M.Sc. PROGRAMME IN ZOOLOGY

(Effective from Session 2024-25)

(Batch: 2024-2026)

SAMBALPUR UNIVERSITY

JYOTI-VIHAR, BURLA, SAMBALPUR, ODISHA-768019

A BREIF INTRODUCTION OF THE PROGRAMME

Zoology is a branch of biology that focuses on animals and animal life. There are many sub-fields in Zoology. Some Zoologists study very small organisms, such as mold, viruses, and even cells and parts of cells. Other Zoologists study very large organisms, such as whales, elephants and even *whole populations* of animals. Zoologists observe and sometimes conduct experiments on animals, either in the wild or in a controlled setting (such as a zoo or a laboratory). The subjects studied range from: inter-species interactions to neural mechanisms; molecular biology to vertebrate evolution; genetic foundations of behaviour to the importance of biodiversity. Zoology is important for many reasons. For one, the study of animals and communities provides insight into how "life" works, and, consequently, how *we* work. The higher mammals provide especially useful insight into the human world. Many Zoologists are directly involved with the conservation of threatened or endangered species; the maintenance of biodiversity is considered by many to be crucial to our survival. These are just a few of the reasons why understanding animal life is important to humans.

The Academic Requirements

Students will take basic and advanced science and math classes, including biology, chemistry, anatomy, ecology, etc. There will be lots of work done in the lab and in the field, preparing the student for typical employment in Zoology professions. Students should do an internship if possible; labs, zoos, farms, and veterinarian offices make great places to look for assistantship positions. Graduate and Ph.D. students will do more intensive lab and field work in a specific area of Zoology. The original research you start now could lead to an entire career's pursuit. This is also a great time to make professional and academic connections. Masters-level courses in Zoological Science are well suited to Biological Science students seeking to specialize further at postgraduate level. Some offer a general grounding in Zoology, but most have a specific focus in the understanding and classification of specific species (and / or their environments). As a result, postgraduate Zoology is as diverse as the animal kingdom itself. Whatever specific interest, it's probably reflected in one or more of the courses below.

Professional Outlook

Jobs in Zoology are usually fall under the heading of research, or of applying research in "real world" situations. Researchers generally hold somewhat regular hours, unless they are deeply involved in a project. Then you may spend extended hours at the lab or in the field - however, the love of research that comes with the field is incentive enough to work extra hours. Researchers, both independent and in teams, usually prepare reports on their findings for upper management or peer review. Researchers need to have good communication skills, a cooperative spirit, and an inquisitive mind. Employment opportunities and outcomes are equally varied. The student's will be well equipped for PhD research, perhaps leading to an academic career. Alternatively, the students could work for a range of organizations, from research centers to conservation groups.

SEMESTER-WISE COURSE STRUCTURE FOR THE TWO YEARS P.G PROGRAMME IN UNIVERSITY P.G DEPARTMENT AND COLLEGES UNDER SAMBALPUR UNIVERSITY

TO BE EFFECTIVE FROM 2023-2024

(Ref: letter No: 4873/Acd.I Dated 21.08.2023)

For M Sc Zoology (Science/ Humanities/Social Sciences/ Commerce)				
Semester	**Core Course Credit**	**Additional Course**	**Additional Course Credit**	**Total Credit**
First	20	**AECC I**: Environmental Studies and Disaster management	2	22
Second	20	Inter Dept. Course (IDC) or open elective	3	23
Third	20	**AECC II**: Entrepreneurship Development	2	22
Fourth (including project of 4 credit)	20	MOOCs one paper	3	23
TOTAL	**80**		**10**	**90**
	Total credit for 2 years course = 90 Credits			
	Furthermore, following non - credit course will be taken by the students			
1. Yuva Sanskar		2. N.C.C/N.S. S/Sports/Performing Arts/Yoga (Of which one has to be opted)		

M. Sc ZOOLOGY

(Effective from the Session 2024-25)

COURSE AT A GLANCE

SL NO	PAPER	COURSE TITLE	CREDITS (CH)	MARKS		
				End term	Mid term	Total
SEMESTER I						
1	ZOOL-411	Animal Diversity (Non-Chordates and Chordates)	4	80	20	100
2	ZOOL-412	Cell Biology and Cancer Biology	4	80	20	100
3	ZOOL-413	Inheritance Biology	4	80	20	100
4	ZOOL-414	Biostatistics and Taxonomy	4	80	20	100
5	ZOOL-415	Practical	4	100		100
		Total credit hours/marks for First semester	**20**	**420**	**80**	**500**
SEMESTER II						
1	ZOOL-421	Biophysical Chemistry and Biochemistry	4	80	20	100
2	ZOOL-422	Enzyme Technology and Microbiology	4	80	20	100
3	ZOOL-423	Molecular Biology	4	80	20	100
4	ZOOL-424	Animal Physiology and Endocrinology	4	80	20	100
5	ZOOL-425	Practical	4	100		100
		Total credit hours/marks for Second semester	**20**	**420**	**80**	**500**
SEMESTER III						
1	ZOOL-511	Immunology	4	80	20	100
2	ZOOL-512	Developmental Biology and Animal Biotechnology	4	80	20	100
3	ZOOL-513	Bioinstrumentation	4	80	20	100
4	ZOOL-514	Evolution and Animal Behaviour	4	80	20	100
5	ZOOL-515	Practical	4	100		100
		Total credit hours/marks for Third semester	**20**	**420**	**80**	**500**
SEMESTER IV						
1	ZOOL-521	Genetic Engineering	4	80	20	100
2	ZOOL-522	Ecology and Conservation Biology	4	80	20	100
		Elective Paper (Students have to Choose any one)				
3	**ZOOL-523E-A**	Environmental Biotechnology	4	80	20	100
4	**ZOOL-523E-B**	Fisheries Science	4	80	20	100
5	ZOOL-524	Project Report	4	50+30	20(Interim)	100
6	ZOOL-525	Practical	4	100		100
		Total credit hours/marks for Fourth semester	**20**	**420**	**80**	**500**
		Grand Total	**80**	**1680**	**320**	**2000**
1	Zool-IDC-426	Economic Zoology	**3**			**100**

NB: In all the practical examinations 10 marks will meant for seminar presentation and seminar report preparation.

SEMESTER I

PAPER: ZOOL 411

ANIMAL DIVERSITY (NON-CHORDATE AND CHORDATE)

100 marks (80+20) **4 CH**

Objectives:

- To be familiar with the different non chordate and chordate phyla, their general and distinguishing characters.
- To study how the different systems evolved in their complexity.
- To compare and contrasts the life processes in different phyla.

