510)

100 marks [4 credits]
100 contact hours

Animal Physiology **30 marks**

1. Study of effect of temperature and pH on the activity of salivary amylase
2. Determination of metabolic rate in cockroach/frog/bird/rat
3. Demonstration of muscle contraction/heart beat by kymograph
4. Differential Leucocyte Count
5. Measurement of Erythrocyte Sedimentation Rate (ESR)
6. Measurement of blood pressure using sphygmomanometer

Endocrinology **20 marks**

1. Hypophysectomy, thyroidectomy and adrenalectomy in rats
2. Study of permanent slides of sections of mammalian endocrine glands (Pituitary, thyroid, adrenal, pancreas, testis and ovary)
3. Assay of blood hormone (s) by ELISA/Chemiluminescence (demonstration)

Evolution **10 marks**

1. Calculation of frequencies of recessive and dominant genes in a population.
2. Study of different Geological Time scale of evolution of animals.

Biosystematics and Taxonomy **20 marks**

1. Identification of museum specimens by studying specific taxonomic characters:
   i. Porifera: *Euplectella, Leucosolenia*
   ii. Coelenterata: *Pennatula, Tubipora, Alcyonium*
   iii. Platyhelminthes: *Taenia saginata, Planaria, Dipylidium caninum*
   iv. Nemathelminthes: *Enterobius, Ancylostoma, Trichuris*
   v. Annelida: *Amphitrite, Hirudinaria, Sabella*
   vi. Arthropoda: *Palamnaeus, Julus, Phyllium, Carausius, Termite Queen, Squilla, Belostoma*
   vii. Mollusca: *Mytilus, Pinctada, Lymnaea, Loligo, Dentalium*
   viii. Echinodermata: *Echinus, Ophiothrix, Cucumaria*
   ix. Hemichordata: *Balanoglossus, Saccoglossus*
   x. Urochordata: *Ascidia, Herdmania*
   xi. Cephalochordata: *Branchiostoma/Amphioxus*
   xii. Cyclostomata*: Petromyzon, Myxine*
   xiii. Fishes: *Rhinobatus, Trygon, Chimaera, Clarias, Anabas, Amphipnous, Exocoetus, Synaptura, Tetradon, Protopterus, Lepidosiren*
   xiv. Amphibia: *Axolotl* larva*, Necturus, Alytes, Ichthyophis, Rhacophorus*,
   xv. Reptilia: *Calotes, Chelone, Testudo, Sphenodon, Mabuia, Ophisaurus, Bungarus*
   xvi. Aves: *Passer, Mellisuga helenae, Corvus*
   xvii. Mammalia: *Sorex, Pteropus, Dasypus, Ornithorhynchus, Echidna*

2. Preparation of temporary slides and identification of selected specimens (bed bug, mosquito larva, fleas, ticks, lice, aphids, Gammarus, etc.)

Laboratory Record Book **10 marks**

Viva voce **10 marks**

OPE - X: Biodiversity and Climate change **100 marks [4 credits]**
100 contact hours

Unit 1:

1. Concept and Principle of Biodiversity; Ecological Importance of Biodiversity
2. Biodiversity Hotspots in India
3. Causes for the loss of Biodiversity

Unit 2:

1. Strategies of Biodiversity Conservation: *in situ* and *ex situ* conservation
2. Status of Biodiversity Conservation in India
3. Protected areas: National Parks and Sanctuaries

Unit 3:

1. Concept of wild life with special reference to India including positive and negative values of wild life; Wild life Protection Act and Conservation
2. Bioprospecting for sustainable development
3. Biopiracy and protection measure

Unit 4:

1. Climate change: Definition, Cause and Impact
2. Cause and effects of global warming
3. Equal right to global warming, Global status for climate change and global warming

Recommended books:

1. Santra, SC: Environmental Science, New Central Book Agency (P) Ltd., Kolkata
2. T.N. Ananthakrishnan & K. Sivaramakrishnan: *Animal Biodiversity: Pattern and Processes* Scientific Publishers.
3. J.S. Singh, S.P. Singh & S. Gupta: *Ecology Environment & Resources Conservation* Anamaya Publishers, New Delhi, 688pp.
4. Gadgil Madhav: *Nurturing biodiversity: An Indian agenda (Environment & Development Series)* by Publ. Centre for Environment Education, 1998.
5. T.S. Krishnan: *Biodiversity Conservation and Management* Swastik Publishers & Distributors, New Delhi.

[***All the books shall be of latest editions***]

SEMESTER III

ZOO-613: Biotechnology and Genetic Engineering 100 marks [4 credits]; 100 contact hours

Unit 1:

1. Animal cell and tissue culture: Design of cell culture laboratory and set up of equipment; Culture media and reagents; Primary culture and cell lines.
2. Techniques, advantages and applications of tissue/organ culture; Primary and secondary cell culture.

Unit 2:

1. Reproductive Biotechnology: *In vitro* fertilization and embryo transfer in human beings, ICSI (Intracytoplasmic sperm injection) and other Assisted Reproductive Technology.
2. Basics of animal cloning; Cryopreservation and Cryoprotection and gamete banking.

Unit 3:

1. rDNA Technology: Enzymes and other tools used in rDNA technology; Cloning vectors (plasmids, bacteriophages, cosmids, phagemids, phasmids, BACs & YACs).
2. General technique of rDNA technology; Construction of cDNA and genomic library; Gene transfer to animal cells; Transgenic technology; Basic idea of molecular probes; DNA fingerprinting and footprinting.

Unit 4:

1. Application of Biotechnology: Production of monoclonal antibodies through Hybridoma technology; Production of human insulin and recombinant haemoglobin; Biotechnology in molecular diagnosis and gene therapy.
2. Biotechnology and Intellectual Property (IPR and IPP).

