

M.Sc. PROGRAMME IN ZOOLOGY



(Effective from Session 2026-27)
(Batch: 2026-2028)



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 2026-2027

(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

COURSE AT A GLANCE

SL NO	PAPER	COURSE TITLE	CREDITS (CH)	MARKS		
				End term	Mid term	Total
SEMESTER I						
1	ZO-C-411	Animal Diversity (Non-Chordates and Chordates)	4	80	20	100
2	ZO-C-412	Cell Biology and Cancer Biology	4	80	20	100
3	ZO-C-413	Inheritance Biology	4	80	20	100
4	ZO-C-414	Biostatistics and Taxonomy	4	80	20	100
5	ZO-C-415	Practical	2	100		100
6	ZO-C-416	Practical	2	100		100
7	ZO-417	Environmental studies and Disaster Management	2	60	40	100

		Total credit hours/marks for First semester	22	580	120	700
SEMESTER II						
1	ZO-C-421	Biophysical Chemistry and Biochemistry	4	80	20	100
2	ZO-C-422	Enzyme Technology and Microbiology	4	80	20	100
3	ZO-C-423	Molecular Biology	4	80	20	100
4	ZO-C-424	Animal Physiology and Endocrinology	4	80	20	100
5	ZO-C-425	Practical	2	100		100
6	ZO-C-426	Practical	2	100		100
7	ZO-IDC-427	Economic Zoology (Interdisciplinary course)	3	60	40	100
		Total credit hours/marks for Second semester	23	580	120	700
SEMESTER III						
1	ZO-C-511	Immunology	4	80	20	100
2	ZO-C-512	Developmental Biology and Reproductive Health	4	80	20	100
3	ZO-C-513	Bioinstrumentation	4	80	20	100
4	ZO-C-514	Evolution and Animal Behaviour	4	80	20	100
5	ZO-C-515	Practical	2	100		100
6	ZO-C-516	Practical	2	100		100
7	ZO-517	Entrepreneurship Development	2	60	40	100
		Total credit hours/marks for Third semester	22	580	120	700
SEMESTER IV						
1	ZO-C-521	Genetic Engineering	4	80	20	100
2	ZO-C-522	Ecology and Conservation Biology	4	80	20	100
		Elective Paper (Students have to Choose any one)				
3	ZO-E-523-A	Biotechnology	4	80	20	100
4	ZO-E-523-B	Fisheries Science	4	80	20	100
5	ZO-E-523-C	Entomology	4	80	20	100
6	ZO-C-524	Project Report	4	50+30	20(Interim)	100
7	ZO-C-525	Practical	2	100		100
8	ZO-C-526	Practical	2	100		100
7	ZO-527 (MOOCS ALT)	Vermitechnology (MOOCs Alternative)	3	80	20	100
		Total credit hours/marks for Fourth semester	23	600	100	700
		Grand Total	90	2340	460	2800

SEMESTER I

PAPER: ZO-C- 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:

By the end of the course, the students will be familiar with the animal world around us. They will be able to appreciate the process of evolution and see how it progressed from simple unicellular organisms 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

Protozoa: Locomotion, Nutrition and reproduction in Protozoa, Protozoan diseases in man, Theories of the origin of metazoans, Porifera: Aquiferous system, Cnidaria: Polymorphism in Siphonophora, Annelida: Adaptive radiation in polychaetes, Trochophore larva and its significance, metamerism and segmentation in annelids.

UNIT-II: Non-chordates

Arthropoda: Evolutionary significance of Trilobites, Crustacean larvae and their significance, vision in insects, Mollusca: Nervous system, torsion and detorsion in gastropoda; Echinodermata: Water vascular system in Echinodermata, Reproduction and development in Echinoderms with evolutionary significance.

UNIT III: Protochordates and Lower Vertebrates

Characteristic features and affinities of Protochordata and Cyclostomata, Accessory Respiratory organs in fishes, Luminous organ in fishes, Lateral line system in fishes, Origin and ancestry of Amphibia. Parental care in amphibians, Neoteny, paedogenesis and metamorphosis in amphibian.