Learning Outcomes:

At the end of the course, the students will be familiar with the animal world that surrounds us. They will be able to appreciate the process of evolution and see how it progressed from simple, unicellular cells to complex, multicellular organisms. Students will be able to identify the invertebrates and vertebrates and classify them up to the class level.

UNIT- I: **Non-chordates**

Protozoan diseases in man, Canal system in Sponges, Coral reef formation and significance, Polymorphism in Coelenterates, Helminthes parasites (Taenia, Ancylostoma), metamerism and segmentation in annelids.

UNIT-II: **Non-chordates**
Vision In insects, Torsion in Gastropoda, Nervous system in Cephalopods, Water vascular system in Echinoderms, Reproduction and development in Echinoderms with evolutionary significance.

UNIT III: Protochordates and Lower Vertebrates
General characters and interrelationship of Proto-chordates. General characters and affinities of Cyclostomata. Accessory Respiratory organs in fishes, Luminous organ in fishes, Origin and ancestry of Amphibia.

UNIT IV: **Higher Vertebrates**
Adaptive radiation in reptiles, Classification of reptiles based on skull pattern, Flight adaptation in Birds. General characters of Prototheria and Metatheria, Adaptive radiation in mammals, Dentition in mammals.

SUGGESTED READINGS

- Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
- Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S.and Nelson
- Parker and Haswell: Text book of Zoology (Vol I).
- Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford university press.
- Pough H. *Vertebrate life,* VIII Edition, Pearson International.

PAPER: ZOOL 412

CELL BIOLOGY AND CANCER BIOLOGY

100 marks (80+20) **4 CH**

Objectives

- To understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes and organelles.
- To understand how these cellular components are used to generate and utilize energy in cell.
- To be familiar with the various genetic and molecular changes occur in a normal cell during malignant transformation.

Learning Outcome:

At the end of this course, Students will be well acquainted with the membrane structure and composition, transport and trafficking, the cytoskeleton and cell movement. The general mechanism of cell division and their regulation through different check points will be thoroughly understood. The association between defect in cell cycle, apoptosis, signal transduction and cancer biology will be the land mark towards understanding different human diseases.

Unit I: Membrane structure and function.

Plasma membrane: chemical composition, structure and function of membrane proteins, membrane lipid and membrane fluidity, membrane dynamics. membrane transport. Junctional complexes. Cell communication: General principle of cell communication. cell adhesion and role of different cell adhesion molecules.

Unit II: Structural organization and function of intracellular organelles.

Endomembrane system: Structure and function of endoplasmic reticulum, Golgi bodies, lysosomes. Structure and function of mitochondria. Cytoskeleton: types and major functions.

Unit III: Nucleus and cell cycle.

Nucleus: nuclear envelope, nuclear pore complex, nucleolus. Chromosomes, Karyotype and its significance, nuclear packaging. Cell cycle: cell cycle *in vivo,* regulation and checkpoints of cell cycle. Apoptosis.

Unit IV: Cancer Biology.

Biology of cancer cell, Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, therapeutic interventions of uncontrolled cell growth.

SUGGESTED READINGS

- Karp, G. (2014). *Cell Biology*. VII Edition. John Wiley and Sons. Singapore Pvt. Ltd.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London.
- Dee Unglaub Silverthorn (2012). Human Physiology An Integrated Approach, VthEdn, PHI Learning Private Limited, New Delhi.

PAPER: ZOOL 413

INHERITANCE BIOLOGY

100 marks (80+20) **4 CH**

Objectives

- To provide a fundamental knowledge on genetics, its laws, genes and chromosomes, inheritance, heredity, causes of genetic disorders and the methods of gene transfer.
- How genetic information in the DNA is selectively expressed as functional proteins.

Learning Outcomes:

The course will able to explain the fundamentals of genetics and the Mendelian laws, the concept of alleles, concept of linkage and crossing over of genes. The course will open an avenue to be familiar with a variety of types of genetic data (genotyping, expression, sequence data), chromosomal mapping, genetic composition of biological population and evolutionary factors that explain the variation.

Unit I: Mendelian principles.

Mendelian principles: Dominance, segregation, independent assortment. Mendels law of inheritance. *Concept of gene*: Allele, multiple alleles, pseudo allele, complementation tests.
Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Unit II: Gene mapping methods, Extra chromosomal inheritance and Microbial genetics.

Gene mapping method: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids. Inheritance of mitochondrial gene, maternal inheritance.
Microbial Genetics: Methods of gene transfer: transformation, conjugation, transduction and sex deduction.

Unit III: Human Genetics and Quantitative Genetics

Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.
Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.

UNIT –IV: Mutation and Recombination

Types of mutation. Causes and detection, mutant types-lethal, conditional,biochemical,loss of function, gain of function, germinal versus somatic mutants, insertional mutagenesis.
Structural and numerical alternation of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
Recombination: Homologous and non-homologous recombination

SUGGESTED READINGS

- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles ofGenetics*. VIII Edition. Wiley India
- Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. VEdition. John Wiley and Sons Inc
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts ofGenetics*. X Edition. Benjamin Cummings
- Russell, P. J. (2009). *Genetics- A Molecular Approach.*III Edition.Benjamin Cummings
- Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B.*Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co
- Fletcher H. and Hickey I. (2015). *Genetics.* IV Edition. GS, Taylor and FrancisGroup, New York and London.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). *Molecular Biology of the Gene*, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

PAPER: ZOOL 414

BIOSTATISTICS AND TAXONOMY

100 marks (80+20) **4 CH**

Objectives

- To learn about key biostatistical concepts and efficient tools for summarizing and plotting data, make decisions in the presence of uncertainty.
- To obtain a thorough understanding of the principle and practices of systematic, diversity and relationship in the animal world and to develop a holistic appreciation of the geological time scale, phylogeny and adaptation.

Learning Outcomes:

The course will provide knowledge of biostatistics approach used to analyze and presentation of data in biological research and other fields. The course provides methodological background and quantitative skills in morphological and molecular phylogeny of taxonomy and systematic.

Unit I: Biostatistics

Concept of Sample and population, sampling methods, Graphical representation of data, probability distributions (Binomial, Poisson and normal), Measures of central tendency: Mean, Median and Mode. Measures of Dispersion.

Unit II: Biostatistics

Testing of Hypothesis: Null hypothesis, alternate hypothesis, t-Test, Chi square test, ANOVA, Correlation and Regression Analysis.

Unit III: Principle and methods of Taxonomy

Origin and development of taxonomy. Concepts of species and hierarchical taxa, biological nomenclature, classical and quantitative methods of taxonomy of plants, animals and microorganisms. Criteria used for classification in each taxon, evolutionary relationships among taxa., Types of classification (artificial, Natural, Phylogenetic and Phenetics).

