ಮಂಗಳೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

MANGALORE UNIVERSITY

(Accredited by NAAC Grade)

ಕ್ರಮಾಂಕ/No. : MU/ACC/CR.5/2025-26/A2

ಕುಲಸಚಿವರಕಛೇರಿ
ಮಂಗಳಗಂಗೋತ್ರಿ – 574 199
Office of the Registrar
Mangalagangothri – 574 199
ದಿನಾಂಕ/Date:31.07.2025

NOTIFICATION

Sub: Revised syllabus of M.Sc. in Zoology Programme.

Ref: Academic Council approval vide agenda No.:ಎಸಿಸಿ:ಶೈ.ಮ.ಸಾ.ಸ.1:1 (2025-26) dtd 18.07.2025.

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The revised syllabus of M.Sc. in Zoology programme which has been approved by the Academic Council at its meeting held on 18.07.2025 is hereby notified for implementation with effect from the academic year 2025-26 and onwards.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)

REGISTRAR

To,

1. The Registrar (Evaluation), Mangalore University.
2. The Chairman, P.G. Board of Studies in Applied Zoology, Dept .of Applied Zoology, Mangalore University.
3. The Chairman, Dept .of Applied Zoology, Mangalore University, Mangalagangothri.
4. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
5. The Director, DUIMS, Mangalore University – with a request to publish in the website.
6. Guard File.

Mangalore University
Department of Applied Zoology

M.SC. ZOOLOGY
CHOICE BASED CREDIT SYSTEM (CBCS)

SYLLABUS

2025

PREAMBLE

In an attempt to make the postgraduate courses competitive and on par with the global standards, University Grants Commission had directed implementation of Choice-Based Credit System (CBCS). The syllabi of various courses are being updated by Mangalore University. In keeping with the current style and developments in Animal Sciences the course content is being modified and designed to make it skill based so as to provide an opportunity to the student to opt for various courses customized for his/her inclination, choice is provided through soft-core courses and open elective courses. A solid grounding in a subject is provided through hard-core courses which are mandatory. There will thus, be a component of hard-core, soft-core and open- elective courses. Open-elective courses are to be opted during 2nd and 3rd Semester.

The present syllabus designed by the Board of Studies (BOS) spans over IV semesters. It will have a total of 92 credits, of which 46 credits (50%) form the hard-core, 40 credits (44%) form the Soft-core and Open electives account for 6 credits. The scheme of examinations and internal assessment is also provided. The calculation of credits and CGPA will be as per the guidelines of the University.

- New syllabus for M.Sc. Zoology program is based on existing CBCS scheme.
- This will be implemented from 2025 onwards.
- Two hard core courses are compulsory in I-III semesters.
- Any two soft core courses are offered /opted in each semester
- In the fourth semester one hard core, Two soft cores and one project work to be offered.
- Project work is in lieu of one hard core theory courses (4 credits).
- Of the two open elective courses only one will be offered in II and III semesters.
- The scheme of examination and evaluation pattern is as per the university guidelines.
- Internal evaluation will be as per the exiting pattern. However, any modification will be decided in department council and as per the University guidelines at the time of implementation.

Sd/-

Chairman
Board of Studies (BOS)

LEARNING OBJECTIVES:

1. This program aims to foster scientific curiosity, critical thinking, and a strong ethical foundation, shaping the next generation of zoologists equipped to make meaningful contributions to science and society.
2. To foster pristine ambiance to the students with plethora of opportunities to gain mastery in distinct facets of Zoology.
3. To enrich proficiency in animal studies and handling, breeding and conservation of animals.
4. To cultivate professional integrity and righteousness through mentoring by connoisseur of subject experts
5. To adept skills required for teaching and research in animal sciences.

LEARNING OUTCOME:

1. Student with master's degree in Zoology will learn how animals are classified, their anatomy, physiology, nutrition, metabolism and adaptations. They will acquire an understanding of genetics and its importance in breeding of animals, waste management and Vermitechnology, applied entomology, Infectious diseases. They will also gain insight into, molecular biology, cancer and its epidemiology, human genetics and diseases, clinical embryology, functioning of immune system, radiation and its effects and applications in biological systems, computational biology. They will acquire competence with wildlife conservation and management, fisheries and aquatic biology and animal tissue culture and biotechnology. Students will gain expertise in toxicology and forensic science, learning to assess the impact of toxins and understand their role in legal investigations. They will study environmental biology and chemical ecology, gaining insights into the interactions between organisms and their environments, and the chemical factors influencing these relationships.
2. To nurture oral and written skills to communicate effectively with scientific fraternity.
3. Retrieve, explore and exploit information, to pen scientific articles and present papers.
4. Well-designed syllabus facilitates students to excel in various competitive exams.

PROGRAMME OUT COME (PO)

PO 1: Students on completion of M Sc. Zoology will acquire the knowledge of: Different branches of animal sciences such as animal systematics, evolution and anatomy, cell and molecular biology, modifications and adaptations of animals to different environments.

PO 2: They will practice ethical, responsible, professional handling of animals and will be well trained in animal physiology, immunology, neurobiology, nutrition and metabolism. Applied aspects like entomology , fishery biology, toxicology, cancer biology, animal cell biotechnology, genetics and animal breeding, aquatic and fishery biology, wildlife conservation and management, vermitechnology.