UNIT IV: Higher Vertebrates

Adaptive radiation in reptiles, Classification of reptiles based on skull pattern, Venom in ophidians 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.
- Kardong, K.V. (2009). *Vertebrates*, VI Edition, Mc Graw Hill

PAPER: ZO-C- 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. Mechanism of sorting and regulation of intracellular transport, electrical properties of membranes; Cell- cell Interaction: Cell adhesion molecules, Cellular junctions, Extracellular matrix.

Unit II: Structural organisation 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. Cell death pathways and their significance: Apoptosis, Necrosis and autophagy.

Unit IV: Cancer Biology.

Biology of cancer cell; Oncogenes – role of growth factors and growth factor receptors; Tumour suppressor genes and familial cancers (retinoblastoma, colorectal and breast cancers); Interaction between oncogenes and tumour suppressor genes; Epigenetic factors, telomerase and centrosome malfunctions in cancer; Virus mediated cell-transformation; Immortalization, Genomics of angiogenesis and metastasis; Cell cycle and cancer ; Cancer and apoptosis , Cancer Stem 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.
- Cowell: *Molecular Genetics of Cancer* (2001, Bios)
- Ehrlich, *DNA Alterations in Cancer* (2000, Eaton)

PAPER: ZO-C- 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.

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 of Genetics*. VIII Edition. Wiley India
- Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. 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 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: ZO-C- 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, Primary and secondary data, Collection of Data, Frequency distribution, Sampling methods and sampling error. Graphical representation of data, Measures of central tendency: Mean, Median and Mode. Measures of Dispersion: Range, Mean deviation, standard deviation; Skewness and Kurtosis.

Unit II: Biostatistics

Probability distributions (Binomial, Poisson, and normal); Testing of Hypothesis: Null hypothesis, alternative hypothesis, t-Test and its application, Chi-square test and its application, Correlation and Regression Analysis; Analysis of Variance (ANOVA): One way and two way and their application.

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. Unicellular, colonial and multicellular forms.

Levels of organization of tissues, organs and systems. Comparative anatomy, adaptive radiation, adaptive modifications. 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, geographic origins and migrations of species. 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: ZO-C- 415

PRACTICAL (BASED ON ZO-C-411 AND ZO-C-412)

100 marks

2 CH

1. Invertebrate Anatomy of preserved animals available in the market. Virtual experiments may be done if Specimen not available.
 - a) Prawn (Nervous system & Statocyst)
 - b) Squilla (Nervous system)
 - c) Sepia (Nervous system)
 - d) Loligo (Nervous system)
2. Vertebrate Anatomy of preserved animals available in the market. Virtual experiments may be done if Specimen not available.
 - a) Scoliodon (Afferent and Efferent blood vessels, cranial nerves, internal ear, ampula of Lorenzini, placoid scale)
 - b) Cycloid and ctenoid scales of bony fishes.
3. Identification with comments upon
 - a) Protozoa: Euglena, Plasmodium, Paramecium
 - b) Porifera: Sycon, Euplactella, Hyalonema, Euspongia
 - c) Coelenterata: Physalia, Gorgonia, Pennatula, Aurelia, Fungia
 - d) Platyhelminthes: Fasciola, Ascaris, Taenia
 - e) Annelida: Hirudinea, Sabella, Aphrodite, Nereis, Heteronereis.
 - f) Arthropoda: Lepas, Sacculina, Eupagurus, Larval forms in Arthropoda.
 - g) Mollusca: Chiton, Dentalium, Larval forms in Mollusca, Sepia, Nautilus, Loligo
 - h) Echinodermata: Larval forms, Asterias, Echinus, Cucumaria