Unit IV: Trends in Taxonomy and Zoogeography

Modern trends in taxonomy (biochemical, serological, numerical and molecular phylogeny). **Zoogeography:** Realms, Major habitat types of the subcontinent, seasonality and phenology of the subcontinent. Distribution of vertebrates in different realms. Theories pertaining to distribution of Animal (Plate tectonic and Continental drift Theory).

SUGGESTED READINGS

- Principle of Animal Taxonomy; G.G. Simpson. Oxford IBH Publishing Company.
  Elements of Taxonomy. E. Mayer.
- Theory and Practice of Animal Taxonomy. V.C. Kapoor. Oxford &IBH Publishing Co. Pvt. LTD.
  Advancement in Invertebrate Taxonomy and Biodiversity. Rajeev Gupta. Agrobios International.
  Principles of animal taxonomy by GG Simpson
- Goulden C. H(1939). Methods of Statistical Analysis, John Wiley and Sons Inc., New York.
- Fundamentals of Applied Statistics- S.C Gupta, V. V Kapoor, Sultan and Chand.
- Robert R. Sakal and F. James Rohlf. (2009).Introduction to Biostatistics. Dover Publication Inc., Mineola, New York.

PAPER: ZOOL 415

PRACTICAL

100 marks **4 CH**

A. Invertebrate and Vertebrate

1. Study of Museum specimens/ slides/Model

i. Protozoa: Euglena, Plasmodium, Paramecium
ii. Porifera: Sycon, Euplactella, Hyalonema, Euspongia
iii. Coelenterata: Physalia, Gorgonia, Pennatula, Aurelia, Fungia
iv. Platyhelminthes: Fasciola, Ascaris, Taenia
v. Annelida :Hirudinea, Sabella, Aphrodite, Nereis, Heteronereis.
vi. Arthropoda: Lepas, Sacculina, Eupagurus,Larval forms in Arthropoda.
vii. Mollusca: Chiton, Dentalium, Larval forms in Mollusca, Sepia, Nautilus, Loligo
viii. Echinodermata : Larval forms , Asterias, Echinus, Cucumaria
ix. Protochordata: Balanoglossus, Amohioxus
x. Cyclostomata: Petromyzon , Myxine
xi. Pisces: Torpedo, Trygon, Exocoetus, Echines, Clarias, Hippocampus
xii. Amphibia: Hyla, Alytes, Ichthyophis, Axolotl Larva, Salamander, Necturus
xiii. Reptilia: Chelone, Varanus, Draco, Russel viper, Naja naja
xiv. Aves: Psittacula, Dinopium, Type of Beaks and claws
xv. Mammalia: Echidna, Sorex, Pteropus, Rattus, Squirrel

B. Cell Biology:

1. Preparation of temporary stained squash of onion root tip to study various Stages of mitosis
2. Preparation of temporary stained squash of grasshopper testis to study of various stages of meiosis.

C. Genetics

1. Pedigree analysis

D. Biostatistics

1. Statistical analysis of the hypothetical data provided according to the course studied.

E. Others

1. Practical Record
2. Viva
3. Seminar Report

SEMESTER II

PAPER: ZOOL 421

BIOPHYSICAL CHEMISTRY AND BIOCHEMISTRY

100 marks (80+20) **4 CH**

Objectives

- To learn the biophysical properties and functioning of life processes
- To appreciate the chemical foundation of life processes.
- To understand the structure and metabolism of biologically significant molecules.

Learning Outcome

At the end of the course the student will be able to: Demonstrate knowledge of the fundamental concepts in physical chemistry that underlie biological processes. The course will provide an understanding of fundamental biochemical principles such as biomolecules, metabolic pathway and regulation of biological process.

Unit I: Biophysical Chemistry

Structure of atoms, molecules and chemical bonds. Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).

UNIT II: Biomolecules

Amino acid and Protein: Structure, types and function. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds). **Carbohydrates:** Structure, types and functions. **Lipid**: Structure, types and function. Nucleic acid: Structure and types. Vitamins.

UNIT III: Bioenergetics

Energy transduction in cell and types of transducers, energetic of biochemical reaction, redox potential. Energy transformation and Bioenergetics in mitochondria. Glycolysis, TCA cycle, oxidative phosphorylation, Electron transport chain and ATP synthesis.

Unit IV: Metabolism

Carbohydrate metabolism and Regulation: Gluconeogenesis, Glycogen metabolism, Regulation of carbohydrate metabolism,. **Metabolism of amino acid**: Transamination, oxidative deamination and urea cycle. **Lipid metabolism and Regulation:** Biosynthesis of fatty acids, beta oxidation of fatty acids. Regulation of fatty acid metabolism. Nucleotide metabolism (Synthesis: de novo and salvage pathway and nucleotide degradation)

SUGGESTED READINGS

- Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). *Instant Notes in Biochemistry*, II Edition, BIOS Scientific Publishers Ltd., U.K.
- Satyanarayan U and Chakrapani U (2006). Biochemistry. Books and Allied Pvt. Ltd. Kolkata.

PAPER: ZOOL 422

ENZYME TECHNOLOGY AND MICROBIOLOGY

100 marks (80+20) **4 CH**

Objectives

- To provide knowledge about nomenclatures, characteristics enzymes.
- To understand the the mechanism of enzyme action, their kinetics and various application of enzymes.
- To understand the microorganism that inhabit soil and water
- To study the contribution of microbes in the field of medicine, Industry and Agriculture,

Learning Outcome

The course will provide an understanding of fundamentals of enzyme properties, nomenclatures, characteristics and mechanisms. The learners will be able to describe the enzyme kinetics, production, purification and immobilization of enzymes. The course will be able to describe the structure of bacterial cells, the form, arrangement and replication of genetic material within a bacterial cell.

Unit I: Enzyme

Enzymes: Nomenclature, Classification and properties, Mechanism of action, Regulation (allosteric, phosphorylation and proteolytic cleavage). Allosteric enzymes and its significance.

Unit II: Enzyme Kinetics

Michaelis-Menten equation, Briggs and Haldane quasi steady-state approximation, enzyme inhibition (competitive, non-competitive, uncompetitive) and inhibition kinetics, Turnover number and Kcat. Factors affecting enzyme activity. Bi-substrate reaction kinetics, ordered and random kinetics, Ping-pong catalysis (Delziel's form)

Unit III: Enzyme modifications and Enzyme Immobilization

Extraction and purification of enzymes illustrating the downstream processing. Enzyme immobilization; types, methods and application of enzyme immobilization in bioreactors. Enzyme biosensors (Bio electrodes, Optrodes, Immunochemical sensors). Application of enzyme in food industries.

