

M. Sc. ZOOLOGY SYLLABUS

Course Structure under
Choice Based Credit System
(CBCS)

**Semester pattern examination
(As per UGC model curriculum)
With effect from: 2020-21Session**



**FAKIR MOHAN UNIVERSITY
VYASA VIHAR, NUAPADHI BALASORE,
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1. The course is of two years' duration comprising of four semesters of both theory and practical. The theory papers carrying 50 marks have external valuation of 40 marks and internal valuation of 10 marks. The theory paper carrying 40 marks will have examination of three hours and internal paper (10 marks) will have one-hour duration. Practical carrying 100 marks will have six hours' duration.
2. The semester system of examination will have internal system (20%) and external system (80 %) of valuation for theory papers. Practical papers will be examined by one internal examiner and one external examiner. If necessary, the practical examination may be extended to the next day.
3. All units of each paper are compulsory having equal weightage.
4. Each student has to go for one supportive course in Semester-III (ZOO-304) and electives at the beginning of the Semester-IV class.
5. For Supportive Course I and II, choice should be exercised amongst all students of different faculties of the University.
6. All students have to attend at least 75% classes each in theory and practical. Students having less than 75% attendance will not be eligible to fill up the forms for each semester examination.
7. **For the session, 25% of the syllabus has been underlined which are to be self-studied by the students.**

M.Sc. ZOOLOGY
SYLLABUS Ist SEMESTER

ZOO-101	Non-Chordate and Chordate	4CH
ZOO-102	Biosystematics, Biodiversity and Wildlife Management	4CH
ZOO-103	Evolution and Biogeography	4CH
ZOO-104	Biochemistry	4CH
ZOO-105	Practical	8 CH
IInd SEMESTER		
ZOO-201	Cell Biology and Genetics	4CH
ZOO-202	Instrumentation, Biophysics and Bioinformatics	4CH
ZOO-203	Animal Physiology and Endocrinology	4CH
ZOO-204	Developmental Biology	4CH
ZOO-205	Practical	8 CH
IIIrd SEMESTER		
ZOO-301	Microbiology and Immunology	4CH
ZOO-302	Ecology, Biostatistics and Economic Zoology	4CH
ZOO-303	Vector Biology, Research Methodology and Ethology	4CH
ZOO-304	CBCS	4CH
ZOO-305	Practical	8 CH
FAKIR MOHAN STUDIES (Non Credit Course)		
IVth SEMESTER		
ZOO-401	Cell and Molecular Biology-I	4CH
ZOO-402	Cell and Molecular Biology-II	4CH
ZOO-401	Biosystematics and taxonomy	4CH
ZOO-402	Biosystematics and taxonomy	4CH
ZOO-403	Practical	8 CH
ZOO-404	PROJECT and Grand Viva voce	8 CH

Semester I

PAPER ZOO-101 Non-Chordate and Chordate

20+80 Marks

UNIT-I

Protozoa (Protist animals): Nucleus and reproduction, Colonial protozoans and theories on the origin of metazoans. Porifera: Canal system.

Cnidaria: Nematocysts and Polymorphism in Siphonophora. Annelida: Adaptive radiation in polychaetes and Trochophore larva: structure and significance.

UNIT-II

Mollusca: Nervous system and Modifications of foot. Arthropoda (excluding insects): Affinities of trilobites, Crustacean larvae and their significance. Echinodermata: larval forms and their significance

UNIT-III

Salient features and affinities of: Placozoa, Mesozoa, Ctenophora, Rotifera , Phoronida, Echiura and Sipuncula. Characteristic features and affinities of the following: Protochordata (Hemichordata, Urochordata, Cephalochordata), Cyclostomes and Dipnoi.

UNIT-IV

Origin of the following: Amphibia, Reptiles, Birds and Mammals. Adaptive radiation in Chordates: Aquatic, Terrestrial, Aerial, Arboreal, Fossorial. Parental care in Amphibians. **Skull in Reptiles. Venom and anti-venom in Ophidians.** Flightless birds. Modification of beaks, feet and palate in birds. **Dentition. Stomach in ruminant.**

Recommended Books

1. Barnes: Invertebrate Zoology (Holt-Saunders International, 4th edition, 1980)
2. Barnes: The Invertebrates – A synthesis, 3rd edition, Blackwell, 2001
3. Hunter: Life of Invertebrates, Collier Macmillan Pub. 1979
4. Marshall: Parker & Haswell Text Book of Zoology, Vol. I, 7th edition, Macmillan, 1972
5. Moore: An Introduction to the Invertebrates, Cambridge University Press, 2001
6. Booloottian, R. A. and Stiles, K. A., College Zoology, 10th edition, Macmillan Publishing Co., Inc. New York, 1981.
6. Colbert, E. H., Morales, M. and Minkoff, E. C. Colbert's Evolution of the Vertebrates: A history of the backbone animals through time, 5th edition, John Wiley - Liss, Inc., New York, 2002. (29)
7. Farner, D. S. and King, J. R., Avian Biology (in several volumes), Academic Press, New York, 1971.
4. Goodrich, E. S, Studies on Structure and Development of Vertebrates, Dover Publication, New York, 1958.
5. Hildebrand, M. Analysis of Vertebrate Structure, 4th edition, John Wiley & Sons, Inc., New York, 1995.
6. Jordan, E. L. and Verma, P. S., Chordate Zoology. S. Chand & Company Ltd, 1998. 7. Kotpal, R. L. The Birds, 4th edition, Rastogi Publications, Shivaji Road, Meerut, 1999.
8. Marshall, A. J., Biology and Comparative Physiology of Birds, Volume I & II, 1960. 9. McFarland, W. N., Pough, F. H., Cade, T. J. and Heiser, J. B., Vertebrate Life, Macmillan Publishing Co., Inc., New York, 1979.
10. Moore, J. A., Biology of Amphibia, Academic Press, 1964.
11. Parker, T. S. and Haswell, W. A., TextBook of Zoology, Vol. II, ELBS, 1978.
12. Romer, A. S. and Parsons, T. S., The vertebrate body, 6th edition, CBS Publishing Japan Ltd, 1986.
13. Sinha, A. K., Adhikari, S. and Ganguli, B. B.: Biology of Animals, Vol. II, New Central Book Agency, Calcutta, 1988.
14. Young, J. Z. The life of vertebrates, 3rd edition, ELBS with Oxford University Press, 1981.