- i) Protochordata: Balanoglossus, Amphioxus
 - j) Cyclostomata: Petromyzon, Myxine
 - k) Pisces: Torpedo, Trygon, Exocoetus, Echines, Clarias, Hippocampus
 - l) Amphibia: Hyla, Alytes, Ichthyophis, Axolotl Larva, Salamander, Necturus
 - m) Reptilia: Chelone, Varanus, Draco, Russell viper, Naja naja
 - n) Aves: Psittacula, Dinopium, Type of Beaks and claws
 - o) Mammalia: Echidna, Sorex, Pteropus, Rattus, Squirrel
4. Preparation of temporary stained squash of onion root tip to study various Stages of mitosis
 5. Preparation of temporary stained squash of grasshopper testis to study of various stages of meiosis.
 6. Demonstration of mitochondria by supravital staining in buccal epithelium
 7. Demonstration of Barr body in hair root and buccal epithelial cells.
 8. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila* larvae

PAPER: ZO-C- 415

PRACTICAL (BASED ON ZO-C-413 AND ZO-C-414)

100 marks

2 CH

Genetics

1. Problem related to the following aspects of genetics
 - a) law of independent assortment
 - b) Complementation test
 - c) Sex linked inheritance
 - d) Pedigree analysis
 - e) linkage map
2. Handling of *Drosophila* and study of its life cycle.
3. Sex linked inheritance in *Drosophila melanogaster*.
4. Linkage and crossing over in *Drosophila melanogaster*.
5. Gene mapping in *Drosophila* by the 3-point test cross.

Taxonomy

1. Collecting different local animals/ photographs (least concern category) and their classification using taxonomic keys.
2. Construction of a phylogenetic tree using basic morphological features.
- 3.

Biostatistics

1. To depict a hypothetical continuous frequency distribution table in the form of histogram, frequency polygon and cumulative frequency curve (ogive)
2. Calculation of mean, standard deviation, standard error from the given data.
3. Testing hypothesis by applying chi-square test.
4. Application of t-test to compare difference between two means.
5. Application of ANOVA for testing variation in different sets of experimental data.
6. Practical related to simple correlation and regression analysis

SEMESTER II

PAPER: ZO-C- 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. Stabilising 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.

UNIT III: Bioenergetics

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

Unit IV: Metabolism

Carbohydrate metabolism and Regulation: Gluconeogenesis, Glycolysis, 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), Vitamins.

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: ZO-C- 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

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 , Ping-pong (double reciprocal). **Enzyme inhibition:** Irreversible inhibition and mapping of active-site; Reversible: Competitive, non-competitive and un-competitive; Determination of K_i and nature of inhibition by L-B and Dixon plots.

Unit III: Enzyme modifications and Enzyme Immobilization

Extraction and purification of enzymes illustrating the downstream processing. Enzyme immobilization: types, methods and application of enzyme immobilisation in bioreactors. Enzyme biosensors (Bio electrodes, Optrodes, Immunochemical sensors). Enzyme engineering: Modifications in the active site and introducing silent mutations, Application of enzyme engineering.

Unit IV: Microbiology

History and development of microbiology; general features of Bergey's Manual for the Classification of Microorganisms. Isolation, culture, and maintenance of microorganisms; microbial growth; continuous culture (chemostat); factors influencing the 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: ZO-C- 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.

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

Signal Transduction: Principles of signal transduction, Types of receptors, second messengers and ion channels, Major Signalling Processes: Growth and proliferation, Metabolism and energy homeostasis, Ageing, Cell death, Immunity , Differentiation and tissue regeneration, Stress response – proteostasis and redox balance; Regulation of signaling pathways. Mechanism of hormone action: Protein hormone (Membrane receptors and signalling pathways' G-proteins, cyclic AMP Signaling cascade, PKC and CaMK signalling pathway), Steroid Hormone: (genomic and nongenomic pathways).

SUGGESTED READINGS

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Harcourt Asia PTE Ltd. W.B. Saunders Company.
- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
- Dee Unglaub Silverthorn (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.

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 K_m and V_{max} by Michaelis-Menten and Lineweaver-Burk Plot
6. Solving the problem related to enzyme kinetics using the supplied data.