Unit IV: Microbiology

History and development of microbiology, General features of Bergy's manual for classification of microbes. Isolation, culture and maintenance of microorganisms, Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and industry. Microbial toxins: types, mode of actions and pathogenicity.

SUGGESTED READINGS

- Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). *Instant Notes in Biochemistry*, II Edition, BIOS Scientific Publishers Ltd., U.K.
- Satyanarayan U and Chakrapani U (2006).Biochemistry. Books and Allied Pvt. Ltd. Kolkata.
- Prescott LM, Harley JP and Klein DA.(2003). Microbiology .Tata Mac Graw Hills Publisher.
- PelzarMJ. Microbiology. Tata Mac Graw Hills Publisher.

PAPER: ZOOL 423

MOLECULAR BIOLOGY

100 marks (80+20) **4 CH**

Objectives

- To provide comprehensive idea about the structure and function of nucleic acids and regulation of gene expression.
- To understand how the DNA in a genome is organized, replicated and repaired.
- How the genetic information in the DNA is selectively expressed as functional protein.

Learning Outcome

The course will open an avenue to be familiar with a variety of types of genetic data (genotyping, expression, sequence data), chromosomal mapping, genetic composition of biological population and evolutionary factors that explain the variation. An in-depth knowledge of chemical and molecular processes that occur in between cell including the central dogma will be assured at the end of this course.

Unit I: DNA replication, Repair and Recombination.

Nucleic acid as Genetic material. DNA replication in prokaryotes: replication fork, initiation, elongation, termination., D-loop model of DNA replication, DNA replication in single stranded DNA, rolling circle replication,. Replication in eukaryotes. Fidelity of replication, extrachromosomal replicons. DNA damage and repair (mismatch repair, base excision, nucleotide excision, direct repair, SOS repair). Homologous and site-specific recombination.

Unit II: RNA synthesis and processing

Transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation and termination. RNA processing, RNA editing, splicing and polyadenylation, structure and function of different types of RNA, RNA transport.

UNIT –III: Protein Synthesis and processing

Genetic code and its attribute. Molecular mechanism of translation (Prokaryotes and eukaryotes). Translational proof reading, translational inhibitors, post-translational modification of proteins.

UNIT –IV: Control of Gene expression at transcription and translation level

Regulating the expression of phages, viruses, prokaryotic and eukaryotic genes. Role of chromatin in gene expression and gene silencing.

SUGGESTED READINGS

- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts,Peter Walter: *Molecular Biology of the Cell*, IV Edition.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*.VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Lewin B. (2008). *Gene XI*, Jones and Bartlett
- McLennan A., Bates A., Turner, P. and White M. (2015). *Molecular Biology* IV Edition.GS, Taylor and Francis Group, New York and London.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). *Molecular Biology of the Gene*, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

PAPER: ZOOL 424

ANIMAL PHYSIOLOGY AND ENDOCRINOLOGY

100 marks (80+20) **4 CH**

Objectives

- To learn and understand the fundamental scientific concepts relating to a broad range of topics in animal physiology and Endocrinology.
- The course aim to provide basic understanding of different physiological systems and their interaction to maintain Homeostasis.
- To understand the role of chemical messenger or hormones, whether they are of endocrine or neural origin.

Learning Outcomes

The course will provide detailed knowledge on the various physiological organ-systems and their importance to the integrative functions of the human body. The students will be able to compare and contrast endocrine and nervous control systems. Students will be able to name the key events involved in signaling by hormones, infertility and birth control measures.

Unit I: Control and Coordinating System

Neuroanatomy of the brain and spinal cord, Organization of central and peripheral nervous system, Blood brain barrier, Neuron: Nerve conduction and synaptic transmission. Muscle: Structure, molecular mechanism of muscle contraction.

Unit II: Life sustaining System

Physiology of digestion of carbohydrate, protein and fat. Respiration: Oxygen and carbon dioxide transport and regulation of respiration. Excretion: Mechanism of urine formation. regulation of water balance, blood volume, blood pressure, electrolyte balance, acid base balance. Circulation: Blood and its composition, ABO and Rh system. Hemostasis. Cardiac cycle and its regulation, ECG.

Unit III: Endocrinology and Hormonal regulation

Endocrine glands. Structure and Function of Hypothalamus, Pituitary, Thyroid and Adrenal. Hormonal Regulation of carbohydrate, calcium and phosphorus metabolism. Thermoregulation, Osmoregulation and hormonal regulation of excretion

Unit IV: Cell Signaling and Hormone action

Receptors: characteristics and types. Signal transduction pathway. Signalling through G protein coupled receptors, Second messengers, regulation of signaling pathways. Mechanism of hormone action (peptide and steroid hormone).

SUGGESTED READINGS

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition.Hercourt Asia PTE Ltd. W.B. Saunders Company.
- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XIEdition John Wiley & sons,
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functionalcorrelations. XII Edition. Lippincott W. & Wilkins.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: TheMechanism of Body Function. XIII Edition, McGraw Hills
- Dee UnglaubSilverthorn(2010). Human Physiology: An integrated Approach. 5th Edition.Pearson Education Inc., New Jersey.
- General Endocrinology - Turner C D and Bagnara JT, Saunders publication,1976.
- Endocrinology: An Integrated Approach; Stephen Nussey and Saffron.

PAPER: ZOOL 425

PRACTICAL

100 marks **4 CH**

A. Biochemistry and Enzyme Technology

1. Estimation of carbohydrate, protein and lipid from the biological samples.
2. Chromatographic separation of the supplied amino acids.
3. Estimation of free amino acid content in the biological sample.
4. Enzyme activity of salivary amylase and demonstrate the effect of temperature, pH and substrate conc.
5. Determination of Vmax and Km of enzyme activity through line Weaver Burke plot.
6. Solving problem related to enzyme kinetics using the supplied data.

B. Molecular Biology

1. Isolation of genomic DNA from animal tissue/blood.
2. Quantitative estimation of DNA.
3. Isolation of RNA from animal tissue/blood.
4. Quantitative estimation of RNA.
5. Agarose gel electrophoresis of DNA.

C. Physiology and endocrinology

1. Estimation of haemoglobin using Sahli's haemoglobinometer.
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Microtomy, microscopic preparation and histological techniques.
4. Study of endocrine glands (microphotograph/visual aid)
5. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, Rectum, liver, trachea, lung, kidney

D. Others

1. Practical Record
2. Viva
3. Seminar Report

SEMESTER III

PAPER: ZOOL 511

IMMUNOLOGY

100 marks (80+20) **4 CH**

Objectives

- To understand the immune system with respect to origin, development and structure
- To understand the underlying complexities and mechanism of different immune reactions.