PO 3: Comply with all applicable regulations and requirements regarding biological effects of radiation and applications of radiation.

PROGRAMME SPECIFIC OUT COME (PSO)

PSO 1: Students of M Sc. Zoology will acquire the skills and ability to teach zoology at UG/PG level and biology at pre -degree level.

PSO 2: The program culminates in a project work, allowing students to apply their knowledge in a research setting, develop critical thinking, and contribute to scientific advancements in zoology and hence can do research in basic and applied aspects of animal sciences.

PSO 3: Take up positions in academic and research institution as lab technician/ forensic experts in toxicology and environmental biology laboratory / drug testing laboratories/ biotechnology and pharmaceutical industries and also in conservation and wildlife organization.

PSO 4: Take up a profession in animal breeding programs/museum curator/ zookeeper/ wildlife biologist / Scientist post in different laboratories and in industries.

List of Hard core, Soft-core and Open elective courses and Credit distributions

SEMESTER	CODE NUMBER	HARD CORE COURSES
I	ZOH 401	Animal Taxonomy, Evolution and Zoo-geography
	ZOH 402	Biochemistry and Metabolism
II	ZOH 451	Genetics and Animal breeding
	ZOH 452	Toxicology and Forensic science
III	ZOH 501	Animal Cell Biotechnology
	ZOH 502	Aquatic Biology and Fisheries
IV	ZOH 551	Immunology
		SOFT CORE COURSES
I	ZOS 403	Comparative Anatomy and Physiology
	ZOS 404	Tools and Techniques in biology
	ZOS 405	Applied entomology
II	ZOS 453	Molecular Cell Biology and Cancer Biology
	ZOS 454	Environmental Biology & Chemical Ecology
	ZOS 455	Developmental Biology and Clinical embryology
III	ZOS 503	Human Genetics and Diseases
	ZOS 504	Biostatistics, Bioinformatics and Computational Biology
	ZOS 505	Wildlife Conservation and Management
IV	ZOS 553	Neurobiology and Behavior
	ZOS 554	Economic Zoology
	ZOS 555	Radiation biology
IV	ZOP 552	**PROJECT WORK**
		OPEN ELECTIVE COURSES
II	ZOE 456	Public Health Entomology
	ZOE 457	Ornamental Fish Production and Management
III	ZOE 506	Infectious Diseases and Management
	ZOE 507	Waste management and Vermitechnology

Credit distributions (total in 4 semesters)

Courses	Credits	Percentage
TOTAL	92	------
Hard core	46	50
Soft core	40	44
Open elective	06	06

Overview and Schematic Syllabus

I Semester

Course Code	Hard/Soft core courses	Teaching Hrs/Week	Exam Hrs.	Credit	Marks		Max. Marks
					IA	Exam	
ZOH 401	Animal Taxonomy, Evolution and Zoogeography	4	3	4	30	70	100
ZOH 402	Biochemistry and Metabolism	4	3	4	30	70	100
ZOS 403	Comparative anatomy and Physiology	4	3	3	30	70	100
ZOS 404	Tools and Techniques in biology	4	3	3	30	70	100
ZOS 405	Applied entomology	4	3	3	30	70	100
ZOP 406	Animal Taxonomy, Evolution and Zoogeography	4	3	2	15	35	50
ZOP 407	Biochemistry and Metabolism	4	3	2	15	35	50
ZOP 408	Comparative anatomy and Physiology	4	3	2	15	35	50
ZOP 409	Tools and Techniques in biology	4	3	2	15	35	50
ZOP 410	Applied entomology	4	3	2	15	35	50
				22			**600**

Any two of the *soft-core* courses to be opted/offered.

II Semester

Course Code	Hard/Soft/Open elective courses	Teaching Hrs/Week	Exam Hrs.	Credit	Marks		Max Marks
					IA	Exam	
ZOH 451	Genetics and Animal breeding	4	3	4	30	70	100
ZOH 452	Toxicology and Forensic Science	4	3	4	30	70	100
ZOS 453	Molecular Cell Biology and Cancer Biology	4	3	3	30	70	100
ZOS 454	Environmental Biology & Chemical ecology	4	3	3	30	70	100
ZOS 455	Developmental biology and Clinical embryology	4	3	3	30	70	100
ZOE 456	Public Health Entomology	3	3	3	30	70	100
ZOE 457	Ornamental Fish Production and Management	3	3	3	30	70	100
ZOP 459	Genetics and Animal breeding	4	3	2	15	35	50
ZOP 460	Toxicology and Forensic Science	4	3	2	15	35	50
ZOP 461	Molecular Cell Biology and Cancer Biology	4	3	2	15	35	50
ZOP 462	Environmental Biology & Chemical Ecology	4	3	2	15	35	50
ZOP 463	Developmental Biology and Clinical embryology	4	3	2	15	35	50
				25			**700**

Any two of the *soft-core courses* to be opted/offered. Any one of the *Open electives* will be offered.