B. Microbiology

1. Preparation of culture media
2. Gram staining
3. Simple staining
4. Negative staining
5. Isolation of pure cultures of bacteria by streaking method.
6. Preservation of bacterial cultures by various techniques.
7. Estimation of Colony forming unit count by spread plate method/pour plate method.
8. Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods.
9. Effect of temperature on growth of *E. coli* Effect of pH on growth of *E. coli*

C. 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.
6. Spectrophotometric assay of
 - i. DNA by diphenylamine method
 - ii. RNA by orcinol method

D. 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

PAPER: ZO-IDC- 427

(Inter Department Course / Open elective)

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 be 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. Mulberry and non-mulberry 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, P.J. 1962. Apiculture, Oxford and IBH, New Delhi.
- Bisht D.S. Apiculture, ICAR publication.

SEMESTER III**PAPER: ZO-C- 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: Basic Concepts of Immunology

Historical background of Immunology, Concept of Clonal selection, Types of Immunity, Immune cells: types and Production. Lymphoid organs. Innate Immunity: Anatomical Barriers, Chemical mediators, Toll-like receptors, Inflammation, Complement system (Classical, Alternate and Lectin pathway). Adaptive immunity: characteristics, types (Passive and active) immunity, Components (Cellular and Humoral Immunity).

Unit II: Humoral Immunity

Antigens and hepten, 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: Cell Mediated Immunity

Cell mediated Immunity: T cell receptors, T helper cell and lymphocyte activation, Major Histocompatibility Complex (MHC) and HLA system, Antigen processing and presentation. Mechanisms of Cell mediated cytotoxicity and antibody dependent cell mediated cytotoxicity. Cytokines- Types and their role in immune regulation.

Unit IV: Immune disorder and therapy

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

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: ZO-C- 512

DEVELOPMENTAL BIOLOGY AND REPRODUCTIVE HEALTH

100 marks (80+20)

4 CH

Objectives

- To understand the basic concept and experimental aspects of developmental biology
- To understand the issues related to reproductive health and possible solutions.

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 successful completion of this course, the students will be able to understand reproductive health issues and technologies available related to reproductive health.

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. Gametogenesis: Spermatogenesis and Oogenesis.

Unit II: Fertilization and early development:

Fertilization: morphological aspects, Biochemical events of fertilization. Embryogenesis: cleavage, Formation of Blastula, Gastrulation: fate maps, cell movement and formation of germ layers. Differentiation and pattern formation: Origin of anterior-posterior and dorsal-ventral polarity in *Drosophila*: role of maternal, segmentation and homeotic genes; HOX gene in vertebrates, Axis formation in frog (Nieuwkoop Centre and primary organizer), chick and mouse

Unit III: Late Embryonic Development

Organogenesis- vulva formation in *Caenorhabditis elegans*, Formation of neural tube in vertebrates, Development of limb in vertebrates: role of HOX and other pattern-forming genes; eye lens induction. Metamorphosis and regeneration in vertebrates. ageing and senescence.

Unit IV: Reproductive Health

Effect of endocrine disruptor, stress and ageing on male and female fertility; female sterility (Premature ovarian failure, polycystic ovarian syndrome), Hormonal control of pregnancy, Biology of Implantation (Cellular and molecular aspects, Cross-talk between embryo and uterus); Assisted reproductive Techniques. Modern contraceptive technologies.

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
- Knobil & Neill: The Physiology of Reproduction, Vol. I & II (1994 Raven Press)
- Knobil & Neill: Encyclopedia of reproduction, Vol. 1-4, Academic Press, 1998.
- Lamming: Marshall's Physiology of Reproduction (1984, Longman)
- Strauss and Barbieri: Yen and Jaffe's Reproductive Endocrinology (6th Ed. Saunders, 2009).

PAPER: ZO-C- 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

Visualisation of cells and subcellular components by light microscopy, resolving power and image processing of different microscopes (Compound, Phase contrast, Fluorescence, Confocal), Electron microscope (Scanning Electron Microscope and Transmission Electron Microscopes), different fixation and staining techniques for Electron Microscopy, freeze-etch and freeze-fracture methods for Electron Microscopy.

Unit II: Biophysical Method

Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy
Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods. 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
- Wilson K and Walker J 2010. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.