Learning Outcome

This course will describe the immune systems of vertebrates that enable them to recognize and respond specifically to foreign substances. The students will be able to understand the roles of antigens, antibodies and immunocompetent cells in pathogenesis and immunity to infectious diseases.

Unit I: Immune system and Immunity

Phylogeny of immune system. Innate immunity, Inflammation, Adaptive immunity: Passive and active immunity, Humoral and cell mediated immunity, Cells and molecules involved in innate and adaptive immunity. Cell mediated cytotoxicity and antibody dependent cell mediated cytotoxicity. Toll-like receptors.

Unit II: Antigen and Antibody

Antigens, antigenicity and immunogenicity. B and T cell epitopes. Structure and function of antibody molecule. Antigen-antibody interactions. Generation of antibody diversity. Generation of monoclonal antibodies, antibody engineering.

Unit III: Immunology

Major histocompatibility complex and HLA system, Antigen processing and presentation. Complement system (Classical, Alternate and lectin pathway), Cytokines- Types and their role in immune regulation.

Unit IV: Immunology

Immunological aspects of transplantation, Hypersensitivity. Immunologic tolerance. Auto immunity: Immune response during autoimmunity (Rheumatoid Arthritis), Immune dysfunction: congenital and acquired immunodeficiencies. Vaccines.

SUGGESTED READINGS

- Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). *Immunology*, VI Edition.W.H. Freeman and Company.
- David, M., Jonathan, B., David, R. B. and Ivan R. (2006). *Immunology,* VII Edition, Mosby, Elsevier Publication.
- Abbas, K. Abul and Lechtman H. Andrew (2003.) *Cellular and Molecular Immunology.*V Edition.Saunders Publication.

PAPER: ZOOL 512

DEVELOPMENTAL BIOLOGY AND ANIMAL BIOTECHNOLOGY

100 marks (80+20) **4 CH**

Objectives

- To understand the basic concept and experimental aspects of developmental biology
- To acquire an in depth knowledge on cell and tissue culture and its application.

Learning Outcome

The course will provide a broad area from embryology to developmental biology. The students will be able to apply their understanding of embryonic development and postembryonic development. On successfully completion of this course the students will be able to understand step-by-step methods of cell culture and its application in research.

UNIT I: Basic concepts of Development

History of developmental biology. Potency, commitment, specification.induction, competence, determination and differentiation. Morphogenetic gradients; cell fate and cell lineages; genomic equivalence and the cytoplasmic determinants; imprinting.

Unit II: Gametogenesis, fertilization and early development:

Gametogenesis: Spermatogenesis and Oogenesis. Fertilization: morphological aspects, Biochemical events of fertilization. Embryogenesis: cleavage, gastrulation, neurulation and primordial organ rudiments, origin and fate of neural crest cells.

Unit III: Morphogenesis and Organogenesis

Post embryonic development- larval formation, metamorphosis, environmental regulation of normal development. Axes pattern formation in Drosophila, amphibian and chick. Organogenesis- vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates.

Unit IV Animal Biotechnology

Equipments and materials for animal cell culture: Design and layout of culture room, Basic equipments used in cell culture, Sterilization and aseptic techniques, Culture media(Composition) :Natural media, Synthetic media, Nutritional compounds of media, Role of serum in cell culture, Primary culture and its maintenance: Various techniques of tissue disaggregation, Monolayer and suspension cultures. Application of animal cell culture. Stem cell culture and its application. Tissue engineering.

SUGGESTED READINGS

- Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
- Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press
- Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers
- Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press
- Animal Cells Culture and Media, D.C. Darling and S.J. Morgan, 1994.BIOS Scientific Publishers Limited.
- Methods in Cell Biology, Volume 57, Jennie P. Mathur and David Barnes,1998. Animal Cell Culture Methods Academic Press.

PAPER: ZOOL 513

BIOINSTRUMENTATION

100 marks (80+20) **4 CH**

Objectives

- To introduce the tools and techniques available for studying biochemical and biophysical nature of life
- To equip the learner to use the tools and techniques for project work/ research in biology

Learning Outcomes

At the end of the course the student will be able to: Define the structural characteristics of nucleic acids and proteins and examine parameters that variously determine their stability and function(s).Describe the principles that govern biomolecular interactions and appreciate how established methods of research and enquiry are employed to analyze the different aspects of these interactions.

Unit I: Microscopy

Principle and operation of light, Fluorescence and Electron microscopy. Different fixation and staining techniques for electron microscope. Image processing method in microscopy.

Unit II: Spectroscopy

Principle, Instrumentation and application of spectrophotometer (UV- VIS, fluorescence, IR) NMR spectroscopy, Mass spectrometry. Autoradiography.

Unit III: Centrifugation, Chromatography and Immuno Techniques

Centrifugation techniques: Basic principles of sedimentation, types and application. Chromatographic techniques: Principles of chromatography and Types. Principle and application of ELISA, Flowcytometry, Immunohistochemistry, immunofluorescence and Fluorescent in situ hybridization.

UNIT IV: Electrophoretic Techniques

General principle of electrophoresis of proteins (SDS - PAGE, native gels, gradient gels, isoelectric focusing gels and two-dimensional gels), Principle and operation of polymerase chain reaction, electrophoresis of nucleic acids (Agarose, pulse-field and sequencing gels). Blotting techniques (Southern, Northern and Western blotting).

SUGGESTED READINGS

- Instrumental Methods of Analysis – H.H Willard and L. L. Dean .John Wiley and Sons
- Modern methods of Chemical Analysis- R. L Recsok and L. D Shields. John Wiley and Sons
- Instrumental method of Chemical Analysis- G.WEuing. Mc Grand Hill
- Fundamentals of Molecular Spectroscopy – C. N Banwell, Mc Grad Hill
- Instrumental Methods of Chemical Analysis- G Chatwal and S Anand, Himalaya Publishing house, Mumbai
- Biophysical Chemistry: Principles and Techniques – A .Upadhyay, K. Upadhyay and N. Nath. Himalaya Publishing house, Mumbai
- Karp, G. (2014). *Cell Biology*. VII Edition. John Wiley and Sons. Singapore Pvt. Ltd
- Wilson K and Walker J 2010. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.

PAPER: ZOOL 514

EVOLUTION AND ANIMAL BEHAVIOUR

100 marks (80+20) **4 CH**

Objectives

- To understand the evidence that living species share descent from common ancestry and how this fact explains the traits of living species
- To understand that evolution entails changes in the genetic composition of populations.
- To introduce animal behaviour taking an integrative approach that addresses animal behaviour from ethological, ecological and evolutionary aspects and to review the basic concepts of behaviour as a science.