PAPER ZOO-102 Biosystematics, Biodiversity and Wildlife Management 20+80 Marks**UNIT I**

Definition and basic concepts of Biosystematics and Taxonomy, Importance and applications of biosystematics in biology, Materials basis of biosystematics: different attributes. Trends in biosystematics - Chemotaxonomy, Cyto-taxonomy and Molecular taxonomy. Principles & methods of Animal Taxonomy: Concepts of species and hierarchical taxa, biological nomenclature, classical & quantitative methods of taxonomy of animals. and Diversity Ecology and Evolutionary Biology Conservation.

UNIT II

Procedure keys in taxonomy, Taxonomic procedures - Taxonomic collections, Preservation, Curation, Process of identification. International Code of Zoological Nomenclature (ICZN)-Complete code. Biodiversity indices and their uses.

UNIT III

Wildlife habitat, species and populations. Threat of species extinction. Wildlife Health and Population Management; Wildlife Health; Population Management- Capture and Handling of Wild Animals. Radio telemetry. Organisms of conservation concern: Rare, endangered species. Conservation strategies. **Genomics and Biodiversity Molecular Tools for diversity Studies-Significance of Molecular Tools in Diversity and Conservation Studies, Barcoding**

UNIT IV

Concept of conservation with special reference to forest and wildlife management: Conservation verses preservation, Conservation Genetics-Genetic management of threatened species and, Management and Conservation Practice, Values of biodiversity and conservation ethics, Significance of ecological restoration in conservation Concept of stakeholders. International conservation bodies; IUCN, UNDP, FAO, WWF

Recommended Books

1. Edward O. Wilson, 1996, Biodiversity, 521pp., National Academy Press.
2. Alison J. Stattersfield, Michael J. Crosby, Adrian J. Long, and David C. Wege. 1998. Endemic Bird Areas of the World: Priorities for Biodiversity Conservation. 846pp.
3. Bibby, J., Collar, N.J., Crosby, M.J., Heath, M.F., Imboden, Ch., Johnson, T.H., Long, A.J., Stattersfield, A.J., and Thirgood, S.J. 1992. Putting biodiversity on the map: priority areas for global conservation.

PAPER ZOO-103 Evolution and Biogeography**20+80 Marks****UNIT-I**

An overview of evolutionary thoughts, developments and the concept of synthetic theory. Population genetics: Gene frequencies in Mendelian population, Hardy-Weinberg law-its formalization and application and Conditions for the maintenance of genetic equilibrium.

UNIT II

Elemental forces of evolution, Mutation, Selection (types of selection, selection coefficient, selection in natural population), Migration and Genetic drift: Changes in gene frequency in small population. **Chromosomal, allozyme and DNA polymorphisms. Adaptive genetic polymorphism. Balanced polymorphism and heterosis.** Genetic coadaptation and linkage disequilibrium. Isolating mechanisms. Concepts of species and models of speciation: allopatric, sympatric and stasipatric.

UNIT-III

Phylogenetic relationship. Chromosome phylogeny in *Drosophila* (based on inversion polymorphism). Molecular phylogenies. Neutral theory, Molecular clock. The polytypic species, subspecies and infraspecies categories. **The role of hybridization in evolution: Definition and immediate effect of hybridization**

UNIT-I V

Biogeography: Deepest Space and Time of Biogeography: Continental Drift and Climate Change; theory of island biogeography; The Species-Area Relationship and the Distribution of Rarity and Commonness. The Equilibrium Theory of Insular Biogeography. Species distribution. Biogeographical zones of India.

Recommended Books

1. Organic Evolution: R.S. Lull
2. Dobzhansky Th.: Genetics and the Origin of Species. Columbia.
3. Freeman S. and Jon C. Herron (1998): Evolutionary Analysis. Prentice Hall
4. Futuyma D. J. (1998): Evolutionary Biology. Sinauer
5. Hartl D. L. and A. G. Clark (1989 & 1997): Principles of Population Genetics. Sinauer
6. Ridley M. (1993): Evolution. Blackwell.
7. Strickberger M. W. (2000): Evolution. White M. J. D. (1978): Modes of Speciation. Freeman

Extended Readings in Biogeography

The Song of the Dodo, by David Quammen

The Future Eaters, by Tim Flannery

The Voyage of the Beagle, by Charles Darwin

Foundations of Biogeography: Classic Papers with Commentaries, edited by Mark V. Lomolino, Dov F. Sax and James H. Brown

PAPER ZOO-104 Biochemistry**20+80 Marks****UNIT I**

Structure of atoms, molecules and chemical bonds. Thermodynamics: Elementary knowledge, oxidation-reduction, Principles of biophysical chemistry: pH, buffer, Handerson-Hasselbach equation, colligative properties. Stabilizing interactions (Van der Waals, hydrophobic interaction). Carbohydrates: Chemistry, Pathways, their integration and regulation [Glycolysis and gluconeogenesis, Kreb's cycle, oxidative phosphorylation, Hexose monophosphate pathway, glycogen metabolism], peptidoglycan.

UNIT II

Amino acid: Sources of amino acids: Dietary proteins and intermediates of carbohydrate metabolism; Protein structure, Ramachandran plot, protein isolation, Solubility and protein targeting. Amino acids as sources for nitrogen, Molecules derived from amino acids, thyroxine Structure, Synthesis and significance of polyamines Amino Acid Catabolism-Transamination, Deamination: Trans-deamination and oxidative deamination, Toxicity of ammonia, Ammonia detoxification, Urea cycle, Lipids: chemistry, Cholesterol: Biosynthesis and degradation, Biosynthesis of eicosanoids: Prostaglandins, leucotrienes and thromboxanes, Nucleic acids: Biosynthesis and regulation of purine and pyrimidine nucleotides, Catabolism of purines and pyrimidines.