Recommended books:

1. Primrose, S. B. and Twyman, R.M.: Principles of Gene Manipulation and Genomics, (7th Ed. 2006), Blackwell Publishing, West Sussex, UK.
2. Bernard R. and Jack: Molecular Biotechnology: Principles and application of recombinant DNA, ASM Press, Herndon, USA.
3. Watson et al: Recombinant DNA: Genes and Genomics – a short course, W.H. Freeman and Company, New York, USA.
4. B.D. Singh: Biotechnology (4th Ed. 2012), Kalyani Publications, Kolkata.
5. Gupta, P.K.: Elements of Biotechnology, Rastogi Publications, Meerut.
6. J. Paul: Animal cell culture.

[***All the books shall be of latest editions***]

ZOO-614: Tools and Techniques in Biology 100 marks [4 credits]; 100 contact hours

Unit 1: Microscopy: principles and applications of Bright field, Dark field, Phase contrast, Confocal, Fluorescence and Electron microscope.

Unit 2: Chromatography: principles and applications of Paper and Thin Layer Chromatography, Column Chromatography, High Performance Liquid Chromatography (HPLC), and Gas Chromatography-mass spectrometry (GC-MS).

Unit 3: Electrophoresis: principles and applications of Agarose and Polyacrylamide gel electrophoresis (PAGE).

Spectrophotometry: Beer-Lambert's Law; Principles and applications of colorimeter, UV-visible Spectrophotometer and Flame Photometer; Brief idea of Nuclear Magnetic Resonance (NMR) Spectrophotometry.

Unit 4: Radio-tracer Techniques: unit of Radioactivity and half-life; Measurement of Radioactivity; Autoradiography and Radioimmunoassay.

DNA Sequencing; Southern, Northern and Western blotting; Enzyme-Linked Immunosorbent Assay (ELISA); Polymerase Chain Reaction (PCR).

Recommended books:

1. Robert, B: Introduction to Instrumental Analysis (Latest Ed.), McGraw Hill International Publ.
2. Wilson, K. and Goulding, K.H.: A Biologist Guide to Principles and Techniques of Practical Biochemistry, ELBS Ed.
3. Wilson, K. & Walker, J.: Practical Biochemistry (2003), Cambridge University Press.
4. Plummer, D.T.: An Introduction to Practical biochemistry (3rd Ed. 2003), Tata-McGraw-Hill Publ. Co., New Delhi.
5. Boyer: Modern Experimental Biochemistry and Molecular Biology (2nd Ed. 1993), Benjamin/Cumin.
6. Switzer and Garrity: Experimental Biochemistry (Latest Ed.), Freeman and Company.
7. Bruce Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: In Molecular Biology of the cell, 6thEdn, 2015; Publisher: Garland Science, Taylor & Francis Group, New York.
8. H. Lodish, D. Baltimore & others: In Molecular Cell Biology, 5th Edn, 2006, Publisher: W.H. Freeman and Company, New York.

[***All the books shall be of latest editions***]

ZOO-615: General Lab-3 (based on ZOO-613 and ZOO-614) **100 Marks (4 Credits)**

Biotechnology and Genetic Engineering **40 marks**

1. Isolation of plasmid DNA.
2. Quantification and checking purity of DNA.
3. Digestion of plasmid DNA by Restriction enzyme.
4. Preparation of animal tissue culture media.
5. Preparation of competent cells and storage.

Tools and Techniques in Biology **40 marks**

1. Demonstration of Paper and Thin Layer Chromatography.
2. Verification of Beer-Lambert's Law and preparation of calibration curve of glucose/amino acids.
3. Demonstration and usage of Electrophoresis.
4. Preparation of tissue for SEM and TEM procedure.

Laboratory Record Book **10 marks**

Viva Voce **10 marks**

ZOO-621: Entomology I 100 Marks (4 Credits); 100 contact hours

Unit 1: Integument and Head in Insects: Structure, composition and functions of integuments and cuticular appendages; Head: Segmentation, appendages and sensory organs.

Unit 2: Body and Appendages of Insect: Thorax, abdomen and the appendages.

Unit 3: Insect Taxonomy: Morphological, Behavioural, Numerical, Molecular and chemotaxonomy including cuticle wash of insects.

Unit 4: Classification of Insects: Principles of construction and use of dichotomous keys in insects, Classification of Hemimetabolous and Holometabolous insects with reference to economically important orders and families.

ZOO-622: Entomology II **100 Marks (4 Credits); 100 contact hours**

Unit 1: Insect Ecology: Insect diversity and density; Ecological factors that influence insect population; Essentials of insect feeding, breeding and communication behavior; Functional ecology of Insect-Plant interaction; Theory of co-evolution, host-plant selection by phytophagous insects, role of allelochemicals in host- plant mediation.

Unit 2: Post embryonic development: Larval and pupal forms, diapause, metamorphosis, types, neuropeptides and neuroendocrine/hormonal regulation, Polyembryology and parthenogenesis in insects.

Unit 3: Insect Physiology I: Digestive, reproductive and excretory systems of insects

Unit 4: Insect Physiology II: Nervous, endocrine, respiratory and circulatory systems of insects; Mechanoreceptors and Chemoreceptors in insects.