III Semester

Course Code	Hard/Soft/Open elective courses	Teaching Hrs./Week	Exam Hrs.	Credit	Marks		Max. Marks
					IA	Exam.	
ZOH 501	Animal Cell Biotechnology	4	3	4	30	70	100
ZOH 502	Aquatic Biology and Fisheries	4	3	4	30	70	100
ZOS 503	Human Genetics and Diseases	4	3	3	30	70	100
ZOS 504	Biostatistics, Bioinformatics and Computational Biology	4	3	3	30	70	100
ZOS 505	Wildlife Conservation and Management	4	3	3	30	70	100
ZOE 506	Infectious Diseases and Management	3	3	3	30	70	100
ZOE 507	Waste management and vermitechnology	3	3	3	30	70	100
ZOP 508	Animal Cell Biotechnology	4	3	2	15	35	50
ZOP 509	Aquatic Biology and Fisheries	4	3	2	15	35	50
ZOP 510	Human Genetics and Diseases	4	3	2	15	35	50
ZOP 511	Biostatistics, Bioinformatics and Computational Biology	4	3	2	15	35	50
ZOP 512	Wildlife Conservation and Management	4	3	2	15	35	50
				25			**700**

Any two of the *soft-core courses* to be opted/offered. Any one of the *Open electives* will be offered.

IV Semester

Course Code	Hard/Soft/Open elective courses	Teaching Hrs/Week	Exam Hrs.	Credit	Marks		Max. Marks
					IA	Exam.	
ZOH 551	Immunology	4	3	4	30	70	100
ZOP 552	**PROJECT WORK**	4	3	4	30	70	100
ZOS 553	Neurobiology and Behavior	4	3	3	30	70	100
ZOS 554	Economic Zoology	4	3	3	30	70	100
ZOS 555	Radiation biology	4	3	3	30	70	100
ZOP 556	Immunology	4	3	2	15	35	50
ZOP 557	Neurobiology and Behavior	4	3	2	15	35	50
ZOP 558	Economic Zoology	4	3	2	15	35	50
ZOP 559	Radiation biology	4	3	**2**	15	35	**50**
				20			**550**

Any two of the *soft-core* courses to be opted/offered.

Grand Total of Maximum Marks 2550

M.Sc. ZOOLOGY
CHOICEBASED CREDIT SYSTEM (CBCS)
SEMESTER PATTERN (2025 on words)

SCHEME OF EXAMINATIONS AND EVALUATION:

The theory, practical and project work component of a course shall be evaluated as below;

Theory	**Marks**
Internal assessment	30
Final examination	70
Practical	
Internal assessment	15
Final examination	35
Total	150
Project work	
Internal assessment	30
Final evaluation	70
Total	100

Pattern of Question Paper:

Theory Final Examination:

Q I. a-e : Short questions one from each unit. (5 x2) = 10 marks
QII to QVI : Essay type questions from each unit (5 x12 or 10x6 or 15x4)= 60 marks
(One question of 12marks or two questions of 6 marks each or three questions of 4 marks each) representing unit I to V with internal choice).

Practical Examination **:**

The final practical examination (3Hrs.) is evaluated for 35 marks and may have one or two major (10to12 marks) and one or two minor (5to 8 marks) questions with 5 marks for Viva voce. The final pattern can be arrived at by the departmental council.

Project Work :

Final evaluation of dissertation/project report shall be by 2 examiners one external and one internal from out of the panel of examiners prepared by the BOS and approved by the University.

Internal assessment shall be as below: Theory :

a. 2 tests of each 2 hrs. duration: (30x2) = 60 marks.
b. The marks obtained shall be reduced to 30 marks.
c. Assignment/Seminar may be given in lieu of a test as decided by the departmental council.

Test pattern

QI. a-d :	Multiple choice questions	(4 x 1) =	04
QII a-c :	Short questions	(3x 2) =	06
QIII to Q IV:	Essay questions	(2x10 or 4x5) =	20
	Total marks		30

Practical/ laboratory:

a. Continuous assessment or a practical test ordinarily during14th week for 10 marks.
b. Records to be valued for 5 marks. The total maximum shall be15 marks.

Project work (field/laboratory work)

Internal assessment shall be based on the following pattern and evaluated by the Guide/Co- Guide and one internal member as decided by the departmental council. (* (By guide/Co-guide); **(by both members)

	Marks
Project report/ Dissertation	10*
Presentation & Viva voce	20**
Total	30

Sd/-
Chairman
Board of Studies (BOS)

SEMESTYER - I

ZOH 401 : ANIMAL TAXONOMY, EVOLUTION AND ZOOGEOGRAPHY
Teaching 10 hours 10/Unit

COURSE OUTCOMES:

- Students will understand the principles, history, and significance of taxonomy and biosystematics, including major classification systems and taxonomic ranks.
- They will learn practical taxonomic procedures such as specimen collection, identification methods, and the use of taxonomic keys along with nomenclature rules.
- The course will enable students to grasp various species concepts, modes of speciation, and evolutionary interactions among species.
- Students will gain knowledge about different evolutionary theories, molecular evolution, and the application of molecular tools in taxonomy and phylogeny.
- They will comprehend paleogeography, biogeographical regions, species distribution patterns, and the evolutionary history of humans and animals

UNIT-I : Definitions, importance and applications of taxonomy and biosystematics. History and objectives of biological classification – Linnaeus to new systematics. Higher order taxonomy – Aristotle to Whittaker's five kingdoms and Carl Woese's six kingdoms and three domains. Hierarchy of categories: Taxonomic ranks- Infra-species, sub species and other categories. Trends in biosystematics- Chemotaxonomy, Cytotaxonomy and Molecular taxonomy.