UNIT III

Nomenclature and classification; Mechanism of enzyme action- Enzyme substrate binding, Binding energy, entropy change; Active site structure and determination-Irreversible inhibitors, affinity labeling & suicide inhibitors; Kinetics-Single substrate reactions: Steady state and equilibrium kinetics, Michaelis-Menten equation and plot, **Linear kinetic plots: Lineweaver Burk, Edie Hofstee, Cornish Bowden, Calculations on enzyme kinetics; Multi-substrate reactions- Random sequential, Ordered, Theorel-Chance mechanism, Ping-pong (double reciprocal) mechanism.**

UNIT -IV

Enzyme Inhibition-Competitive; Non-competitive; Un-competitive and mixed, **Determination of nature of inhibition and Ki by LB & Dixon plots; Regulation: allosterism, covalent modifications; Multi enzyme complex and multifunctional enzymes; Enzyme distribution, diversity and evolution;** Coenzymes and cofactors; Enzyme assay: principles and techniques-Fixed time, continuous and coupled assays (Spectrophotometric, Isotopic, Spectrofluorometric & Titrimetric.); **Enzyme purification,- Objective and strategy, Choice of source, Methods of homogenization, Methods of separation, Basis of solubility(pH treatment; Salting in & salting out; Changing dielectric constant; Heat treatment), Basis of size and mass.**

Recommended books

1. Berg et al.: Biochemistry (5th Ed.), Freeman, 2001
2. Nelson et al: Lehninger Principles of Biochemistry (3rd Ed.), Pearson, 2004
3. Mathews et al.: Biochemistry (3rd Ed.), Benjamin/Cummings Publishing, 1990
4. Segal Biochemical calculations (2nd.), John Wiley & Sons, 1976
5. Watson et al: Molecular Biology of the Gene (2nd Ed.), Benjamin/Cummings, 1976
6. Zubay et al: Principles in Biochemistry (2nd Ed.), WCB, 1995
7. Rawn: Biochemistry, Neil Patterson, 1989

PAPER ZOO-105 PRACTICAL**100 Marks**

1. Identification of common Invertebrate and Vertebrate taxa (museum specimen).
2. Permanent slide identification and slide preparation.
3. **Preparation of taxonomic key**
4. Estimation of biodiversity indices
5. Quantitative estimation of protein- Lowry method or by FolinCiocalteu reagent.
6. **Estimation of Glucose by Dinitrosalicylic (DNS) acid reagent.**
7. **Estimation of Fructose by Resorcinol reagent.**
8. Estimation of DNA by Diphenylamine reagent.
9. Detection of reducing sugars by Benedict's, Barfoed's& Fehling's reagents.
10. Detection of amino acids by Ninhydrin reaction.
11. **Determination of K_m & V_{max} of enzymes Amylase and/or Alkaline phosphatase.**
12. **Preparation of Progress Curve of the above mentioned enzymes.**
13. Submission of model specimen.
14. Seminar presentation

Semester II

PAPER ZOO-201 Cell Biology and Genetics

20+80 Marks

UNIT I

Prokaryotes- Viruses: Structure and Replication, Bacteriophage (Lambda phage, Phi x 174), Animal DNA virus (SV 40), Retroviruses (HIV), Bacteria: Structure and reproduction of E. coli, Culture media and determination of growth rate, Plasmid and their functions; Eukaryotes- Cell Membrane, Lipid bi-layer, Membrane proteins & Fluid mosaic model, Transport, Diffusion, Osmosis and measurement of osmotic pressure, Active transport: Mechanism and related calculations, Targetting and sorting of proteins, Processing through endomembrane system, Targetting of cytosolic proteins; Mitochondria-Structure: Assemblies of respiratory chain & Fo-F1 ATPase Cytoskeleton: Organization of Microtubules, Microfilaments and Intermediary filaments; Nucleolus: Structure and biogenesis of ribosomes; Cell Signalling-Cell-cell interaction, Chemical mediators, Cell surface and intracellular receptors; Cell death, Apoptosis.

UNIT II

Eukaryotic chromatin structure and chromosome Organization-Classes of DNA, Chromosomal proteins: histones and their modifications, non-histon proteins, scaffold/matrix proteins, Levels of chromatin condensation at interphase and metaphase stages; Nuclear matrix and organization of interphase nucleus; Centromere, kinetochore and telomere; Metaphase chromosome bandings.

UNIT III

Giant chromosomes: models for studies on chromosome organization and gene expression. Cell division- Mitosis: Role of maturation promoting factor, Chromosomal movement, Exit from mitosis; Cytokinesis; Meiosis: Overview Chromosome pairing and recombination, Genetic regulation of meiosis. Human cytogenetics: Karyotype and nomenclature of metaphase chromosome bands, Chromosome anomalies and disease, Common syndromes caused by aneuploidy, mosaicism, deletion and duplication, Chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma and Wilms' tumour), Fragile site and X-linked mental retardation

UNIT IV

Mendel's laws and their chromosomal basis; Extensions of Mendelism; Dominance relationships; Epistasis; Pleiotropy; Expressivity and penetrance; Methods of gene mapping: 3-point test cross in *Drosophila*, Gene mapping in human by linkage analysis in pedigrees, Tetrad analysis in *Neurospora*, Gene mapping in bacteria by conjugation, transformation and Transduction. Gene Mutation and DNA repair: Types of gene mutations, Methods for detection of induced mutations; P-element insertional mutagenesis in *Drosophila*; DNA damage and repair.

Recommended Books

1. Lodish, Molecular Biology of the Cell.
2. Karp, G. (7th Edition), Cell and Molecular Biology: Concepts and Experiments.
3. Alberts ET Al., Essentials of Cell Biology
4. Brooker: Genetics : Analysis and Principles (Addison-Wesley, 1999)
5. Gardner et al: Principles of Genetics (John Wiley, 1991)
6. Griffith et al: Modern Genetic Analysis (Freeman, 2002)
7. Hartl & Jones: Essential Genetics: A Genomic Perspective (Jones & Bartlet, 2002)
8. Lewin, Genes VIII (Wiley, 2004)
9. Russell: Genetics (Benjamin Cummings, 2002)
7. Snustad & Simmons: Principles of Genetics (John Wiley, 2003).