PAPER: ZO-C- 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 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. The course also describes and explains 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-Weinberg 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

Approaches and methods in study of behaviour; Proximate and ultimate causation; Altruism and evolution-Group selection, Kin selection, Reciprocal altruism; Neural basis of learning, memory, cognition, sleep and arousal; Biological clocks; Development of behaviour; Neural & hormonal control of 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: ZO-C- 515

(Based on ZO-C-511 and ZO-C-512)

PRACTICAL

100 marks

2 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
5. Preparation of the paraffin block of tissue samples.
6. Histological staining of paraffin sections using haematoxylin and eosin.
7. Demonstration of immunohistochemical technique.

B. Developmental Biology

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. Study of frog embryonic development through models
5. Window preparation to study chick embryo development

PAPER: ZO-C- 515
(Based on ZO-C-513 and ZO-C-514)

PRACTICAL

100 marks

2 CH

Bioinstrumentation

1. Separation of protein fraction using SDS- PAGE.
2. Demonstration of centrifugation.
3. Demonstrations of Electrophoresis
4. Demonstrations of PCR
5. Demonstration of Chromatography
6. Demonstration of the Spectrophotometer and Quantification of protein using Biuret method, the Lowry method.
7. Quantitative measurement of Biomolecules using Spectroscopy
8. Study of different components of the student's microscope and its assembly
9. Study of different components of the stereo binocular microscope and its assembly

Evolution and Animal Behaviour

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

2. Calculations of genotypic, phenotypic and allelic frequencies from the data provided.
3. Simulation experiments using coloured beads/playing cards to understand the effects of Selection and Genetic drift on gene frequencies.
4. Study of circadian functions in humans (daily eating, sleep and temperature patterns).
5. Study of chemotaxis and phototaxis in animals.

SEMESTER IV

PAPER: ZO-C- 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). Production of genetically modified organisms, production of cloned and transgenic animals: Induction of superovulation, Embryo collection and evaluation, Embryo splitting, Embryo sexing, Embryo transfer, Applications of transgenic animals. Advantages of embryo transfer in farm animals. 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, Biosafety and Bioethics

Application of genetic engineering in medicine, agriculture (Pest resistant plant and BT-Cotton) and industries. Therapeutic proteins and peptides (Insulin). Ethical Issues: Public concerns on GMOs & LMOs, Roles of Institutional Biosafety Committee; Ethics in clinical trials, Genetic testing. Basic biosafety practices in the laboratory, Bioethics guidelines in India. Intellectual Property Rights (IPR) : Patent, Trade, Copyright and trade mark; Indian patent Act, filing of patent application; Management and benefits of IPR; Biopiracy.

SUGGESTED READINGS

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

PAPER: ZO-C- 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 of different animals.

Learning Outcome

The students will be 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: ZO-E- 523- A

BIOTECHNOLOGY

100 marks (80+20)

4 CH

Objectives:

- To acquire an in depth knowledge on cell and tissue culture and its application
- To Understand the basics of biofuels and associated technologies.
- Understand the principles of bioremediation, phytoremediation, and to know the basic design and application of microbial fuel.
- To understand the drug administration and its pharmacokinetics aspects.

Learning outcomes:

The student will acquire knowledge on the role of Biotechnology in animal tissue culture, fuel management, environmental clean-up and pharmaceutical applications. The knowledge will be helpful in the development of more advanced and newer technologies than the existing technology.

Unit I: Animal Tissue culture

Introduction, Equipments and materials for animal cell culture; Design and layout of culture room; 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, Subculture, Evolution of continuous cell lines: Transformation, maintenance of cell lines; Monolayer and suspension cultures. Application of animal cell culture. Stem cell culture and its application. Tissue engineering.

Unit II: Fuel Biotechnology

Solar energy converters: passive heating and cooling, active solar heating, solar cells, conversion of solar energy into chemical energy; Biofuels: energy crops, Modes of utilization of Biomass; Biogas: The substrate, digester, process of Biogas production, advantage and disadvantage; Bioethanol: Production and recovery; Biobutanol; Biodiesel: Sources and production; Biohydrogen: Sources and production.