Recommended Books:

1. David, B. V. and Ananthakrishnan, T. N. (2013): *General and Applied Entomology*, Tata McGraw Hill, New Delhi.
2. Dungston Ambrose (2004): *The insects: Structure, function & biodiversity*, Kalyani Publications, New Delhi.
3. Tembhare, D. B. (2006). *Modern Entomology*, Himalaya Publishing House, New Delhi, himpub@vsnl.com pp.623
4. Chapman, R. F.: *The insect structure and function*, English Language Book Society, New Delhi.
5. Fenemore, P. G. and Alka Prakash (2006): *Applied Entomology*, New Age International Pvt. Ltd., New Delhi.
6. Ananthakrishnan, T. N. and Douglas Whitman (2005) *Insect Phenotypic Plasticity, Diversity of Responses,* Science Publishers, Inc., Enfield (NH), USA, Printed in India, sales@scipub.net pp.213.
7. Ananthakrishnan, T. N. (2010): *Insect Biodiversity: Functional dynamics and Ecological Perspectives.* Scientific Publishers (India).
8. Ananthakrishnan, T. N. : *Dimensions of Insect Plant Interactions*, Oxford Books and Periodicals, New Delhi.
9. Snodgrass, R. E. : *Principles of Insect Morphology*, Tata McGraw Hill, New Delhi.
10. William S. Romoser and John G Stoffolano (1994): *The Science of Entomology*, Win C Brown Publishers, England.
11. Richards and Davies (1993): *Imm's General Textbook of Entomology*, Volume I & II, Chapman & Hall, London. (B. I. Publication, Pvt. Ltd., 54-Janpath, New Delhi)
12. Roeder, K. S.: *Insect Physiology*, (Indian Print – 1994): International Books and Periodicals Service, 24B/5, Karol Bagh, New Delhi – 5.
13. Wigglesworth, V. B. : *Principle of Insect Physiology*, Chapman & Hall, English Language Book Society.
14. Larry P. Pedigo (1999): *Entomology and Pest Management* ,Third Edition, Prentice Hall, New York (Indian print available from MacMillan Publishing Company) 691 pp.

[***All the books shall be of latest editions***]

ZOO-623: Entomology Lab I 100 Marks (4 Credits); 100 contact hours

Experiments:

1. Permanent slide preparation of insect/insect body parts (antennae, mouthparts, legs, wings, tentorium, empodium, arolium and pollen basket) and drawing of the parts using Camera lucida.
2. Estimation and identification of chitin in insect integument.
3. Study of Haemocytes: Types, structures and counting using Neubauer's Haemocytometer.
4. Dissection of reproductive system, nervous system and neuro-endocrine organ of selected common pest species.
5. Food preference and quantification of food intake by insects.
6. Estimation of proteins, sugars & lipids in insect haemolymph by Colorimetric method.

ZOO-631: Fishery I (Fish Biology) 100 Marks (4 Credits); 100 contact hours

Unit 1: **Fish Taxonomy**: Classification of fishes; Freshwater fish taxonomy; Techniques for identification of fishes of northeast India; Modern techniques of fish taxonomy- DNA barcoding; Freshwater ecoregions, drainage basins and distribution, status of freshwater fishes of northeast India.

Unit 2: **Exo-Endoskeleton**: Integuments, types of scales; Pigmentation and coloration; Skeletal system: cranium, visceral arches, vertebral column, fins and skeleton and caudal vertebrae; Importance of osteology in fish classification.

Unit 3: **Nutrition and Circulation**: Nutritional requirements of fish: proteins, carbohydrates, fats, vitamins and minerals; Digestion: Alimentary canal and its modification in relation to food and feeding habits, Physiology of digestion; Feed formulation: General principles, different types of feed formulation, classification of feed ingredients; Circulation: Different types of fish heart, working of heart, regulation of cardiac activity.

Unit 4: **Respiration, Excretion and Osmoregulation**: Aquatic respiration, gills, gas exchange, gill ventilation; Air breathing: condition for air breathing, accessory respiratory organs; Swim bladder and its types, composition of gas and hydrostatic control; Kidney- glomerular and aglomerular, excretion of nitrogenous wastes, water and ion balance; Stenohaline and euryhaline teleosts; Osmoregulation in migratory teleosts.

ZOO-632: Fishery II (Culture Fisheries) 100 Marks (4 Credits); 100 contact hours

Unit 1: **Fish farm**: construction and layout of different types of ponds; Pond management: physico-chemical properties of pond water and soil and their maintenance; Nursery pond management: pond fertilization, aquatic weeds, insect weed fish, predatory fish and their control, pond manuring and fertilization, artificial feeding.

Unit 2: **Ornamental fish and Shellfish culture**: Ornamental fish culture; Construction of aquarium and its maintenance; Brief accounts of shellfish; Biology of shrimps and its culture; Pearl culture; Hill stream fishes and its structural modifications, histology of adhesive structures.

Unit 3: **Inland fish culture techniques**: Sewage-fed fish culture, cage culture, pen culture, raft and raceway fish farms; Exotic fish culture: selection of fish species, invasive species and its impacts on natural fisheries; Integrated fish culture: Paddy cum fish culture, composite fish culture, integrated fish culture; Aquaponics and its operation.

Unit 4: **Fish environment and health**: Fish environment: relationship between environment and fisheries, water pollution and its impacts on fisheries; Fish food organisms: Zooplanktons, phytoplanktons and their role in fisheries; Culture of fish food organisms; Fish health management; Diseases in aquaculture, parasitic and non-parasitic: bacterial, viral and fungal pathogens of fish; Fish pathology: prophylaxis and therapy.

ZOO-633: Fishery Lab I 100 Marks (4 Credits); 100 contact hours

Section A

1. Identification and classification of freshwater fishes of Northeast India using morphometric and meristic characters, use of key characters, description.
2. Identification of eggs, fries and fingerlings of commercially important fishes.
3. Preparation of fish skeleton and study: cranium, visceral skeleton, vertebrae, girdles, fins and caudal skeleton.
4. Study of food and feeding habits of fishes, Bucco-pharynx of economically important fishes, Pharyngeal teeth.
5. Examination of gut contents, qualitative and quantitative.
6. Dissection and examination of gills.
7. Dissection and examination of accessory respiratory organs.
8. Dissection of Weberian Ossicles.