PAPER ZOO-202 Instrumentation, Biophysics and Bioinformatics 20+80 Marks**UNIT-I**

Microscopy: Principle of operation and Instrumentation of light, Fluorescent and Electron microscopy, Microtomy. Chromosome analysis, Karyotyping and Karyo-morphometrical analysis, Taxidermy. Centrifugation: Principle of sedimentation, Methods in preparatory ultracentrifugation (Differential and density gradient Centrifugation),

UNIT-II

Chromatography: Principle and application of molecular exclusion chromatography, Ion exchange chromatography, Affinity chromatography, Gas-liquid chromatography and HPLC. Electrophoresis: Principle and application of electrophoretic separation, Types of solid support used (Cellulose acetate, Starch, Agar, Agarose and PAGE) and its importance, Isoelectrofocusing.

UNIT-III

Spectrophotometry: Principle and application of ultraviolet and visible spectrophotometry and Spectrofluorimetry, X-ray diffraction crystallography. **Radioisotopic techniques: Nature of radioactivity, application of radioactivity in biology (carbon dating, liquid scintillation counting, Geiger- Muller counter, autoradiography).** **Gibb's free energy. Model Membrane and dynamics. Nanotechnology – Characteristics of nanoparticles and application.**

UNIT-IV

Basics of computers. Internet: Webpages, Internet protocols, Search engines, Subject Directories etc. Biological Database management systems, Nucleic acid sequences databases, Genome databases (e.g. Human Genome Project), Protein sequence and structure databases. Applications of bioinformatics: Data retrieval systems: data query and data mining (Pubmed, Entrez), Sequence retrieval system (SRS) and protein identification resource (PIR). Molecule structure: domains, folds and motif analysis.

Recommended Books

1. Biophysics Tools and Techniques by Mark C. Leake · 2016
2. Foundations of Biophysics by A. L. Stanford · 2013
3. Introduction to Experimental Biophysics Biological Methods for Physical Scientists
By Jay L. Nadeau · 2016.
4. Fundamentals of Bioinformatics by S. Harisha · 2010
5. Introduction to Bioinformatics a Theoretical and Practical Approach 2003

Paper ZOO-203 Animal Physiology and Endocrinology**20+80 Marks****UNIT-I**

Blood and circulation - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.

Cardiovascular System: Comparative study of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above. Respiratory system - different modes of respiration in animal kingdom, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

UNIT-II

Nervous system - Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. Sense organs - Vision, hearing and tactile response. Excretory system - Comparative physiology of excretion, kidney, urine formation, Thermoregulation - Comfort zone, body temperature– physical, chemical, neural regulation, acclimatization. Stress and adaptation Digestive system - Digestion, absorption, energy balance, BMR.

UNIT-III

Chemical messengers, Hormones and their feedback systems. Mechanisms of hormone action (Fixed membrane - and mobile-receptor mechanisms), Receptor signal transductions, Techniques in endocrinology (Bioassay and Radioimmunoassay) Pineal, Thymus and Gastrointestinal Hormones Anatomy, Chemistry, Assay and Biological action of adenohipophysial and neurohipophysial hormones, Pituitary pathophysiology

UNIT-IV

Hypothalamic control of adenohipophysial function, Neuroendocrine system and neurosecretion Clinical aspects of the hypothalamo-hipophysial system Thyroid gland: Anatomy, biosynthesis and function of thyroid hormones, Antithyroid agents and control of thyroid secretion, Parathyroid gland: Anatomy, Regulation of secretion and function of parathyroid hormone. Endocrine pancreas: Anatomy, regulation and functions of insulin and glucagon. Adrenal gland (cortex and medulla): Anatomy, biosynthesis, function and regulation of their secretion.

Recommended Books

1. Comparative Physiology: Primitive Mammals by International Conference on Comparative Physiology (4: 1978: Crans-sur-Sierre) · 1980
2. Comparative Physiology of the Vertebrate Digestive System by C. Edward Stevens, Ian D. Hume · 2004
3. Comparative Physiology of Vertebrate Respiration by G. M. Hughes, George Morgan Hughes, Comparative Unit for Comparative Animal Respiration G M Hughes · 1963
4. Advances in Animal and Comparative Physiology Advances in Physiological Sciences: Proceedings of The 28Th International Congress of Physiological Sciences Budapest 1980
5. By V. L. Frenyó · 2013
6. Oxford Desk Reference: Endocrinology 2018.
7. Endocrinology an Integrated Approach by S.S. Nussey, S.A. Whitehead · 2001.
8. Williams Textbook of Endocrinology E-Book by Shlomo Melmed, Kenneth S. Polonsky, P. Reed Larsen, Henry M. Kronenberg · 2011

PAPER ZOO-204 Developmental Biology**20+80 Marks****UNIT-I**

Developmental Biology: Four principles of Karl Ernst Von Baer; Gametogenesis Spermatogenesis and Oogenesis; Ultrastructure of sperm and ovum, Model organisms in developmental biology (Caenorhabditis elegans, Drosophila, Amphibians, chick and mouse)

UNIT-II

Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in animal; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis.

UNIT-III

Descriptive embryology with particular reference to frog and chick Egg types; Cleavage Patterns; Fate maps; Morphogenetic movement and formation of germ layers; Gastrulation in amphibian and birds.

UNIT-IV

Organizer concept: Properties and physiology of organizer; Primary Organizer and Primary Induction, neurulation. Secondary Induction: Development and patterning of vertebrate limb, proximal- distal and dorso- ventral axis formation, Involvement of pattern forming genes, IVF, Amniocentesis, Cloning.

Recommended Books

1. Alberts et al.: Molecular biology of the cell. Garland, 2002.
2. Gilbert: Developmental biology. Sinauers, 2003.
3. Kalthoff: Analysis of biological development. McGraw-Hill, 1996.
4. Wolpert: Principles of development. Oxford, 2002.