UNIT-II : Taxonomic procedures: Taxonomic collections, preservation, curating, process of identification. Taxonomic keys, different types of keys, their merits and demerits. International Code of Zoological Nomenclature (ICZN)- Operative principles, interpretation and application of important rules. Verification and validation by type specimens. Major classes of taxonomy (Phenetics, Cladistics, and Phylogenetics). Taxonomic research in India and abroad – Historical faunal collections- Important institutions and their current status. Zoological Survey of India and its role.

UNIT- III : Species concepts- Biological, lineage and morphological concepts. Pattern, process and geographic modes of speciation-Allopatric, Peripatric, Parapatric and Sympatric speciation. Factors affecting speciation process. Origin and mechanisms of reproductive isolation. Rate of speciation – gradual speciation model and punctuated equilibrium model. Adaptive radiation vs Convergent evolution. Co-evolution and Interactions among species (competition, predation, parasitism, mutualism, coloration and mimicry).

UNIT-IV : Theories of evolution - Lamarckism, Neo-Lamarckism, Darwinism, Neo -Darwinism. Natural selection and sexual selection. Anatomical and embryological evidences for evolution- Homologous and analogous features. Molecular evolution: Concepts of neutral evolution, molecular divergence and molecular clocks. Origin of new genes and proteins- Gene duplication and divergence- Gene conversion and evolution of genes and gene families. Molecular tools in phylogeny, classification and identification.

UNIT-V : Paleogeography- Permanence of continent; Theory of land bridges; Continental drift theory; Plate tectonics. The evolutionary time scale- Eras, periods, and epoch. Major events in the evolutionary time scales. Patterns of species distribution- Cosmopolitan, Discontinuous, Endemic, Isolated and Bipolar. Biogeography and distribution of species- Zoo-geographical regions- Palearctic, Nearctic, Neotropical, Oriental, Australian and Ethiopian regions- their Climatic and faunal peculiarities, Insular fauna. Human evolution- Hominins and their distributions.

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ZOP 406: ANIMAL TAXONOMY AND ZOOGEOGRAPHY- LABORATORY
(4 hours/ week)

COURSE OUTCOME :

- Students will develop skills in collecting, preserving, and identifying various insect species enhancing their taxonomic expertise which is essential for laboratory work and museum curation
- They will also acquire hands-on experience in the collection, preservation, and preparation of specimens, including the creation of permanent slides,
- They will gain insights into the functional adaptations that influence feeding behaviours and ecological roles.
- They will engage in field surveys to record and report on local vertebrate species and fostering skills in ecological monitoring and biodiversity assessment.
- They will develop competencies in systematic biology and bioinformatics.

Experiments:

1. Collection and identification of aquatic insects/ zooplanktons.
2. Collection and identification of mosquito larvae.
3. Collection, preservation of local insects- butterflies, moths, beetles, mosquito and ants (2 species each).
4. Identification of insects up to order level (any 10 orders).
5. Collection, preservation and identification of earthworms and spiders (2 species).
6. Collection, preservation and identifications of molluscan shells (2 species).
7. Study the feeding strategies in insects - mounting of mouth parts of cockroach, butterflies, mosquito, honey bee, drosophila (any two).
8. Recording and reporting the life cycle of an insect.
9. Recording and reporting vertebrates (Fish, frogs, reptiles, birds and mammals-1 species each).
10. Collection of 5 invertebrates and preparation of permanent slides/specimens and submission of report.
11. Construction of dichotomous key using museum specimens.
12. Construction of cladogram.
13. Computational analysis of size, shape and structure of insect wings.
14. Construction of phylogenetic tree using DNA/ protein sequence.

ZOH 402: BIOCHEMISTRY AND METABOLISM
Teaching 10 hours 10/Unit

COURSE OUTCOME:

- Students will understand the classification, structure, and physiological roles of key biomolecules like carbohydrates, lipids, proteins, nucleic acids, and vitamins.
- They will describe major metabolic pathways including glycolysis, citric acid cycle, oxidative phosphorylation, and lipid metabolism, focusing on their regulation and energy production.
- Learners will analyze enzyme function, kinetics, inhibition, and their applications in medicine and biotechnology.
- They will explore the chemistry of genetic material and protein structures, along with the biochemical basis of genetic diseases.
- Students will evaluate the impact of nutrition and metabolic markers on human health and prevention of nutritional deficiencies.

UNIT-I: Carbohydrates-Classification, structure and properties. Monosaccharides, Disaccharides, Homopolysaccharides, Heteropolysaccharides-Hyaluronic acid, chitin, heparin, chondroitin and keratin sulphate. Physiologically important carbohydrates. Lipids-Classification, structure and properties of fatty acids, triglycerides. Oxidation of fatty acids – β oxidation, bile salts and bile pigments. Ketone bodies and their importance. Prostaglandins and their significance.

UNIT - II: Amino acids- classification, chemical nature and properties. Classification of proteins, physical-chemical properties, structure – primary, secondary, tertiary and quaternary. Methods for determining amino acid sequences – N-terminal, C- terminal and amino acid analysis of proteins. laboratory synthesis of peptides. Metabolism of aromatic amino acids. Nucleic acids - classification, nucleosides, nucleotides, nucleoside analogs and polynucleotides. Biosynthesis and break down of purines and pyrimidines. Salvage pathway. Disorders of nucleic acid metabolism.