Section B

1. Water and soil sampling from fish farms. Physicochemical analysis of water – turbidity, temperature, dissolved oxygen, carbon dioxide, alkalinity, pH, BOD.
2. Identification of weed fishes, predatory fishes and predatory insects in fish pond.
3. Eradication of predatory insects: Calculation of water surface area, preparation of soap – oil emulsion and application.
4. Manuring of ponds, calculation of quantity, methods of application and effects of water quality and biota.
5. Setting up of an aquarium and its maintenance.
6. Identification of exotic and invasive fish species.
7. Planktons: Identification of common zoo and phyto-planktons of the freshwater ponds. Plankton counting using Sedgwick-Rafter scale.
8. Identification of common fish parasites.

Recommended Books:

1. Jhingran, V.G.: Fish and Fisheries of India3rd. En Today and Tomorrow Book agency, New Delhi.
2. Pillay, T.V.R. 1990 : *Aquaculture, Principles and Techniques*. Fishing News Bk. Ltd.
3. Edmonson, W.I.: *Freshwater Biology*, Ward and Weipel.
4. Abidi, R.: *Fish Pathogen & Diseases in India*.
5. Amlacher, E.: *Text Book of Fish Diseases*.
6. S.K. Gupta & P.C. Gupta : General and Applied Ichthyology (*Fish and Fishery*) , S. Chand & Co. Ramnagar, New Delhi, 110055.

[***All the books shall be of latest editions***]

ZOO-641: Animal Physiology and Endocrinology I (General Physiology)

100 Marks (4 Credits); 100 contact hours

Unit 1: Gastrointestinal and Respiratory Physiology

1. Neural and endocrine regulation of gastrointestinal movement and secretion; Regulation of food intact and thirst.
2. Pulmonary volumes and capacities; Neural and chemical regulation of respiration.
3. Respiratory pigments in animals.

Unit 2: Cardiovascular and Renal Physiology

1. Composition and functions of blood; Regulation of heart pumping; Regulation of blood pressure.
2. Regional circulation (cerebral, coronary, portal and foetal circulation).
3. Chemistry, synthesis and catabolism of haemoglobin; Haemopoiesis; Basal Metabolic Rate.
4. Regulation of urine formation; Renal regulation of acid-base balance; Concepts of ammonotelism, uricotelism and ureotelism.

Unit 3: Muscle and Nerve Physiology

1. Mechanism of skeletal and smooth muscle contraction.
2. Molecular aspect of development of action potential and conduction in a nerve fibre.
3. Molecular mechanism of release of neurotransmitters and their actions in synaptic transmission and neuromuscular junctions.

Unit 4: Physiology of special senses

1. Photochemistry and neurophysiology of vision.
2. Eye movement and their control; Accommodation of eye.
3. Neural and molecular mechanism of sensory transduction of smell and taste.

ZOO-642: Animal Physiology and Endocrinology II (Endocrine Physiology)

100 Marks (4 Credits); 100 contact hours

Unit 1: Concept of Endocrinology and Neuroendocrinology

1. Introduction to endocrine system; Classification of hormones; Mechanism of hormone action (steroid, epinephrine/protein/peptide and insulin).
2. Hormonal Feedback mechanisms and their neuroendocrine control.
3. Concept of neurosecretory cells and their secretions; Chemistry and functions of hypothalamic hormones.
4. Biosynthesis of melatonin and its regulation; Role of pineal gland in reproduction.

Unit 2: Physiology of pituitary, thyroid, parathyroid and adrenal

1. Physiological functions of pituitary hormones; Pathophysiology of pituitary gland.
2. Biosynthesis of thyroid hormones and its regulation; Transport, functions and metabolism of thyroid hormones; Pathophysiology of thyroid.
3. Role of parathyroid gland in calcium homeostasis.
4. Biosynthesis of catecholamine in adrenal gland and its regulation; Functions of epinephrine and nor-epinephrine; Biosynthesis, transport, functions and metabolism of adrenocortical hormones; Pathophysiology of adrenal gland.

Unit 3: Endocrine pancreas and gonads

1. Synthesis and chemistry of glucagon and insulin; Role of insulin and glucagon in glucose homeostasis.
2. Diabetes mellitus: Etiology of Type 1 and Type 2, Clinical features.
3. Biosynthesis and functions of estrogen, progesterone and testosterone.

Unit 4: Hormones of other tissues

1. Functions of gastrointestinal hormones (secretin, gastrin, and cholecystokinin).
2. Functions of hormones of heart, kidney, adipose tissues and placenta.
3. Non-classical hormones: EGF, TGFα, TGFβ, anti-Mullerian hormone, inhibins, activins, FGF, IGF-I & II.

Recommended books:

1. Arthur C. Guyton and John E. Hall: *Text book of Medical Physiology*, 12th Edn. Elsevier Saunders.
2. Kim E. Barrett, Scott Boitano, Susan M. Barman and Heddwen L. Brooks: *Ganong's Review of Medical Physiology*, 23rd Edn. 2010. Tata McGraw Hill Education Private Limited, New Delhi.
3. Henry M. Kronenberg, S. Melmed, K.S. Polonsky and P. Reed Larsen: *Williams Text book of Endocrinology*, 12th Edn. 2011. Saunders Elsevier.
4. Mac E. Hadley: *Endocrinology*, 5th Edn. 2004. Pearson Education, Delhi.
5. Keel et al: Samson Wright's Applied Physiology (13th ed1989, Oxford Press)
6. West: Best and Taylor's Physiological Basis of Medical Practice (11th ed 1981, Williams
1. and Wilkins)
2. A.K. Jain: *Text book of Physiology, Vol. I & II*, 4th Edn. 2011. Avichal Publishing Company, New Delhi.
3. William S. Hoar: *General and Comparative Physiology*, 3rd Edn. 1983. Prentice Hall of India, New Delhi.
4. Prosser, C.L. and Brown: *Comparative Animal Physiology*, Acad. Press.