PAPER ZOO-205 PRACTICAL

100 marks

1. Probability in Mendelian Inheritance
2. Chi-square, degree of freedom, test for Independence (contingency Chi square),
3. Homogeneity Chi-square, Independent Assortment and probability (binomial expansion)
4. Genetic cross
5. Family pedigree analysis for autosomal /sex linked, dominant /recessive trait.
6. Identification of different stages of cell division and cell organelle.
7. Mitochondrial staining
8. Life cycle of *Drosophila*.
9. b. Analysis and interpretation of genetic crosses with special reference to *Drosophila*
10. Study of polytene chromosome of *Drosophila*
11. Estimation of pH and its impact on plankton.
12. Observation of gut movement in frog/rat/fish under hypoxia using Dale's apparatus
13. Extraction and identification of different stages of chick embryos (24 hours, 48 hours and 72 hours)
14. Histological sectioning and staining of different stages of chick embryo.
15. Identification of permanent slide endocrine gland
16. Effect of temperature on pH.
17. Paper chromatography,
18. Thin layer chromatography
19. Sequence data retrieval (protein, nucleotide)
20. Sequence alignment and validation
21. Molecular interaction study of (ligand and receptor)
22. Seminar presentation

Semester III

PAPER ZOO-301 Microbiology and Immunology

20+80 Marks

UNIT-I

Introduction: Concept of microbiology, Microbes and man, History of microbiology, Divisions of Microbiology, Microscopy, Microscopic units, Microbial culture, Pure culture, Subculture, Stains of microbes. Structural organisation: Prokaryotic microorganisms, Structural details of prokaryotic cell. Structure of bacteria, virus (Bacteriophage) and multiplication (Lytic cycle and Lysogenic cycle). Microbial Physiology: Growth in Bacteria: normal growth curve; methods of measuring growth. Yield and characteristics, strategies of cell division. Bacterial chemotaxis and quorum sensing. Microbes in soil ecology: fertility, petroleum formation. Microbial fermentation: manufacture of industrially important products.

UNIT-II

Infection and microbial diseases: Host-parasite relationship, Types of diseases Control of microorganisms by physical, chemical and chemotherapeutic agents, Microbial genetics: Methods of genetic transfers — Transformation, Conjugation, Transduction, Mapping genes by interrupted mating, and Transposable elements.

UNIT-III

Cells and organs of the immune system: Haematopoiesis, Cells of the immune system, Organs of the immune system; Innate immunity: Anatomical barriers, connection between innate and adaptive immunity, Toll like receptors, Inflammation, phagocytosis; Antigen and antibody: Immunogenicity versus antigenicity, Epitope, basic structure of antibody, Antibody binding site, antibody classes and biological activity, antigenic determinant on immunoglobulin (Isotype, Allotype, Idiotype). Complement system (classical, alternative and lectin pathway).

UNIT-IV

Antigen-antibody interaction: Strength of antigen-antibody interactions, Cross reactivity, precipitation reactions, agglutination reactions; ELISA (indirect, sandwich, competitive) and ELISPOT assay, Western blotting); Major Histocompatibility Complex (MHC) and antigen presentation; B-cell and T-cell receptor; B-cell maturation, activation and differentiation, T-cell maturation, activation and differentiation; T-cell maturation, activation and differentiation; Cell mediated cytotoxic responses; Hypersensitivity reactions (Type I,II,III and IV), Cytokines, vaccine

Recommended Books

1. Black, A text book of Microbiology.
2. Crichton T.E., Proteins- Structure and Molecular Properties, W.H. Freeman and Company, New York.
3. Freifelder D., Essentials of Molecular Biology.
4. Freifelder D., Physical Biochemistry, W.H. Freeman and Company.
5. Kuby, W.H., Immunology, Freeman, USA.
6. Madigan et al., Brock Book of Microorganisms.
7. Paul W, Fundamentals of Immunology.
8. Prescott, Microbiology.
9. Roitt L.M., Essential Immunology, ELBS Edition.
10. Voet D. and Voet J.G., Biochemistry, John Wiley and Sons.

PAPER ZOO-302 Ecology, Biostatistics and Economic Zoology**20+80 Marks****UNIT I**

Ecological principles and environmental biology -Introduction to environmental biology, Concept of ecosystem; Population and environmental health; Population dynamics- Intrinsic rate of natural increase, Population growth form, Population fluctuations and cyclic oscillation, Population density and structures, r- and k- selections and carrying capacity Biological communities and species interactions -Types of interactions between two species, Interspecific competition; Lotka-Volterra Model of interspecific competition. Modern concepts of Niche. Niche parameters. Niche overlap.

UNIT II

Bioaccumulation and Bio magnification. Biogeochemical cycles: Nitrogen, Phosphorous and Sulphur cycles in terrestrial and aquatic ecosystems. Community organization and its dynamics. Energy flow models. Energy in ecological system- Law of thermodynamics as they relate to ecological energetic. Food webs. Ecological succession, its types and concept of climax. Ecology of various habitats. Remote sensing, Practical applications of ecology.

UNIT III

Mean, median, mode, standard deviation and Quartile deviation of grouped and ungrouped data; Concepts of Coefficient of Variation, Skewness and Kurtosis; Linear Regression and Simple Correlation; Elementary idea of Probability and Application of Theorems of Total and Compound Probability, relative frequency, probability distribution. **Economic Entomology- Sericulture, Apiculture, Lac culture, Aquaculture, Fish culture, Prawn culture, Pearl culture, Poultry, Dairy industry, Pest Management, Insects, Rodents.**

UNIT IV

Method of drawing of Random Sample from a Finite Population, Finding Standard Error of Sample of Mean and Confidence interval of Population Mean. Binomial, Poisson and Normal distribution; Chi-square Test of Independence and Goodness of Fit., Comparison of Means for one Sample and Two Samples (Z and t-tests) ANOVA- One Way and Multiple Comparison, Testing Equality of k Variances, Randomized Blocks.