UNIT – III: Classification of enzymes. Enzyme kinetics. Factors affecting enzyme catalyzed reactions. Enzyme inhibition. Allosteric regulations of enzyme activity co-enzymes, metalloenzymes, isoenzymes and multienzyme complexes, ribozymes. Clinical applications of enzymes.

UNIT -IV : High energy phosphate compounds. Overview of metabolism and the provision of metabolic fuels. Glycolysis and oxidation of pyruvate- pathway, regulation and energetics of pathway. Citric acid cycle- importance, pathway regulation and energetics, Glyoxylate cycle, amphibolic role. Respiratory chain and oxidative phosphorylation. Chemiosmotic theory, ATP synthesis, inhibitors and uncouplers of respiratory chain.

UNIT-V: Macronutrients- sodium, potassium, chloride, calcium, phosphorus and magnesium. Trace elements -zinc, iron, selenium, iodine, copper, manganese, fluoride, chromium, and molybdenum. Vitamins- water and fat-soluble vitamins, functions, dietary fibre, antioxidants and Phyto-chemicals, sources and deficiency symptoms. Nutritional basis of health, BMR, balanced nutrition, nutrients, vitamins and their importance and recommendations.

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ZOP 407: BIOCHEMISTRY AND METOBOLISM – LABORATORY
4 Hours/ week.

COURSE OUTCOME :

- Students will develop skills to identify and quantify biomolecules such as carbohydrates, proteins, and lipids using qualitative and quantitative methods.
- They will gain insights into enzyme behavior by studying the effects of temperature, pH, substrate concentration, and metal ions on enzyme activity.
- Students will learn to separate and identify amino acids and sugars using paper chromatography, enhancing their analytical capabilities.
- They will acquire practical knowledge in determining the molecular weight and purity of proteins through SDS-PAGE, a key technique in molecular biology.
- Students will be trained to estimate clinical parameters such as blood glucose, cholesterol, urea, and creatinine, preparing them for laboratory diagnostics.

Experiments :

1. Color reactions of carbohydrates.
2. Identification of unknown carbohydrates.
3. Color reactions of proteins.
4. Precipitation reactions of proteins.
5. Identification of an unknown protein.
6. Estimation of blood glucose.
7. Estimation of cholesterol.
8. Paper chromatography for sugars.
9. Estimation of total serum proteins by biuret/Lowrys method.
10. Determination of urine creatinine by Jaffe's method.
11. Estimation of blood urea by diacetylmonoxime method.
12. Paper chromatography for amino acids.
13. Determination of molecular weight and purity of proteins by SDS-polyacrylamide gel electrophoresis.
14. Assays of phosphatases/transaminases/dehydrogenases.
15. Effect of substrate concentration, enzyme concentration and time on enzyme kinetics.
16. Effect of temperature / pH / metal ions on enzyme activity.

ZOS 403: COMPARATIVE ANATOMY AND PHYSIOLOGY
Teaching 10 hours/Unit

COURSE OUTCOME:

- Students will explain animal body plans and evolutionary relationships, focusing on protochordates and chordates and vertebrate evolution.
- They will demonstrate knowledge of comparative anatomy and functional morphology of key systems across major animal groups, highlighting adaptations.
- Learners will integrate physiological processes like digestion, respiration, circulation, and excretion across invertebrates and vertebrates.
- They will describe hormonal regulation and reproductive mechanisms, including fertilization and fertility control strategies.
- Students will apply comparative physiology concepts to analyse evolutionary adaptations in different environments, deepening their understanding of animal diversity and homeostasis.

UNIT-I : Body plan of animals-evolutionary perspectives. Methods and tools used to study animal body. Characters and Classification of Proto-Chordata, significance of protochordates in the evolution. Origin of chordates and classification. Structure of skin in vertebrates. Integumentary derivatives -glands, scales, horns, claws, hooves, feathers & hair. Skeleton - Components of the head skeleton. Comparative account of jaw suspension. Cranial kinesis, Comparative account of vertebral column, girdles and limbs. Muscles- Gross structure of muscles; muscles of primary swimmers. Axial, Hypobranchial, Appendicular and Branchial muscles of tetrapods.

UNIT-II: Patterns of feeding and digestion in lower metazoans**.** Filter feeding in polychaeta, mollusca and Echinodermata**.** Anatomy of gut in relation to feeding habits- herbivores, carnivores and omnivores. Organization of gastro-intestinal tract. Digestive enzymes & Gastro-intestinal hormones. Mechanisms of digestion and absorption of carbohydrates, proteins and lipids. Digestion in ruminants and non- ruminants. Gastro-intestinal motility. Gastro-intestinal disorders- Dyspepsia, Achalasia, peptic ulcer, Appendicitis, Inflammatory Bowel's disease, Crohn's disease, Hernia and Malrotation. Evolution of heart, aortic arches and portal system in vertebrates.

UNIT -III : Comparative anatomy of brain in relation to its function. Nerves - cranial, peripheral and Autonomous nervous system. Sense organs-eye, organs of olfaction and taste, Lateral line system and Electric organs. Respiratory structures -Internal and external gills, lungs and gas bladder, air sacs in birds. Evolution of lungs from amphibians to mammals. Comparative account on respiratory structures in invertebrates. Organization of respiratory system- Types of respiratory surfaces. Ventilation. Tidal volume. Dead space, Comparative study of aquatic and terrestrial respiration. Respiration in birds and insects. Diffusion of gases- Transport of O_2 and CO_2. Oxygen- Hemoglobin dissociation curve. Haldane effect. Bohr effect. Role of blood as buffer. Hemodynamics. Regulation of respiration.