[***All the books shall be of latest editions***]

ZOO-643: Animal Physiology and Endocrinology Lab I

100 Marks (4 Credits); 100 contact hours

Animal Physiology **45 marks**

1. Determination of platelet count in human blood.
2. Determination of packed cell volume (PCV)/haematocrit value.
3. Effect of acetylcholine and adrenaline on rat/mouse ileum.
4. Demonstration of compound action potential in a frog's sciatic nerve.
5. Determination of the effect of posture on blood pressure.
6. Effect of adrenaline, acetylcholine and atropine on frog's/rat's heart.
7. Recording of simple muscle twitch and effect of temperature on it in an amphibian model.

Endocrinology **30 marks**

1. Study of permanent slides of sections of mammalian endocrine glands (hypothalamus, pituitary, pineal, thyroid, parathyroid and adrenal).
2. Assay of human serum TSH, T4 and T3 by ELISA.
3. Effect of thyroid hormones in oxygen consumption in bird/rat/mouse.
4. Castration and ovariectomy in rat/mouse.

Laboratory Record Book **10 marks**

Viva Voce **15 marks**

SEMESTER IV

ZOO-616: Genetics and Cytogenetics **100 marks [4 credits]; 100 contact hours**

Unit 1: Mendel's Principles and their chromosomal basis; Extensions of Mendel's Principles: Incomplete dominance, Co-dominance, Epistasis, Pleiotropy, Penetrance and Expressivity, Multiple allelism and complementation test; Inheritance of mitochondrial and chloroplast genes.

Unit 2: Methods of gene mapping: 3-point test cross in *Drosophila*, gene mapping and pattern of inheritance by pedigree analysis, human genome and mapping; Tetrad analysis in *Neurospora*.

Unit 3: Gene mutation: Types of gene mutations, methods for detection of induced mutations, P-element insertional mutagenesis in Drosophila; DNA damage, repair and recombination.

Unit 4: Structure and organization of eukaryotic chromosomes: chromatin condensation, euchromatin and heterochromatin; Structure, organization and function of telomere; Polytene chromosomes.

Mechanism of sex determination in *Drosophila* and human being; Basic concept of dosage compensation.

Recommended books:

1. Griffiths, AJF et *al*.: Modern Genetic Analysis, W.H. Freeman & Co., New York, 2000.
2. Gardner, E.J. et al: Principles of Genetics, John Wiley & Sons, INC. New York, Toronto, Singapore.
3. Ashburner, M. et al. (Eds.): Genetics and Biology of *Drosophila*, Academic Press.
4. Old, R.W. & Primerose, S.B.: Principles of Genetic Manipulation. Blackwell Sci. Publ. 1994.
5. Brown,T.A. : Genetics: A Molecular Approach, Chapman & Hall .
6. Ayala, F.J. & Kiger, J.A.: Modern Genetics, Benjamin Cummings.
7. W.S. Klug & M.R. Cummings: Essentials of Genetics, Pearson Prentice Hall, 2005.
8. Lewin, B.: Genes X, Oxford University Press.

[***All the books shall be of latest editions***]

ZOO-617: Biostatistics, Computational Biology and Bioinformatics

100 marks [4 credits]; 100 contact hours

Unit 1:

1. Introduction to biostatistics, scope and application of statistics in biological sciences.
2. Population and sampling: Characteristics, advantages and methods of sampling and sampling errors.
3. Types of data and methods of data collection; Data arrangement and presentation, formation of tables and charts (bar diagrams, histograms, pie diagrams, etc.).

Unit 2:

1. Measures of central tendency and dispersal: Computation of mean, median and mode from grouped and ungrouped data.
2. Measures of dispersion: Computation of variance, standard deviation, standard error and their co-efficient; Skewness and Kurtosis.
3. Probability distributions: Normal, binomial and poisson; Hypothesis testing: Student's t-test, Chi-square test and F-test; Analysis of variance; Regression and correlation; Interpretation of ANOVA results and Non-parametric test.

Unit 3:

1. Basic components of computers: Hardware (CPU, input, output, storage devices) and software (operating systems).
2. Introduction to MS EXCEL: Use of worksheet to enter data, edit data, copy data, move data; Graphical tools in EXCEL for presentation of data.
3. Introduction to MS-WORD processor: Editing, copying, moving, formatting, table insertion, drawing flow charts, etc.; Introduction to power point, image and data handling.

Unit 4:

1. Introduction to Bioinformatics: Definition, scope, applications and limitations; Types of databases: Biological database, primary and specialized databases, genome databases (NCBI, TIGR, EBI, SANGER) and nucleic acid databases (Genbank, DDBJ, EMBL, etc.).
2. Basic ideas of molecular phylogenetics, gene phylogeny (gene tree) and species phylogeny (species tree); Construction methods of phylogenetic tree; Application of phylogeny (evolutionary study and pedigree analysis).
3. Genomics: Types, significance and techniques of genome sequencing; Proteomics: Protein sequence databases (SWISS-PROT, PIR, etc.), protein microarrays, application of proteomics; Introduction to drug discovery.

Recommended books:

1. Kwanchai A. Gomez, Arturo A. Gomez: Statistical Procedures for Agricultural Research, 2nd Edition, Inter science publication, John Wiley & Son, New York
2. Snedcor, G.W. and W.G. Cochran: Statistical Method, 7th Edition, Iowa State University Press, Ames, USA.
3. Freederic, E. Croxton and Dudley: Applied General Statistics, 2nd en, New Delhi.
4. Bliss, CI: Statistics in Biology, Vol. 1 & 2, Mc-Graw Hill, New York.
5. DOEACC: "CCC" Course on Computer concepts. Doeacc Society, Electronics Niketan, New Delhi.
6. French, C.S.: Data Processing and Information Technology, BPB Publication.
7. Jin, Xiong: Essential of Bioinformatics, Cambridge University Press, 2007
8. 2. David W. Mount. Bioinformatics: sequence and Genome Analysis, Cold Spring Harbor Laboratory Press; 2nd edition
9. Prakash, S. Lohar: Bioinformatics, MJP Publishers, Chennai, 2015.