Recommended Books

1. Venkitaraman: Economic Zoology (Sudarsana Publishers, 1983)
2. Srivastava : A Text Book of Applied Entomology, Vol. II & III (Kalyani Publishers,1988 & 1991)
3. Shukla & Upadhyaya : Economic Zoology (Rastogi Publishers, 1999-2000)
4. Odum : Fundamentals of Ecology (Saunders, 1971)
5. Primark : A Primer of Conservation Biology (2nd ed. Sinauer Associates)
6. Calabrese : Pollutants and High-Risk Groups (John Wiley,1978)
7. Raven, Berg, Johnson : Environment (Saunders College Publishing, 1993)
8. *Bruning J.L. and B. L. Kintz (1977) Computational Handbook of Statistics, Scott, Foresmaln and Company.*
9. Daniel W.W. (2000) Biostatistics: A Foundation for Analysis in Health Sciences, John Wiley.
10. Milton J.S. and J.O. Tsokos (1983) Statistical Methods in the Biological and Health Sciences, McGraw Hill Book Co.
11. Quinn G.P. and Keough M.J. (2002) Experimental Design and Data Analysis for Biologists, Cambridge Univ. Press.
12. Sokal R.R. and F.J. Rohlf (2000) Biometry Freeman.
13. Steel R.G.D. and J.H. Torrie (1980) Principles and Procedures of Statistics: A Biometrical Approach, McGraw Hill Book Co.
14. *Zar J.H. (2003) Biostatistical Analysis, Pearson Education.*

PAPER ZOO-303 Vector Biology, Research Methodology and Ethology 20+80 Marks**UNIT-I**

Principles of Epidemiology and epidemiological studies, Definition, aim and scope of epidemiology, target population, sampled population, Descriptive studies, Case reports, Case series – ecological and cross sectional studies. Analytical studies, observational (case-control, cohort), experimental (clinical/community trials), Surveillance concepts, tools and methods for vectors and disease, epidemic outbreak investigations. Vector Control and management.

UNIT-II

General concept of molecular diagnosis for parasitic infection, Advantages and disadvantages of molecular diagnosis, Fundamental techniques used in molecular diagnosis of endoparasites. Biology, clinical and laboratory diagnosis of *Hymenolepis nana*, *Clonorchis sinensis*, *Enterobius vermicularis*, *Dracunculus medinensis*, *Toxoplasma gondii* and *Trichomonas vaginalis*. Clinical features of hookworm anaemia. Laboratory diagnosis of Amoebiasis, Xenodiagnosis of Parasites. Parasites as Therapeutic Organisms.

UNIT-III

Research: Definition, importance, meaning and characteristics. Steps in Research. Research problem: identification, selection and formulation. Data: definition, types, sources, data collection methods. Review of literature and Bibliography. Research report: types, contents, styles and steps in drafting. Editing the final draft, way of writing papers and Thesis writing. Significance of Impact factor, citation index, science citation index and SCOPUS.

UNIT-IV

Definition and general mechanism of animal behavior. Major contribution of scientists: In classical ethology and modern behavioural biology. Modern concepts of animal behavior, Methods of study of animal behavior, Development of behaviour: Innate and Learned; Comparative account on characteristics of instinct and learning; Types of fixed action patterns (FAPs); Neuro-genetic mechanism of instinct. Learning and Memory: Classification or forms of learning and memory, Neural mechanisms of learning and memory. Evolution of behaviour, Hormones and behaviour, Motivation and behavior

Recommended Books

1. Schimdt, G.D. and Roberts, L.S. Foundations of Parasitology
2. Hempel, P.S. Evolutionary Parasitology
3. Gunn, A. and Pitt, S.J. Parasitology: An Integrated Approach
4. Alcock : Animal Behaviour- An Evolutionary Approach. (7th ed.) Sinaur Associates, Inc. 2001.
5. Drickamer & Vessey: Animal Behaviour –Concepts, Processes and Methods (2nd ed.), Wadsworth,1986.
6. Gadagkar: Survival Strategies-Cooperation and Conflict in Animal Societies. Universities Press,1998.
7. Goodenough et al: Perspectives on Animal Behaviour, Wiley, 1993.
8. Grier: Biology of Animal Behaviour, Mosby, 1984.
9. Hallidy and Slater: Animal Behaviour (vols. I-3) Blackwell Scientific Publ., 1983.
10. Krebs & Davis: Behavioural Ecology. (3rd ed.) Blackwell, 1993.
11. Lehner: Hand Book of Ethological Methods. (2nd ed.) Garland, 1996.
12. Manning & Dawkins: An introduction to Animal Behaviour (5th ed.), Cambridge Univ. Press, 1998.
13. Slater & Halliday: Behaviour and Evolution, (1st ed.) Cambridge Univ. Press, 1994
14. Research Methodology Methods and Techniques by C. R. Kothari · 2004
15. Research Methodology a Handbook for Beginners by Pagadala Suganda Devi · 2017

16. Research Methodology by P. Sam Daniel, Aroma G. Sam · 2011

PAPER ZOO-303 CBCS (Zoology) Syllabus

20+80 Marks

Unit I: Animal Diversity

Introduction to Animal World, Invertebrate in general, vertebrate in general. Basic concepts of Animal taxonomic and classification system.

Unit II: Evolution and Ecology

Concepts of evolutionary mechanism (Speciation; Variation; Isolation; Lamarckism and Darwinism), Ecosystem: Structural and functional components of ecosystem and energy flow models in ecosystem; Biotic and abiotic interactions. Environmental pollution and prevention (Air, water and Soil)

Unit III: Cell Biology Genetics & Histology

General Organization of Animal cell, Structure and functions of Plasma membrane, Mitochondrion, ER, Nucleus, Ribosomes Golgi apparatus. Cell division (Mitosis and Meiosis). Mendelian Principles (Monohybrid and Dihybrid Cross), Mutation. Types, Structure and function of epithelial tissue, connective (bone, cartilage), muscle and nerve tissue.

Unit IV: Economic Zoology

Basic concepts of Sericulture, Apiculture, Pisciculture, Lac culture and Earthworm farming (Vermiculture). Other applied aspects of animal science: marine, dairy, biotech based products etc.