UNIT-IV: Hormones – classification, secretions and storage. Hormone-receptor interactions. Mechanism of water and lipid soluble hormone action. Important endocrine glands and their hormones. Pituitary hormones and their control by the hypothalamus. Oestrous cycle and its hormonal basis. Endocrine regulation of insect metamorphosis. Insect reproductive systems- male and female reproductive systems. Type of sperms and ovarioles. Reproductive system in vertebrates. Spermiogenesis –functions of testosterone and other hormones. Pineal gland and its function. Oogenesis–hormonal regulation. Fertilization- molecular mechanisms of fertilization in mammals. Chemical, mechanical and immunological methods of controlling fertility.

UNIT-V : Excretory organs- Organs of excretion among invertebrates. Gross anatomy, development and evolution of kidneys in vertebrates. Structure of the nephron in relation to excretion and osmoregulation. Osmoregulation in aquatic, amphibious and terrestrial animals. Patterns of N_2 excretion- Urea, Uric acid, Ammonia. Physiological anatomy of kidney. Structure of nephron, Formation of urine in nephrons, Normal, Inorganic and abnormal constituents of urine. Factors affecting urine formation and control volume of urine. Regulation of renal function-hormones. Renin angiotensin-Aldosterone system (RAAS). Homeostatic regulation of kidney.

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ZOP 408: COMPARATIVE ANATOMY AND PHYSIOLOGY–LABORATORY

4 hours/week

COURSE OUTCOME :

- Students will gain proficiency in identifying and analysing adaptive modifications in insect wings and legs, understanding their functional significance in various ecological contexts.
- They will develop skills in dissecting and studying the external and internal anatomy of insects like cockroaches and mice, focusing on systems such as digestive, reproductive, and respiratory.
- They will acquire hands-on experience in preparing and staining tissue sections from various organs (e.g., liver, kidney, lungs) of mice, fish, or frogs, to examine their microscopic structures.
- They will conduct experiments to evaluate physiological parameters for enhancing their understanding of metabolic processes.
- Students will perform biochemical and applying techniques like glucose oxidase method and diacetyl -monoxime method, to understand metabolic health indicators.

Experiments:

1. Adaptive wing modifications in insects.
2. Adaptive leg modifications in insects.
3. Dissection-study of external and internal features of Cockroach.
   (a) Digestive system/Reproductive system.
   (b) Temporary mounts of cockroach-Gizzard/Trachea.
4. Histology of artery, vein, lung, kidney, liver, oesophagus, stomach, intestine, testis and ovary of mice/ fish/frog.
5. Study of embryological slides–fish/chick.
6. Dissection-study of external and internal features of mice- Demonstration.
7. Fixation of tissue and preparation of paraffin block/ paraffin slides and staining of paraffin sections.
8. Types of beaks/ feet / feathers in birds.
9. Determination of glucose by glucose-oxidase method
10. Starvation and liver glycogen levels in vertebrates.
11. Lipase activity in the intestinal content of fish.
12. Enzymatic digestion of carbohydrates and proteins.
13. Rate of oxygen consumption in fishes.
14. Detection of urea, uric acid, ammonia and creatinine in the test sample provided.
15. Evaluate lung function through spirometry and other PFTs..
16. Study of oestrous cycle by vaginal smear technique in rat/mice.

ZOS 404: TOOLS AND TECHNIQUES IN BIOLOGY
Teaching 10 hours /Unit

COURSE OUTCOME

- Students will understand key chemical and biophysical concepts, including pH, buffers, and various microscopy techniques.
- They will develop hands-on skills in culturing animal cells, bacteria, and fungi using proper sterilization and preservation methods.
- Learners will gain competence in histological and immunological procedures, including tissue staining and antibody-based techniques.
- They will be trained in using analytical and separation tools like spectrophotometry, chromatography, and electrophoresis.
- The course will equip students with knowledge of molecular biology and bioinformatics tools for analysing genes and proteins

UNIT-I: Solution and types of solutions. Concepts of acids and bases. pH and its significance. Types of buffers and role of blood as a buffer. Molarity and normality of solutions. Microscopy-Principle and applications of microscopes- Light microscopy- bright field microscope, darkfield microscope, phase contrast microscope, fluorescence microscope, UV microscope. Electron microscopy-SEM and TEM. Confocal microscopy. X-ray crystallography.

UNIT-II: Cell culture and applications. Culture of animal cell, bacteria and fungi. Sterilization methods- physical and chemical, inoculation and sub culture. Pure culture techniques and growth monitoring. Cytological staining methods for bacterial and fungal strains. Types and uses of bio-fermenters. Cryopreservation of cells, tissues, organs and organisms. Cryosurgery, Cryotomy, freeze fracture and freeze drying.

UNIT-III: Histological preparations and applications. Collection & preservation of animal tissue – fixation, embedding, sectioning and staining. Tissue preparation techniques for the light microscopy and electron microscopy. Localization of proteins and carbohydrates. Centrifugation-principle of sedimentation. Svedberg coefficient. Types and applications of centrifuge. Immunological techniques- antigenicity and immunogenicity. Generation of antibody. Production of monoclonal antibody. Immuno-precipitation and immune-diffusion.