10. S.C.Rastogi,N. Mendiratta and P. Rastogi : Bioinformatics-Methods and Applications , PHI Learning Private Limited, Delhi, 2013.
11. Sharma,V., Munjal,A. and Shanker, A. : A Text Book of Bioinformatics , Rastogi Publications , Meerut-2008.
12. C.S.V. Murthy: Bioinformatics: Himalaya Publishing House Pvt. Ltd. Mumbai, 2008.

[***All the books shall be of latest editions***]

ZOO-618: General Lab-4 (based on ZOO-616 and ZOO-617) 100 Marks (4 Credits)

Genetics and Cytogenetics 40 marks

1. Chromosome banding pattern (C, G H, Q banding).
2. Preparation and study of human/mammal metaphase chromosomes.
3. Study of mutant phenotypes of *Drosophila*.
4. Demonstration of dosage compensation by study of Barr body/sex-chromatin in human female buccal smear.
5. Study of inheritance pattern of some human/animal traits by using pedigree charts.

Biostatistics, Computational Biology and Bioinformatics 40 marks

1. Construction of frequency distribution tables and diagrammatic and graphic representation of data.
2. Practical application of probability laws and goodness of fit test for binomial and poisson probability distributions in biology.
3. Computation and tests of significance for correlation and regression coefficients.
4. Preparation of tables, sorting of data, creating charts and calculation of average using MS-EXCEL.
5. Statistical analysis of data using MS-Word.
6. Phylogenetic analysis using software/Phylogenetic tree generation.
7. Sequence analysis using BLAST and result analysis.

Laboratory Record Book 10 marks

Viva Voce 10 marks

ZOO-624: Entomology III (Agricultural Entomology, Bionomics & Pest Management)
100 Marks (4 Credits); 100 contact hours

Unit 1: Pest of cereals: Paddy and maize; Pulses: Pea & Grams; Oilseeds: Mustard & Sunflower; Fruits: Banana, Citrus & Mango.

Unit 2: Pest of vegetables: Brinjal, Cabbage, Potato & tomato; Fibre Crops: Cotton & Jute; Spices: Chillies, Ginger & Turmeric.

Unit 3: Pest of plantation crops: Tea & Sugarcane; Forest trees: Teak & Pine; Storage pests: Grains & pulses.

Unit 4: Management of insect pest: Using biological, botanical, cultural, organic farming, pheromones, hormonal, mechanical, physical, chemical, legal and quarantine, radiation, enzyme inhibitors and biotechnological interventions; Pesticide classification, mode of action, formulation, pesticide resistance and methods to minimize the toxic effects of pesticide.

ZOO-625: Entomology IV (Applied Entomology)

100 Marks (4 Credits); 100 contact hours

Unit 1: Industrial Entomology: Natural enemies and diseases infecting the silkworm, bees and lac insects and their control strategies to enhance the product yield.

Unit 2: Mass production of Natural enemies: Conservation, mass production and field release of selected bio-control agents like predators, parasitoids and pathogens.

Unit 3: Cell culture and Forensic Entomology: Insect cell culture and its application with baculovirus expression vectors; role of Entomology in forensic science & insects as bio resources from the industrial point of view.

Unit 4: Medical & Veterinary Entomology: Biology, disease dissemination and management of housefly, tsetse fly, sand fly, mosquitoes, fleas, bed bug, head louse and sarcoptic mites in the context of vector borne human diseases and horse fly, cattle warble fly, equine botfly, cattle and poultry ticks from the view point of animal of veterinary importance.

Recommended books:

1. David, B. V. and Ramamurthy, V. V. (2012): *Elements of Economic Entomology*, Namrutha Publications , Chennai.
2. David, B. V. and Ananthakrishnan, T. N. (2011): *General and Applied Entomology*, Tata McGraw Hill, New Delhi.
3. Atwal, A. S*. : Agricultural Pests of India and South East Asia*, Kalyani Publishers, New Delhi.
4. Dhaliwal, GS and Opendra Koul (2007): *Biopesticides and Pest Management*, Kalyani Publishers, New Delhi.
5. Ananthakrishnan, T. N. (1996): *Biotechnological perspectives in chemical ecology of insects*, Oxford & IBH Publishing Co. PVT. LTD., New Delhi.
6. Ananthakrishnan, T. N. (1998): *Technology in Biological Control*, Oxford IBH Publishing Co. PVT. LTD., New Delhi.
7. Nair, MRGK*,: Insect and Mite Pests of crops in India*, ICAR Publications, New Delhi.
8. Tyagi (2000): *Medical Entomology*, Scientific Publishers (India), Jodhpur.
9. Rathnaswamy, G.K. (1986): *A handbook of medical entomology and elementary parasitology*, Viswanathan (Printers & Publishers), Chennai.
10. Fenemore, P. G and Alka Prakash (2006): *Applied Entomology*, New Age International (P) Ltd., New Delhi.
11. Ignacimuthu, S. and David, B. V. (2009): *Ecofriendly Insect Pest Management*, Elite Publishing House Pvt. LTD., New Delhi.
12. Muraleedharan, N. (1991): *Tea Pest Management*, UPASI Tea Research Institute, Valparai, Coimbatore.
13. M.L. Thakur (2000): *Forest Entomology (Ecology and Management),* Sai Publishers, Dehra Dun.
14. C.F.C. Beeson (1993): *The Ecology and Control of the Forest Insects of India and the neighboring countries*, Shiva offset Press, Dehra Dun.