Learning Outcome

The students will able to demonstrate an understanding of key concepts in evolutionary biology, the history of life on earth, and phylogenetic relationships between organisms and of structure/function relationships in organisms. The course also describe and explain the basic concepts of animal behaviour using two approaches – ethology and behavioural ecology. It gives a thorough idea about biological rhythm and instinct behavior.

Unit I: Evolution

Theories of evolution (Lamarckism, Darwinism), Evidences of evolution (Morphology to molecular level), **Molecular evolution**: concept of neutral evolution, molecular divergence and molecular clocks. Molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new gene and proteins; gene duplication and divergence.

Unit II: Mechanism of Evolution

Population Genetics: Gene pool, gene frequency, Hardy-Weienberg law; gene flow, genetic drift. Variation and selection as underlying mechanisms' of evolution (Isolation, speciation and Natural selection). Evolutionary trends (micro, macro and mega patterns of evolution). Coevolution.

UNIT III Animal Behaviour

Classification and analysis of behavior patterns, Tools and Techniques in behavioral study, Neural & hormonal control of behavior, neural basis of learning, memory, cognition, sleep and arousal, development of behavior; aggressive behavior.

Unit IV Behaviour and Evolution

Communication in animals: social communication; social dominance, use of space and territoriality, mating systems, parental investment and reproductive success. Aggressive behavior, Parental care, habitat selection and optimality in foraging. migration, orientation and navigation; Domestication and behavioural changes. Biological rhythms: types and characteristics, Circadian rhythms.

SUGGESTED READINGS

- Ridley,M (2004) Evolution III Edition Blackwell publishing
- Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett Publishers.
- Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
- Organic Evolution- V. B Rastogi. MEDTEC publication.
- Ridley,M (2004) Evolution III Edition Blackwell publishing.
- David McFarland, Animal Behaviour, Pitman Publishing Limited,London, UK.
- Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge, University Press, UK.

PAPER: ZOOL 515

PRACTICAL

100 marks **4 CH**

A. Immunology

1. Determination of ABO blood group (Antigen antibody interaction)
2. Preparation of blood smears for differential count and type of leucocytes.
3. Study of lymphoid organ.
4. Histological study of spleen, thymus and lymph nodes through slides/photographs

B. Developmental Biology and Animal Biotechnology

1. Study of life cycle of different anurans
2. Whole mount preparation of chick embryos
3. Study of Chick development through prepared slides.
4. Study of Frog development through prepared slides.
5. Sterilization and Preparation of media (liquid and solid)
6. Estimation of plasma level of any hormone using ELISA

C. **Bioinstrumentation**

1. Separation of protein fraction using SDS- PAGE.
2. Demonstration of centrifugation.

D**. Evolution and Animal behaviour**

1.Population genetics and Hardy-Weinberg Law (blood group, ear lobe and tongue rolling movement)

2 Study of circadian functions in humans (daily eating, sleep and temperature patterns).

E**. Others**

1. Practical Record
2. Viva
3. Seminar Report

SEMESTER IV

PAPER: ZOOL 521

GENETIC ENGINEERING

100 marks (80+20) **4 CH**

Objectives

- To illustrate creative use of modern tools and techniques for manipulation and analysis of genomic sequences.
- To expose students to application of recombinant DNA technology in biotechnological research.
- To train students in strategizing research methodologies employing genetic engineering techniques.

Learning Outcome

The course will acquaint the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology. A sound knowledge on methodological repertoire allows students to innovatively apply these in basic and applied fields of biological research. This course may be deemed as a foundation course serving as a platform for introduction of more advanced cutting-edge technologies that essentially are an amalgamation of basic techniques combined in diverse forms of modern applications.

Unit I: Recombinant DNA Technology

Concept and scope of genetic engineering, molecular techniques in gene manipulation, DNA isolation and purification, Restriction endonucleases, ligase, Cloning vectors: Plasmid, Cosmid, Lambda bacteriophage, M13, BAC, YAC and expression vectors.

Unit II: Genetic Transformation

Genetic transformation, Strategies for gene transformation (Calcium phosphate method, electroporation, biolistic,liposomal, microinjection and agrobacterium mediated transformation). Selection and screening of transgenic animal using molecular marker (RAPD and RFLP).

Unit III: Molecular Techniques

Nucleic acid hybridization, DNA finger printing, site directed mutagenesis, Gene knock out strategies. RNA interference, Anti-sense technology, siRNA, miRNA, DNA microarray. Genomic and C-DNA libraries.DNA sequencing method (Maxam-Gilbert, Sangers Method).

Unit IV: Application and Limitation

Production of genetically modified organisms, production of cloned and transgenic animals: nuclear transplantation, retroviral method, DNA microinjection. Application of genetic engineering in medicine, agriculture and industries. Genetic engineering regulation and guidelines.

SUGGESTED READINGS

- Mulhardt C. Molecular Biology and Genomics. Academic Press, Elsevier.
- Broown T A. Gene Cloning and DNA analysis. Blackwell Science ltd.
- Molecular Clonning: A laboratory manual by J. Sambrook and E.F. Fritsch.
- DNA Science. A First Course in Recombinant Technology by Mickloss and Freyer
- Molecular Biotechnology by S.B. Primrose
- Watson JD, Baker TA,BellSP,Gann A, Levine M, Losick R. 2004. Molecular Biology of Gene. 5th Edn.Pearson education Inc., Publishing as Benjamin Cumming.Sanfransico, Canada.

PAPER: ZOOL 522

ECOLOGY AND CONSERVATION BIOLOGY

100 marks (80+20) **4 CH**

Objectives

- Describe the structure and function of ecological systems and explain how ecological systems work at different spatial and temporal scales.
- To understand the interaction of organisms with their environment
- To understand the conservation strategies f different animals.

Learning Outcome

The students will able to demonstrate an understanding of ecological relationships between organisms and their environment. Also be able to demonstrate an understanding of key concepts in evolutionary biology, the history of life on earth, and phylogenetic relationships between organisms and of structure/function relationships in organisms.

Unit I Fundamentals of Ecology

Physical environment; biotic environment; biotic and abiotic interactions. Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Unit II: Population and community Ecology

Population ecology: Basic concept, Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, inter demic extinctions, age structured populations. Population interactions: Types of interactions, interspecific competition.

Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Unit III: Ecosystem Ecology

Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).

Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Unit IV: Pollution and Conservation Biology:

Environmental pollution: Air pollution, Water pollution, Noise pollution, global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

SUGGESTED READINGS

- Essentials of Ecology: Miller and Spoolman
- Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Fundamentals of Ecology –M. C Dash, McGraw Hills publication

PAPER: ZOOL 523E- A

ENVIRONMENTAL BIOTECHNOLOGY

100 marks (80+20) **4 CH**

Objectives:

- Know the basic physiology of a microorganism and how their structure dictates their function in the environment
- Understand the bases for microbial metabolism of environmental contaminants
- Know various techniques to modify and augment microorganisms in the laboratory and environment
- Understand the principles of bioremediation, phytoremediation, and to know the basic design and application of microbial fuel.

Learning outcomes:

The student will acquire knowledge of degradation and elimination of persistent, bioaccumulative and toxic organic substances, pollutants Bioremediation, remediation processes in use in the biotic, abiotic environment, as well as in manufacturing technologies.

Unit I:

Basic Environmental biotechnology: Scopes and issues, basic environmental problems-pollution, land degradation, deforestation, biodiversity loss and eutrophication, biotechnology for safer environment, biotechnology for resource management and biomass production, biotechnology for generation of biogas and bio fuels.

Unit II:

Bioaccumulation: Concept and measurement, food chain and lipophilicity approach, quantitative structure activity relationship, kinetics of uptake and retention, factors affecting bioaccumulation. Bioaccumulation of metals: metal accumulation by flora and fauna; biosorption, phytofiltration, phytochelation and phytoextraction.

Unit III:

Bioremediation: Types and application, Biodegradation of pesticides and hazardous wastes, Degradation of oil spills. Biosorption, use of bacteria in biosorption, use of fungi in biosorption, use of algae in biosorption, biomineralisation and bioleaching. Microorganism involved in bioleaching of ores, mechanism of bioleaching.

Unit IV:

Biological Wastewater treatment and disposal: Activated sludge process, biological filters, rotating biological contractors. Anaerobic Biological treatment (contact digester, packed Bed reactor Baffled digester, Biological reactor). Land reclamation and crop productivity.

SUGGESTED READINGS

1. Mahapatra, P.K. (2006) Textbook of Environmental Biotechnology, IK International Publishing House.
2. Varun Mehta (2008). Environmental Biotechnology, 1st edition, Campus Book s International, New Delhi
3. M. Jay (2007). Environmental Microbiology and Biotechnology. 1st edition. Swastik Publishers & Distributors, New Delhi
4. P. Vashisth (2005). Environmental Biotechnology. 1st Edition, Dominant Publishers and Distributors, New Delhi
5. D.K. Markandey and Neelima Rajvaidya (2004). Environmental Biotechnology. Ist Edition. APH Publishing Corporation, New Delhi.
6. Indu Sekhar Thakur (2006). Environmental Biotechnology: Basic concepts and applications. IK International Publishing House.
7. B. E. Rittmann, P. L. McCarty, (2001) Environmental Biotechnology: Principles and Applications, McGraw-Hill.
8. Seviour R, and P.H. Nielsen. (2010.) Microbial Ecology of Activated Sludge, IWA Publishing,

PAPER: ZOOL 523E- B

FISHERIES SCIENCE

100 marks (80+20) **4 CH**

Objectives

- To appreciate the scope of study of fishery biology
- To understand the structure and functioning of different organ systems.
- To acquire an in depth understanding of the unique feature of fishery biology.

Learning outcomes:

This course will provides a comparative examination of selected freshwater and marine fishes to illustrate the influence of aquatic environments on life styles, behavioral patterns, physiological responses, population biology and community structure.

Unit I: Systematics

Classification of fish with distinguish characters and important examples of principal subdivisions, phylogenetic significance of Acanthodians and placoderms. Evolution and adaptive radiation of chondrichthyes Elasmobranchi and Bradyodonti.

Unit II: Special organ

Sound production mechanism, electric fishes-their types, location of electric organ, structure and function of electric organ. Bioluminiscence- physiology and biological significance of luminescence, poisonous fishes and their poisonous apparatus.

Unit III: Breeding and Culture

Natural breeding of Indian major carps, factors responsible for natural breeding, techniques of breeding in Indian major carps. Induced breeding of fishes special reference to major carps. Fisheries of Indian sea with special reference to costal fisheries of Odisha. Fresh water fish culture in India.

Unit IV: Pathology and sustainable aquaculture

Sustainable aquaculture, extensive, semi intensive and intensive culture of fish, pen culture, cage culture, composite fish culture. Role of water quality in aquaculture; Fish pathology symptoms, etiology, prophylaxis and treatment of common diseases and pathological condition in cultivable fish.Exotic fishes, history of transportation of important exotic fishes in India.Larvivorous fishes, exotic and indigenous species with special reference to malarial control.

SUGGESTED READINGS

- Q Bone and R Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.
- H. Evans and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor.The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
- C.B.L. Srivastava, Fish Biology, Narendra Publishing House
- J.R. Norman, A history of Fishes, Hill and Wang Publishers
- S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House

PAPER: ZOOL 524

PROJECT REPORT

100 marks (80+20) **4CH**

Objectives: The objectives of this course are to develop research aptitude, scientific temper and critical analysis among students.

Learning Outcome: Students are expected to gain the basic skill in project handling and writing of their project report, which will be helpful for them to be an independent scientist.

Plan and Execution: Project work of IVth semester will be assigned to the students at the beginning of IIIrd semester and will be completed in the IVth semester. The students will plan and carryout projects with self-involvement through understanding and learning of different research tool and techniques. During their research tenure the students learn the skill of writing theses, articles and project for their future benefits.

Project Report/Dissertation: At the end of the project, students have to submit the project report. Project report should include introduction, background of the problem, Review of literature, objectives, methodology, results, discussion and references. Evaluation of the project report and viva voce will be open defense type through power point presentation and evaluated by both external and internal examiner.

Distribution of Mark/work:

<table>
<tr><td colspan="5">SEMESTER WISE WORK AND DISTRIBUTION OF MARKS IN % FOR PROJECT</td></tr>
<tr><td colspan="5">IIIrd SEMESTER (20%) EVALUATION OF INTERIM REPORT OF THE PROJECT WORK</td></tr>
<tr><td>Background of the problem (5%) (5 marks)</td><td>Review of Literatre (5%) (5 mark)</td><td>Objectives (5%) (5 marks)</td><td>Methodology (5%) (5 marks)</td><td>Total (20%) 20 marks</td></tr>
<tr><td colspan="5">IVth SEMESTER (80%) EVALUATION OF FINAL REPORT OF THE PROJECT WORK</td></tr>
<tr><td colspan="2">Project work (50%) – 50 marks</td><td colspan="2">Viva (30%) = 30 marks</td><td>Total (80%) - 80 marks</td></tr>
<tr><td colspan="2">GRAND TOTAL</td><td colspan="2">4CH</td><td>100 MARKS</td></tr>
</table>

PAPER: ZOOL 525

PRACTICAL

100 marks **4CH**

A. Ecology and Conservation Biology

1. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community.
2. Determination of COD in the water samples.
3. Determination of free carbon dioxide in the water samples.
4. Determination of dissolved oxygen in the water samples.
5.