UNIT-IV: General principle, types and applications of Spectrophotometry and Flame photometry. NMR and MASS spectroscopy. Principle, types and applications of chromatography-paper chromatography, TLC, GC, HPLC, LCMS and GCMS. Electrophoresis- PAGE and agarose gel electrophoresis. One- and two-dimensional gel electrophoresis. Isoelectric focusing.

UNIT-V: Blotting techniques- Southern, Northern, Western and Eastern blot. Principle, types and applications of PCR (RFLP, RAPD and AFLP), RT-PCR and qPCR. DNA finger printing. Fluorescent techniques- FISH and GISH. Chromosome banding techniques. Chromosome painting. Protein and DNA sequencing methods. Bioinformatics tools: sequence analysis tools- BLAST, file formats – FASTA and VCF. DNA micro array. Software and tools in biodiversity study - GPS, photography, videography and drone technology.

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ZOP 409: TOOLS AND TECHNIQUES IN BIOLOGY- LABORATORY
4 hours/week

COURSE OUTCOME:

- Students will develop skills in operating various microscopes, including bright field, dark field, phase contrast, fluorescence, UV, and electron microscopes (SEM and TEM), to study cellular and tissue structures.
- Students will gain hands-on experience in molecular biology methods such as PCR, DNA/protein sequence analysis, and electrophoresis, enabling them to analyse genetic material and proteins effectively.
- Students will learn tissue fixation, paraffin embedding, sectioning, and staining, along with chromosome banding techniques to study tissue morphology and chromosomal structures.
- They will become adept at using laboratory instruments like spectrophotometers, pH meters, and centrifuges, and will perform analyses such as buffer preparation, pH measurement, and absorption spectroscopy.
- Students will acquire skills in preparing culture media, performing paper chromatography for amino acids and sugars, and applying cryopreservation techniques for preserving biological samples.

Experiments:

1. Microscopy – Principle and applications of bright field, darkfield, phase contrast, fluorescent and UV microscopes. Electron microscopy-SEM and TEM. Confocal microscopy.
2. Micrometry – calibration of microscopes and measurements of cell dimension.
3. Buffer preparation and measurement of pH using pH meter.
4. Chromosome banding techniques (G-, C-, Q-).
5. Media preparation for different cultures (Bacterial culture, cell culture, *Drosophila* culture etc.)
6. Cryopreservation technique.
7. Localization of proteins and carbohydrates.
8. Determination of absorption spectra of coloured solutions using spectrophotometer.
9. Separation of amino acids and carbohydrates using paper chromatography.
10. Separation of DNA using agarose gel electrophoresis (Demonstration)
11. Polymerase Chain Reaction (PCR) (Demonstration)
12. DNA / proteins sequence analysis using computational tools.
13. Photography, micrography, audio-videography and submission report.

ZOS 405: APPLIED ENTOMOLOGY
Teaching 10 hours 10/Unit

COURSE OUTCOME :

- Students will gain a solid understanding of insect biology, including their structure, development, and classification.
- They will learn about insect behavior, ecology, and the role of environmental factors in insect life cycles.
- The course covers beneficial insects like pollinators and natural enemies, and their role in ecosystems and agriculture.
- Students will identify insect pests and vectors, and understand methods to manage them effectively.
- They will be introduced to various pest control techniques, including Integrated Pest Management (IPM) for sustainable insect control.

UNIT-I: Brief history of entomology and insect biodiversity. Insects' taxonomy and systematics - Morphology and anatomy of insects. Identification, purpose, methods, character matrix, taxonomic keys. Species specific variations. Polythetic and polymorphic taxa. Sexual dimorphism. Metamorphosis in insects (complete and incomplete)- Insect growth, life cycle, stages of development, nutritional requirements of insects.

UNIT-II: Insect physiology (digestion, respiration, reproduction). Insect behaviour (foraging, mating, social structure). Insect sense organs (mechano-, photo- and chemoreceptors). Insect ecology - interaction with plants, animals and the environment (phytophagy, entomophagy, haemophagy). Factors affecting abundance- environmental factors. Dispersal and migration. Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) , aestivation and hibernation.

UNIT-III: Beneficial insects in ecosystems. Biology and ecology of natural enemies and biocontrol agents (predatory insects .and Parasitoids). Pollinators. Honeybees and apiculture- Bee keeping-managing colonies for honey production and pollination. Artificial queen rearing. Pests and diseases of honey bees. Bee poisoning. Establishment and management of apiaries. Silkworm- characteristic features. Rearing and management of silkworms. Silk and its uses, pests and diseases of silkworms.

UNIT-IV: Insects as vectors of human and animal diseases. Parasitic insects. Biology and ecology of disease vectors (e.g., mosquitoes, fleas, lice, ticks). Control and management of disease vectors. Insect pests - major pest of paddy, maize, vegetables, fruits, other local commercial crops. Urban insect pests (cockroach, bedbugs). Pests of economically beneficial insects.

UNIT-V: Chemical control of insect pests. Classification, formulations and toxicity of insecticides. Importance and limitations of chemical control. Recent methods of pest control, repellents, antifeedants, hormones, attractants, and gamma radiation. Insecticides Act 1968- Important provisions. Application techniques of spray fluids. Symptoms of poisoning, first aid and antidotes. Concept of Integrated Pest Management (IPM) with emphasis on biological and pheromone tools. Practices, scope and limitations of IPM.