PAPER ZOO-305 PRACTICAL**100 marks**

1. Staining and identification of bacteria, endospores, etc. from a culture media.
2. Different methods of staining: Gram staining, Negative and differential staining
3. Preparation of different culture media with Sterilization techniques.
4. Inoculation of microbes to respective culture media through proper culture methods.
5. Enumeration of Coliform bacteria using multiple tube fermentation method.
6. Determination of human blood group
7. Study of macrophage.
8. Chi square test for goodness of fit with a Mendelian frequency
9. distribution.
10. Computation and significance test of product – moment r between two continuous measurement variables.
11. Computation of simple linear regression.
12. Computation of variance ratio (F) and multiple comparison of Scheffe's F test for one-way ANOVA and their interpretation.
13. Significance of observed sex ratios using binomial distribution.
14. Vermitechnology and related matter: Analysis of biota from urban waste materials & identification of suitable specimen for vermicomposting.
15. BOD and COD estimation.
16. Recording/documentation and submission of terrestrial / aquatic faunal components in and around University campus – (Collection, preservation, identification and analysis of aquatic biota – phytoplankton, zooplankton, benthos, periphyton, aquatic insects, nekton and macrophytes).
17. Whole mount preparation of mosquito vector
18. Preparation of Ehtogram (any domesticated animal)
19. Seminar presentation

Semester IV

PAPER ZOO-401 Cell and Molecular Biology-I

20+80 Marks

UNIT-I

Genes and genome in prokaryotes and eukaryotes, Regulation of gene expression in Prokaryotes: Operon concept, lac-operon; trp-operon, transcription attenuation, Lytic and Lysogenic cascades. Regulation of gene expression in eukaryotes: Types of eukaryotic promoters, DNA-binding domains and protein-protein binding domains of regulatory proteins, Signal integration and combinatorial control, Transcriptional repressors, Signal transduction and control of transcription and control of transcriptional regulators, Gene silencing, siRNA.

UNIT-II

DNA replication, Enzymes and accessory proteins involved in DNA replication; DNA damage and repair; DNA amplification: Polymerase Chain Reaction, Genetic Engineering: Restriction enzymes, Different methods of construction of recombinant DNA, Cell transformation and Cloning, Transgenic animal, Expression of recombination protein using bacterial/animal vectors, Gene Knock out strategies.

UNIT-III

Molecular techniques in genetic engineering: Isolation of DNA and RNA from animal tissues and blood, Probes, Restriction Fragment Length Polymorphism, Blotting techniques (Southern, Northern and Western), Genome sequencing (Shotgun and paired end strategies and comparative genome analysis, Study of gene expression: Transgenic and Knockout animals.

UNIT-IV

Application of biotechnology in Medicine and Health: Diagnosis of diseases, Production of Pharmaceuticals (hormones), Recombinant vaccines and Gene therapy. Forensic science, Human genome project, Enzyme and whole cell mobilization and its industrial application.

Recommended books

1. Alberts B., Bray D., Lewis J., Raff M., Roberts K. and Watson J.D., Molecular Biology of the Cell, Garland Publishing Inc., New York.
2. Darnell J., Lodish H. and Baltimore D., Molecular Cell Biology, Scientific American Book Inc. USA.
3. Dupraw W.J., Advances in Cell and Molecular Biology.
4. Glick, Molecular Biotechnology.
5. Lehninger, Principles of Biochemistry.
6. Meyers R.A. (E.D.), Molecular Biology and Biotechnology: A comprehensive Desk Reference, VCH Publishers, Inc., New York.
7. Robertis De, Cell Biology.
8. Sambrook J., Fritsch E.F. and Maniatis T., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, New York.
9. Stryer, Biochemistry.
10. T.S. Brown, Genom 1.
11. Voet D. and Voet J.G., Biochemistry, John Wiley and Sons.
12. Watson J.D., Hopkins N.H., Roberts J.W., Steitz J.A. and Weiner A.M. Molecular Biology of Genes, The Benjamin/Cummings Publishing Company Inc., Tokyo.

PAPER ZOO-402 Cell and Molecular Biology-II**20+80 Marks****UNIT-I**

Introduction - from genomics to metagenomics, global impact of metagenomics; Approaches to metagenomics analysis, 16S rRNA microarray (phylochip), sequence base analysis, functional based analysis, gene expression system, single cell analysis; data management and bioinformatics challenges of metagenomics, the importance of metadata, databases for metagenomics data, software, analysis of metagenomics sequence data.

UNIT-II

G-protein, Receptor tyrosine kinase, Intracellular receptors, Signal transduction through second messengers, cAMP dependent pathway, IP 3 /DAG pathway, MAPK pathway Mechanism of Steroid hormone action. RNA synthesis and processing: Transcription factors and machinery, Formation of initiation complex, RNA types and function.

UNIT-III

Antisense and ribozymes: Application of antisense and ribozyme technology in biotechnology; Heat shock proteins and their biological significance, Protein synthesis and processing: Ribosome, Formation of initiation complex, Elongation, Termination; **Genetic code; Aminoacylation of tRNA; Post-translational modification of proteins, Protein array, Gene chip, Protein Sequencing and peptide characterization (MALDI-TOF).**

Unit IV

Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, Epigenetic modification, Angiogenesis, Interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.

Recommended Books

1. Alberts B., Bray D., Lewis J., Raff M., Roberts K. and Watson J.D., Molecular Biology of the Cell, Garland Publishing Inc., New York.
2. Berg, Tymoczko and Stryer, Biochemistry, W.H. Freeman, NY.
3. Darnell J., Lodish H. and Baltimore D., Molecular Cell Biology, Scientific American Book Inc. USA.
4. Dupraw W.J., Advances in Cell and Molecular Biology.
5. Glick and Pasternak, Molecular Biotechnology.
6. Meyers R.A. (E.D.), Molecular Biology and Biotechnology: A comprehensive Desk Reference, VCH Publishers, Inc. New York.
7. Nelson and Cox, Lehninger Principles of Biochemistry, W. H. Freeman, NY.
8. Robertis De, Cell Biology.
9. Sambrook J., Fritsch E.F. and Maniatis T., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, New York.
10. T.S. Brown, Genome.
11. Voet D. and Voet J.G., Biochemistry, John Wiley and Sons.
12. Watson J.D., Hopkins N.H., Roberts J.W., Steitz J.A. and Weiner A.M., Molecular Biology of Genes, The Benjamin/ Cummings Publishing Company Inc. Tokyo.