B. Fisheries and Environmental Biotechnology

1. Study of petromyzon, Myxine, Pristis, Chimaera, Exocoetus, Hippocampus, Gambusia, Labeo, Heteropneustes, Anabas.
2. Study of different types of scales (through permanent slide/photograph).
3. Study of crafts and gears used in fisheries.
4. Water quality assessment of aquaculture (pH, Conductivity, total solid, total dissolved solid).
5. Determination of alkalinity of different water samples.
6. Determination of total hardness of different water samples.
7. Determination of chloride content of different water samples.
8. Determination of primary productivity in different water samples.

C. Others

1. Practical Record
2. Viva
3. Seminar Report

PAPER: ZOOL-IDC 426
(Inter Department Course / Open elective)

ECONOMIC ZOOLOGY

100 marks **3 CH**

Objectives

- To understand the cultivation of honeybee, extraction of honey and honeybee products.
- To understand the culture and rearing of silk worm.

Learning Outcome

The students will able to understand development of sericulture and apiculture for sustainable growth and generation of gainful employment. The course will motivate the learners to be self-employed through sericulture and apiculture.

Unit I: Apiculture

History, Biology of honey bee species. Social organization of honey bee. Bee hive, flora for apiculture. Method of bee keeping and indigenous method of extraction of honey.

Unit II: Apiculture

Modern methods of apiculture, applications for modern method. Products of bee keeping: Honey, bee wax, chemical composition and economic importance of honey bee wax. Bee keeping industries. Modern method in employing honey bees for cross pollination in horticultural garden.

Unit III: Sericulture

Sericulture**:** Definition, history and present status. Types of silkworms, distribution and races. Exotic and indigenous races. Mulbery and non-mulbery sericulture. Selection of mulberry variety and establishment of mulberry garden. Rearing house and rearing appliances. Silkworm rearing technology: early age and late age rearing. Spinning, harvesting and storage of cocoons. Prospectus of sericulture in India. Sericulture industries in different states, employment, potential in mulberry and non mulberry sericulture.

SUGGESTED READINGS

- Manual on sericulture; Food and agricultural organization, Rome 1976
- Handbook of Practical Sericulture: S. R. Ullal and M.N. Narasimhanna CSB, Bangalore.
- Handbook of silkworm rearing: Agriculture and Technical Manual-1, Fuzi Pub Co Ltd, Tokyo, Japan 1972.
- Prost, PJ. 1962. Apiculture, Oxford and IBH, New Delhi.
- Bisht DS. Apiculture, ICAR publication.

M. Sc – ZOOLOGY

DISTRIBUTION OF MARKS IN PERCENTAGE FOR THEORY PAPERS

(Reference: Letter No 6220/Acd I dated 01.10.2022 of Sambalpur University)

End Term	Mid term	Total
80% - 80 marks	20% - 20 marks	100%- 100 marks

MID TERM EXAMINATION

In each theory paper following distribution of marks for mid semester exam will be followed.

Class test (5%)	Class test (5%)	Assignment (5%)	Case study (5%)	Total (20%)
5 marks	5 marks	5 marks	5 marks	20 marks

END TERM EXAMINATION

(Four unit course)

Time: 3h Full Mark: 80

Q 1. Twenty questions of 1 mark each (MCQ/fill in the blanks/True-False, Definition etc) 1x20= 20

2. For Unit-I, Unit –II, Unit-III and Unit- IV 15x4=60

Each question will be of 15 marks and it should have alternative in each unit

(Suggested pattern of distribution of 15 marks are 15; 8+7; 7.5+7.5; 5+10; 2+3+10; 5+5+5)

M. Sc – ZOOLOGY

SAMPLE QUESTION PAPER

PRACTICAL

Time: 6h Full mark – 100

Answer all questions

Q1. Minor experiment (Any One) 20marks

a. ---
b. ---
c. ----
d. ---
e. Any other experiment suggested by the examiner

Q2. Major experiment (Any One) 30marks

a. ---
b. ---
c. ---
d. ---
e. Any other experiment suggested by the examiner

Q3. Spotting (Any **08** in consultation with external examiner)

(Museum specimen/ slides/models/ visual aid/instrument

3.5x8=28 marks

Q 4.Practical Record. 05 marks

Q5. Seminar presentation and Report 10 marks

Seminar Presentation in class seminar -05 marks

Seminar Report Preparation – 05 marks

Q6. Viva voce 07 marks

QUESTION PATTERN AND DISTRIBUTION OF MARKS IN THEORY PAPER OFFERED BY OTHER DEPARTMENTS

(Reference: Letter No 6220/Acd I dated 01.10.2022 of Sambalpur University)

Theory Paper offered by other Department	
End Term	Mid Term
60%	40%

MID TERM EXAMINATION

Class test	Class test	Assignment	Case study	Total
10%	10%	10%	10%	40%

END TERM EXAMINATION

For end term examination of total marks 60 (Four unit course)

Q1. Twelve questions of 1 mark each (MCQ/fill in the blanks/True-False, Definition etc) 1x12= 12

2. For Unit-I, Unit –II, Unit-III and Unit- IV 12x4=48

Each question will be of 12 marks and it should have alternative in each unit. The distribution of marks will be decided by the paper setter.

(Suggested pattern of distribution of 12 marks are 12; 8+4; 6+6; 2+3+7; 4+4+4 etc.)

MOOCs COURSE (3CH)

The students will take one MOOCs course according to his /her preference in consultation with HOD and submit the documents in support of undertaking the MOOCs course to the Department. The students will prefer the course related to subject concerned or as per suggestion of the University. The duration of course will be **12-16** week. The students are required to submit their course certificate after completion of course in the Department. For MOOCs course the pass percentage is as per the programme guidelines.

NON CREDIT COURSE

1. Yuva Sanskar- **Ist Semester** –HOD of the concerned Department will take care of the course
2. N.C.C / N.S.S / Sports/ Performing Arts /Yoga (of which one has to be opted) – **IInd or IIIrd Semester**

   The course in charge will float the course at the beginning of the semester

PASS PERCENTAGE

1. For each paper pass percentage is 30% (G P 4). For clearing the semester Grade Point Average (GPA) should be 4.5 (40%).
2. For IDC, Environmental studies and Disaster Management and Entrepreneurship Development Programme the pass percentage is 30% (G P 4).
3. For MOOCs course the pass percentage is as per the Programme guideline.