[***All the books shall be of latest editions***]

ZOO-626: Entomology Lab II 100 Marks (4 Credits); 100 contact hours

1. Laboratory study on rearing and studying the biology of an economically important insect.
2. A short term field study on the survey & assessment of insect population using appropriate sampling technique on a particular habitat and correlating the incidence pattern with relevant environmental factors.
3. Visit to a plantation sector and observing the pest diversity and density and submitting a field report on the availability of economically important insect pests of a crop.
4. Lab bio assay of biopesticides/ pathogens against selected insect pests.
5. Observing and recording of various insect traps and insect collecting equipments and insecticide appliances.
6. Field collection of important insect pests of crops, stored grain pests and haematophagous insects & submitting them in a well preserved manner.

ZOO-634: Fishery III (Fish Biology II) 100 Marks (4 Credits); 100 contact hours

Unit 1: **Fish Reproduction**: Functional morphology of gonads, gonadal maturity, types and modes of reproduction; Fecundity. Induced breeding: hypophysation, natural and synthetic hormones, bundh breeding.

Unit 2: **Fish Behaviour**: Age and growth and Behaviour: Determination of age. Length-weight relationship, condition factor, gonado-somatic index; Fish migration, courtship and parental care; Adaptation of fishes to hill stream mode of life; Locomotion, role of fins in locomotion, factors affecting locomotion; Electroreception and Sound production and reception.

Unit 3: **Fish biotechnology**: Gynogenesis, androgenesis and polyploidy; Cryopreservation techniques; Hybridization, production of monosex population, transgenic fish and its merits and demerits; Feed Biotechnology: Probiotics, single cell proteins, Nutraceuticals.

Unit 4: **Fish as food**: Chemical composition and nutritive value of fish; Post harvest technology; Fish processing and preservation: refrigeration and freezing, drying, salting, canning, pickling; Fish fermentation in South East Asia; Fish by products.

ZOO-635: Fishery IV (Capture Fisheries) 100 Marks (4 Credits); 100 contact hours

Unit 1: Inland capture fishery: Inland capture fisheries resources of India: Riverine fishery resources, regulation and exploitation; Dams and its effect on fish migration and remedies; Lake reservoir; Estuarine fishery: management, development and exploitation; Cold water fishery; its resources in north east India; Fish species and prospects for culture; Mahseer fishery.

Unit 2: Fish seed production: Fish seed collection, methods, packing and transport; Transport of brood fishes; Hatching: Hapa, Glass jar and Chinese hatchery.

Unit 3: Fishing techniques: Different types of fishing crafts and gears, their operation and maintenance; Indigenous fishing techniques; Modern equipment for fishing.

Unit 4: Fish marketing and extension: Fish marketing and economy; Fisheries extension; Role of fisheries in Indian economy; Domestic and export marketing of fish and fish products; Modern marketing methods and channels. Role and status of women in fisheries.

ZOO-636: Fishery Lab II 100 Marks (4 Credits); 100 contact hours

Experiments

1. Study of gonads, gonado-somatic index, determination of absolute and relative fecundity of fishes
2. Study of gonadal development in Carps and other Finfishes
3. Determination of Age: removal of scales and different parts of skeleton, spines, otolith. Preparation and examination.
4. Study of adaptation of fishes to hill stream mode of life.
5. Induce breeding: location and removal of pituitary, preservation, preparation of injectable materials and administration.
6. Study of Length- Weight relationship of fishes and determination of condition factor.
7. Study of fishing Crafts and gears, indigenous fishing techniques.
8. Histology: Slide preparation and study of skin, gills liver, stomach, intestine, testis, ovary, pituitary.

Case study related to fisheries and report submission.

Recommended Books

1. Wedmeyer, A.F.S.*: Fish hatchery and management*.
2. Von Brandts: *Fish catching techniques of the world*. Blackwell Pub.
3. George Borgstrom Elsevier: *Fish as Food*, Vol. I & II
4. Chonder, S.L. 1994*: Induce carp breeding*. CBS publishers and Distributors, New Delhi -110002.

[***All the books shall be of latest editions***]

ZOO-644: Animal Physiology and Endocrinology III (Neurobiology, Chronobiology, Environmental and Stress Physiology)

100 Marks (4 Credits); 100 contact hours

Unit 1: Neurobiology

1. Cerebrospinal fluid (CSF) and Blood-brain-barrier.
2. Learning and memory: types and molecular basis.
3. States of brain activity: sleep, wakefulness, brain waves, epilepsy and psychoses.
4. Common neurodegenerative diseases: Alzheimer's disease, Huntington's disease and Parkinson's disease.

Unit 2: Chronobiology

1. Biological timing system: concepts and methods; circadian, infradian, ultradian and circannual rhythms.
2. Rhythm characteristics: free running rhythms; Zeitgebers (photic and non-photic, parametric and non-parametric entrainment).
3. Phase shift, Phase Response Curves (PRC) and Phase Transition Curves (PTC).
4. Photoperiodism in animals.

Unit 3: Thermal Physiology

1. Neuroendocrinology of homeostasis and regulation of body temperature.
2. Heat exchange between animals and environment.
3. Metabolic and physiological adjustments in extreme environmental conditions.
4. Heat exhaustion and heat stroke.

Unit 4: Adaptations to stress

1. Basic concepts of environmental stress; Neuroendocrinology of the stress response.
2. Acclimation, acclimatization, avoidance and tolerance.
3. Physiological responses to high altitude and high atmospheric pressure with special reference to man.
4. Importance of antioxidants in prevention and amelioration of stress-related diseases.

ZOO-645: Animal Physiology and Endocrinology IV (Endocrinology and Reproductive Physiology)

100 Marks (4 Credits); 100 contact hours

Unit 1: General account on Reproductive Physiology

1. Hormonal control of spermatogenesis and oogenesis; Estrous and menstrual cycle.
2. Mechanism of ovulation: hormonal and molecular changes during preovulatory period and factors involved in follicular rupture.
3. Molecular mechanism of fertilization and prevention of polyspermy in man/mammal.
4. Neuroendocrinology of adolescence and puberty.