PAPER ZOO-401 BIOSYSTEMATICS AND TAXONOMY**20+80 Marks****UNIT-I**

Taxonomic evidence and evolutionary interpretation: Definition and evidence, Kinds of evidence, Similarity, Homology and Homoplasy.

UNIT-II

Taxonomy to classification: Principles, objectives and arbitrariness, Monophyly and polyphyly, Grades and clades, Vertical and horizontal relationships, Divergence and diversity splitting and lumping, Relative antiquity, Ranks of characters.

UNIT-III

Taxonomic collection: Species registry, Collection methods, Preservation of collected material (curating preparation, relaxing, mounting, storage, cataloguing, maintaining quality of collection). Reference works in taxonomy: Zoological record, Abstracts (biological, dissertation, entomology, helminthology, protozoology), Taxonomy on web.

UNIT-IV

Identification methods: Literature, Keys, Pictures, Direct comparison, Combination of different methods in identification, Taxonomic publication, Preparation of taxonomic papers (description of keys, classification, synonymies, bibliography, nomenclature, illustrations).

Recommended Books

1. Goto H.E., Animal Taxonomy, Hodder Arnold H & S.
2. Gregg J.R., The Language of Taxonomy- An Application of Symbolic Logic to the Study of Classificatory System, Columbia University Press, New York.
3. Kapoor V.C., Principles and Practices of Animal Taxonomy, Science Publishers, New Delhi.
4. Mayr E. and Ashlock P.D., Principles of Systematic Zoology, Mac Graw-Hill, Inc, New Delhi.
5. Minelli A., Biological Systematics- The State of Art, Chapman and Hall, London.
6. Narendran T.C., An Introduction to Taxonomy, Zoological Survey of India, Kolkata.
7. Scott-Ram N.R., Transformed Cladistics, Taxonomy and Evolution, Cambridge University Press, Cambridge.
8. Simpson G.G., Principles of Animal Taxonomy, Columbia University Press, New York.
9. Willams D.M. and Ebach M.C., Foundations of Systematics and Biogeography, Springer Science + Business Media, LLC, New York.
10. Willams D.M. and Foley P.L., Milestones in Systematics, CRC Press LLC, Boca Raton, Florida, USA.

PAPER ZOO-402 BIOSYSTEMATICS AND TAXONOMY 20+80 Marks**UNIT-I**

Molecular taxonomy: Population structure, Identification of species boundaries, Estimation of phylogenies.

UNIT-II

Collection and storage of tissues: Regulations, Removing and preserving tissues in the field (packing, documentation, preservation), Procedures (anesthesia, blood and haemolymph collection, venom collection), Transportation and storage of tissues.

UNIT-III

Barcoding: An initiative to inventorize species; Human Resources; Institutions- National and International organizations associated with taxonomic studies; Rules of Zoological Nomenclature. Species concept and lower categories: The genetic species, Evolutionary species, Other kinds of species (taxonomic species, morphospecies, palaeospecies, biospecies, agamospecies), Subspecies, Other intraspecific groups, Superspecies.

UNIT-IV

Higher categories: Base for recognition of higher taxa, Definition and characteristics of higher categories, Analysis of phylogenetic pattern, Examples of mammalian phylogeny, Evolutionary basis of taxa.

Recommended Books

1. Goto H.E., Animal Taxonomy, hodder Amold H & S.
2. Gregg J.R., The Language of Taxonomy-An Application of Symbolic Logic to the Study of Classificatory System, Columbia university Press, New York.
3. Hillis Eds. David M. and Mortitz Craig, Molecular Systematics, Sinauer Associates, Inc. Publishers, Sunderland, USA.
4. Mayr E. and Ashlock P.D., Principles of Systematic Zoology, Mac graw-hill, Inc, New Delhi.
5. Minelli A., Biological Systematics. The State of Art, Chapman and Hall, London
6. Narendran T.C., An introduction to Taxonomy, Zoological Survey of India, Kolkata.
7. Principles and Practices of Animal Taxonomy, by V.C. Kapoor, Science Publishers, New Delhi.
8. Scott-Ram N.R., Transformed Cladistics, Taxonomy and Evolution, Cambridge University Press, Cambridge.
9. Simpson G.G., Principles of Animal Taxonomy, Columbia University Press, New York.
10. Willams D.M. and Ebach M.C., Foundations of Systematics and Biogeography, Springer Science + Business Media, LLC. New York.
11. Willams D.M. and Foley P.L., Milestones in Systematics, CRC Press LLC, Boca Ration, Florida, USA.

PAPER ZOO-403 PRACTICAL

100 Marks

CELL AND MOLECULAR BIOLOGY

- 1) Study on the life history of *Drosophila*.
- 2) Slide preparation of wild and mutant varieties of *Drosophila*.
- 3) Preparation of salivary gland chromosome of *Drosophila*.
- 4) Spectrophotometric estimation of DNA and RNA.
- 5) Preparation of permanent histological slides.
- 6) Isolation of plasmid.
- 7) Separation of DNA through agarose gel electrophoresis.
- 8) Demonstration of DNA ladder/smear formation during apoptosis.
- 9) Extraction and purification of protein by column chromatography.
- 10) Separation of protein on SDS-PAGE and determination of molecular weight.
- 11) Isolation of protein fragments from gel.
- 12) Study on the effect of temperature on plasma proteins.
- 13) Estimation of inorganic composition of biological materials.
- 14) Seminar presentation

PAPER ZOO-404 PROJECT WORK AND GRAND VIVA-VOCE

100 Marks