Unit III: Environmental Biotechnology

Introduction, Wastes and pollutants; Waste treatments: Solid waste and Liquid waste; Waste water treatment: Aerobic and anaerobic treatment of waste water. Biodegradation of xenobiotic compounds; Bioaccumulation of metals: metal accumulation by flora and fauna; biosorption, phytofiltration, phytochelation and phytoextraction.; Bioremediation: Types and application. Land reclamation and crop productivity.

Unit IV: Pharmaceutical Biotechnology

Introduction to pharmaceutical industry and development of drugs; Economics and regulatory aspects; quality management; Bioavailability and factor affecting bioavailability; Pharmacokinetics. Advanced drug delivery systems; Sustained release of drug dosage form and controlled release; Mechanism of drug absorption, distribution, biotransformation and excretion; Factors affecting ADME process.

SUGGESTED READINGS

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, R. Ian Freshney, Oxford University Press (2000). ISBN-13: 9780199632138.
2. Mahapatra, P.K. (2006) Textbook of Environmental Biotechnology, IK International Publishing House.
3. Varun Mehta (2008). Environmental Biotechnology, 1st edition, Campus Books International, New Delhi
4. M. Jay (2007). Environmental Microbiology and Biotechnology. 1st edition. Swastik Publishers & Distributors, New Delhi
5. P. Vashisth (2005). Environmental Biotechnology. 1st Edition, Dominant Publishers and Distributors, New Delhi
6. D.K. Markandey and Neelima Rajvaidya (2004). Environmental Biotechnology. 1st Edition. APH Publishing Corporation, New Delhi.
7. Indu Sekhar Thakur (2006). Environmental Biotechnology: Basic concepts and applications. IK International Publishing House.
8. B. E. Rittmann, P. L. McCarty, (2001) Environmental Biotechnology: Principles and Applications, McGraw-Hill.
9. Seviour R, and P.H. Nielsen. (2010.) Microbial Ecology of Activated Sludge, IWA Publishing,
10. Introduction to Nanotechnology, C.P. Poole, F.J. Owens, Wiley Publishers
11. Pharmaceutical Biotechnology: Fundamentals and Applications, Daan J. A. Crommelin, Robert D. Sindelar, Bernd Meibohm, Springer (2016). ISBN-13: 9781493943395.
12. Pharmaceutical Biotechnology: Concepts and Applications, Gary Walsh, cbspd (2007). ISBN-13: 9780470012451
13. G. R Chatwal (2011). Biopharmaceutics and Pharmacokinetics. Himalaya Publishing House.

PAPER: ZO-E- 523- 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 and Fishery Resources

Classification of fish with distinguish characters and important examples of principal subdivisions, phylogenetic significance of Acanthodians and placoderms. **Fishery resources of India** : Inland fishery, Marine fishery and Estuarine Fishery. Chemical composition and nutritional value of fish.

Unit II: Special organ

Sound production mechanism, electric fishes-their types, location of the electric organ, structure and function of the electric organ. Bioluminescence- 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, and techniques of breeding in Indian major carps. Induced breeding of fishes special reference to major carps. Fish culture system: Pond culture and Management; cage culture, raft culture, pen culture and raceway culture. Role of water quality in aquaculture, Inland fishing gears and fishing methods.

Unit IV: Fish Pathology and Preservation

Fish pathology: Pathology, prophylaxis and therapy of diseases: - Protozoan diseases: Cyclochaetiasis, Costiasis; Helminth parasites: *Gyrodactylus*, *Dactylogyrus*; Crustacean parasites: *Ergasilus*, *Lernaea*; Fungal diseases: branchiomycosis (gill rot), Saprolegniasis; Bacterial diseases: tail and fin rot, furunculosis; Viral diseases: papillomatosis (cauliflower disease), dropsy; Nutritional diseases: Avitaminoses, fin erosion disease and pathological condition in cultivable fish.

Fish Preservation: Methods; Fish byproducts: Production and utilization.