Unit 2: Embryo implantation

1. Morphological, physiological and molecular aspects of embryo-uterine interactions.
2. Implantation window and mechanism of implantation.
3. Proposed mechanism of implantation failure, recurrent abortions, preeclampsia, and gestational diabetes.
4. Fetal-placental physiology and decidualization.

Unit 3: Physiology of pregnancy, parturition and lactation

1. Hormonal regulation of pregnancy and prevention of menstruation during pregnancy.
2. Role of hormones in the regulation of immune system during pregnancy.
3. Parturition and its neuroendocrine control.
4. Lactation and its neuroendocrine control.

Unit 4: Control of male and female fertility

1. Chemical interference: suppression of spermatogenesis and prevention of sperm maturation in epididymis.
2. Immunological interference, surgical interference with reference to vasectomy.
3. Inhibition of ovulation with reference to oral contraceptives.
4. Mechanical methods for control of fertility with reference to intrauterine devices.

Recommended books:

1. Arthur C. Guyton and John E. Hall: Text book of Medical Physiology, 12th Edn. Elsevier Saunders.
2. Kim E. Barrett, Scott Boitano, Susan M. Barman and Heddwen L. Brooks: Ganong's Review of Medical Physiology, 23rd Edn. 2010. Tata McGraw Hill Education Private Limited, New Delhi.
3. T.W. Sadler: Langman"s Medical Embryology, 11th Edn. 2010. Lippincott, Williams & Wilkins.
4. An Introduction to Neuroendocrinology: Michael Wilkinson and Richard E Brown (2015), Cambridge University Press, UK.
5. Endocrine and reproductive physiology, 4th edition, edited by Bruce A. White and Susan P. Porterfied, Paperback ISBN: 9780323087049 Copyright, 2013 Elsevier Inc.
6. The Physiology of Reproduction, second edition, Vol 1 and 2, edited by Ernst Knobil and Jimmy D. Neil. Raven Press, 2014.
7. Male Reproductive Function, edited by Christina Wang. Kluwer Academic Publishers, 1999.
8. The ovary, edited by Peter C.K. Leung and Eli Y. Adashi, Elsevier (Academic Press), 2004.
9. Cell and Molecular Biology of Testis, edited by Claude Desjardins and Larry L. Ewing. Oxford University Press US.

10. Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management, edited by Samuel S. C. Yen, Robert B. Jaffe, Robert L. Barbieri. Saunders publisher.
11. Regulation of Implantation and Establishment of Pregnancy in Mammals, Editors: Rodney D Geisert, Fuller W. Bazer, ISBN 978-3-319-15856-3, Springer International Publishing, 2015.
12. Covacs W.J. and Odeja S.R. (2011): Text Book of Endocrine Physiology, 6th Edn. Oxford University Press, New York.
13. Martine C.R. (1985): Endocrine Physiology, Oxford University Press, London.
14. Bently P.J. (1998): Comparative Vertebrate Endocrinology, Cambridge University Press, London.
15. Schiemdt Nielsen, Animal Physiology: Adaptation and Environment, Cambridge.
16. Prosser, C.L., Environmental and Metabolic Animal Physiology, Wildey-Liss Inc., New York.
17. Eckert, R., Animal Physiology: Mechanisms and adaptation, W.H. Freeman and company, New York.
18. Nalbandov, A.V.: Reproductive Physiology, W.H. Freeman and Company.
19. Parkes, A .V.: Marshall's Physiology of Reproduction, Longman.
20. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
21. Circadian Medicine: Christopher Colwell (ed.) Wiley-Blackwell (2015).
22. Circadian Physiology: Roberto Refinetti, CRC Press (3rded) 2016.
23. Biological Timekeeping: Clock, Rhythms and Behaviour, Vinod Kumar (ed. 2017), Springer India Pvt. Limited.
24. Henry M. Kronenberg, S. Melmed, K.S. Polonsky and P. Reed Larsen: Williams Text book of Endocrinology, 12th Edn. 2011. Saunders Elsevier.
25. Mac E. Hadley: Endocrinology, 5th Edn. 2004. Pearson Education, Delhi.
26. Keel et al: Samson Wright's Applied Physiology (13th ed1989, Oxford Press).
27. West: Best and Taylor's Physiological Basis of Medical Practice (11th ed 1981, Williams and Wilkins).
28. William S. Hoar: General and Comparative Physiology, 3rd Edn. 1983. Prentice Hall of India, New Delhi.

[***All the books shall be of latest editions***]

ZOO-646: Animal Physiology and Endocrinology Lab II

100 Marks (4 Credits); 100 contact hours

Experiments **75 marks**

1. Studies on learning and memory in rat/mouse model by Morris-Water-Maze Test.
2. Study of circadian temperature rhythm in human.
3. Assay of circadian rhythms using animal model systems.
4. Measurement of total estrogen in the urine of pregnant/non-pregnant women.
5. Study of estrous cycle of rat/mouse by vaginal smear preparation.
6. Assay of testosterone/progesterone/estrogen in human serum by ELISA/Chemiluminescence.
7. Determination of sperm count in rat/mouse.
8. Study of stages of spermatogenesis in mammals using histological slides.
9. Study on follicular development using sections of mammalian ovary.
10. Study of permanent slides of mammalian female reproductive organs (ovary, uterus, oviduct/fallopian tube, and vaginal tract).
11. Study of permanent slides of mammalian male reproductive organs (epididymis, vas deference, penis, seminal vesicle, prostate and Cowper's gland).

Laboratory Record Book **10 marks**

Viva Voce **15 marks**