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

ENTOMOLOGY

100 marks (80+20)

4 CH

Objectives

To enable the students to get acquainted with origin and classification of insects. It also give insight to commercial entomology, public health entomology, house hold pest, Integrated Pest Management modules for various important crops. They will also learn about the various management strategy especially eco-friendly means of control.

Learning outcomes:

After the completion of the course the students will be acquainted with the different vectors, their characteristics and process of transmission and infection. The students will also learn about the management techniques of different vectors. Further, the students will also be acquainted with the different means of insect-pest management. They will also learn about the different application techniques of insecticides, and its management.

Unit I: Origin and Classification of Insects

1. Origin and Evolution of Insects
2. Classification of insects upto order with examples.
3. Growth development and metamorphosis of Insect
4. Collection and preservation of insects

Unit II: Economical Entomology

1. Biology of honey bees and apiculture
2. Lac insects and their management.
3. Prospects and status of Silk producing species - their distribution and life cycle, structure of the silk gland.
4. Predators, parasites and pathogens of Insects

Unit III: Morphology and Bionomics of Insects

1. Morphology, Bionomics and Management of important pests of Rice.
2. Morphology, Bionomics and Management of pests of Mango.
3. Morphology, Bionomics and Management of pests of Banana .
4. Morphology, Bionomics and Management of household pests (Mosquitoes and Housefly)

Unit IV: Social and Physiological Aspects of Insects

1. Social behaviour in Insects
2. Physiology and mechanism of Compound vision
3. Insect Hormones with special reference to Pheromones
4. Thermoregulation in Insects

SUGGESTED READINGS

1. The Insects: An Outline of Entomology, P.J. Gullan, P.S. Cranston
2. General Text book of Entomology, O.W. Richard, R.G. Davies, Part I & II
3. Insect Biology-A textbook of Entomology, H.E. Evans, Wesley Publ. Co.
4. General Entomology. M.S. Mani, Oxford & IBH Publ. Co.
5. Insects, M.S. Mani, National Book Trust, India
6. A Textbook of Entomology, H.H. Ross, C.A. Ross, J.R.P. Ross, John Wiley & Sons

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:

SEMESTER WISE WORK AND DISTRIBUTION OF MARKS IN % FOR PROJECT				
III rd SEMESTER (20%) EVALUATION OF INTERIM REPORT OF THE PROJECT WORK				
Background of the problem (5%) (5 marks)	Review of Literature (5%) (5 mark)	Objectives (5%) (5 marks)	Methodology (5%) (5 marks)	Total (20%) 20 marks
IV th SEMESTER (80%) EVALUATION OF FINAL REPORT OF THE PROJECT WORK				
Project work (50%) – 50 marks		Viva (30%) = 30 marks		Total (80%) - 80 marks
GRAND TOTAL		4CH		100 MARKS

A. Recombinant DNA Technology

1. Demonstration of Bacterial Transformation and calculation of transformation efficiency.
2. Isolation of Genomic DNA
3. Designing of primers for DNA amplification.
4. Amplification of DNA by PCR.
5. Demonstration of Southern blotting.

B. Ecology and Conservation Biology

1. Determination of population density in a natural/hypothetical community by quadrat 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.

A. Cell Culture

1. Preparation and sterilization of different types of cell culture media i.e. RPMI 1640, Balanced Salt solutions etc.
2. To isolate lymphocytes from whole blood by gradient centrifugation.
3. To check cell viability by cell counting.
4. To check cell viability by MTT staining.
5. Demonstrate the complete process of animal cell culture including freezing, thawing, proliferation, etc., by taking suitable example of cell line/ Primary cell culture.

B. Environmental Biotechnology

1. Water quality assessment of aquaculture (pH, Conductivity, total solid, total dissolved solid).
2. Determination of alkalinity of different water samples.
3. Determination of total hardness of different water samples.
4. Determination of chloride content of different water samples.
5. Determination of primary productivity in different water samples.

PAPER: ZO-E- 526
[Based on ZO-E-523 (B)]

FISHERIES SCIENCE

PRACTICAL

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. Seasonal analyses of pond water by measuring the following physico-chemical properties:
 - i. Dissolved CO₂ and O₂ contents
 - ii. Alkalinity and pH
 - iii. Total solid and Total dissolved solid
5. Identification and taxonomic status of locally available fishes and their economic importance
6. Study of efficacy of different methods (freezing, drying, salting, and salting and drying simultaneously) of fish preservation.
7. Estimation of protein content in muscle/liver of fresh and preserved fish
8. Electrophoretic analysis of proteins in muscle/liver of fresh and preserved fish.
9. Demonstration of induced breeding in fishes
10. Collection of pituitary gland and preparation of injection extract
11. Demonstration of parental care in fishes through visit to any fish farm
12. Dissection of afferent/Efferent branchial arteries of Scoliodon
13. Dissection of cranial nerves of Scoliodon (virtual dissection may be done if dissection not allowed)
14. Study of air breathing organ in Channa, Heteropneustes, Anabas and Clarias.

PAPER: ZO-E- 526
[Based on ZO-E-523 (C)]

ENTOMOLOGY

PRACTICAL

100 marks

2CH

1. Collection and preservation of insects by

- 1.1 Dry preservation methods (direct pinning, carding and pointing)
- 1.2 Liquid preservation and processed mounting methods
2. Identification of insects belonging to economically important insect orders (Orthoptera, Hemiptera, Lepidoptera, Hymenoptera, and Diptera) till family level, by using *dichotomous keys*
3. Dissection and permanent whole mount preparation of
 - 3.1 Mouthparts of cockroach and *Dysdercus koenigii*
 - 3.2 Mouth parts and legs of honey bee
4. External features of available field collected insects
5. Wing venation, types of wings and wing coupling apparatus
6. Types of insect antenna, mouth parts and legs
7. Study of some public health important insect pests with the help of specimens or slides
8. Study of life cycle of mosquitoes and their habitats.
9. Study of life cycle of house flies and their habitats.
10. Study of external morphology of different castes of honey bee and preparation of a permanent mount of sting apparatus
11. Study of food utilization by silkworm *Bombyx mori*
12. Visit to a silkworm rearing/training centre
13. Study of pre- and post-cocooning characteristics of *B. mori*
14. Study of silkworm diseases using permanent slides/specimen

PAPER: ZO-C- 527
(MOOCS ALTERNATIVE COURSE)

VERMITECHNOLOGY

100 marks (20+80)

3 CH

Objectives:

1. To introduce the students with the scope and importance of vermitechnology.
2. To introduce the students with different methods of vermicomposting.
3. To introduce the students with the role of vermicomposting.

Learning Outcome:

1. Students will learn about the scope and importance of vermitechnology.
2. Students will be able to know different methods of vermicomposting
3. Students will be able to comprehend the role of vermicomposting and its potential

Unit I:

Vermiculture: Definition, scope and importance; Common earthworm species for vermiculture; Environmental parameters; Culture methods-warmery-breeding techniques; monoculture & polyculture

Unit II:

Vermicomposting of wastes in field its, ground heaps, tank method, roof shed method, harvesting the compost, storage, vermiwash-preparation & application

Unit III:

Use of vermicomposting in organic farming; management of solid wastes using vermitechnology; predator/pathogen control in wormeries; potential and constraints for vermiculture in India.

Text Books:

1. Sreenivasan, E. (2014). Handbook of Vermicomposting Technology. The Western India Plywoods Ltd, Kerala, India.

Reference book:

1. Anand, K., & Sinha, P. B. (2020). Vermitechnology: a solution for agricultural waste. In Innovative Waste Management Technologies for Sustainable Development (pp. 273- 290). IGI Global.
2. Walia, S. S., & Kaur, T. (2024). Vermitechnology: History and Its Applications. In Earthworms and Vermicomposting: Species, Procedures and Crop Application (pp. 37-53). Singapore: Springer Nature Singapore.

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

4. 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. Major Expt / Spotting (Any **10** in consultation with external examiner)

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

3.0x10=30 marks

Q 4. Practical Record.

10 marks

Q5. Viva voce

10 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.