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ZOP 410: APPLIED ENTOMOLOGY – LABORATORY
4 hours/week

COURSE OUTCOME:

- Students will develop skills to identify, collect, and preserve insect pests affecting crops such as coconut, areca nut, paddy, and other local agricultural and horticultural plants. They will also learn to assess the damage caused by these pests and understand their ecological roles.
- Students will gain knowledge in identifying and managing major pests of stored food grains and insect vectors responsible for transmitting human diseases. This includes understanding the biology and control measures of these pests and vectors.
- They will learn to assess the toxicity of various control methods and apply field techniques to manage insect pests effectively.
- They will also conduct field surveys to collect data on insect pest populations and analyse trends using statistical methods.
- They will determine the respiratory quotient in insects and study the life cycles of economically important insects such as honey bees, silkworms, and other pests, predators, and parasitoids.
- Students will acquire hands-on experience in handling beekeeping equipment, inspecting hives, extracting honey, and processing hive products. Visits to bee nurseries and local apiculture centres will provide practical insights into bee management and honey production.

Experiments:

1. Collection, preservation and identification of coconut and areca nut insect pests.
2. Collection, preservation and identification of insect pests of paddy/local agricultural/horticultural crops.
3. Collection, preservation and identification of major pests of stored food grains.
4. Collection, preservation and identification of the major insect vectors of human diseases.
5. Study of malarial parasites and their vector.
6. Toxicity assessment - Different field methods to control the insect pest.
7. Conduct field surveys to collect data on insect pest populations, and analyse the data using statistical methods to understand trends and patterns.
8. Determination of respiratory quotient in insects.
9. Identification and handling of bee-keeping equipment. Handling of honey bees, hive and frame inspection- Honey extraction and processing methods of hive products extraction - Visit to bee nursery.
10. Rear and study the life cycle of honey bees/silkworm/economically important insects (pests, predators and parasitoids).
11. Collection, identification and understanding of stored grains/seed insect pests and nature of damage caused by them; detection of insect infestation in stored food grains. estimation of losses in stored food grains.
12. Visit to the food storage industry- submission of reports
13. Visit to CPCRI/Entomology institutes and submission of reports.

SEMESTYER - II

ZOH 451 GENETICS AND ANIMAL BREEDING
Teaching 10 hours /Unit

COURSE OUTCOME:

- Understand the principles of classical and molecular genetics, including gene structure, inheritance, mutations, and gene regulation.
- Learn about genetic linkage, recombination, and gene transfer techniques using model organisms like *Drosophila* and mice.
- Gain knowledge of animal breeding objectives, breed classification, selection methods, heritability, and genetic improvement.
- Understand various breeding methods, including inbreeding and crossbreeding, and the use of laboratory animals in research.
- Explore breeding and management practices for farm and pet animals, reproductive technologies, bioethics, and the role of bioinformatics in animal genetics

UNIT –I: Historical highlights - Development of the gene concept. Mendelian principles; Mendelian inheritance and probability. Extra chromosomal inheritance. Sex determination in drosophila and human. Molecular structure of a gene. Genetic code. Gene mutations, Transposable elements in prokaryotes and eukaryotes. DNA repair mechanism. Regulation of gene expression in prokaryotes and eukaryotes- Operon concept, attenuation and anti-termination. Giant chromosomes.

UNIT- II: Linkage- Linkage groups and types of linkage, Construction of linkage maps in drosophila. Cytological demonstration of crossing over in drosophila. Mitotic recombination. Intra genic recombination. Genetic basis of development in drosophila- genes involved in drosophila development and their functional role. Gene transfer techniques- electroporation and microinjection. Transfection of cells- principles and methods. Germ line transformation in Drosophila and transgenic mice- Strategies and methods.

UNIT- III: Objectives of animal breeding – concept of breeds, *varieties and* lines. Livestock breeding- classification of livestock breeds. Breeds and their economic important traits. Methods of selection for breeding: Selection criteria *and evaluation of breeding* animals - Selection of superior breeding stock- breeding value - performance record, reproductive efficiency, production traits and selection indices. Artificial selection, gametic selection, zygotic selection. Heritability and genetic improvements- broad and narrow - sense heritability. Selection differential, generation interval, genetic gain.

UNIT -IV: Methods of breeding – principals of inbreeding: genetic effects of inbreeding: genetic effects of inbreeding, consequences of homozygosity- advantages and disadvantages of inbreeding. Line crossing- out crossing & cross breeding, advantages and disadvantages – Hybrid vigor, advantages and disadvantages. Requirements and methods of breeding small laboratory animals (Rats and mice). Importance of laboratory animals in biomedical research. Common disease of laboratory animals and their control.

UNIT- V: Breeds and methods of breeding and management of farm animals: cattle, swine, poultry and horse. Breeds of pet animals. Diseases and their control in farm animals. Production of specific pathogen free (SPF) and Gnotobiotic animals. Artificial insemination, Super ovulation, Embryo transfer techniques. Animal cloning. Institutional Animal ethical Committee. Animal husbandry practices in India – historical and current status. Bio-informatics in animal genetics and breeding. Pharming of Pharmaceuticals. Conservation of animal genetics resources.

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ZOP 508: GENETICS AND ANIMAL BREEDING – LABORATORY
4 hours/week

COURSE OUTCOME:

1. Structure of specialized chromosome explains their significance in the expression of adult normal and mutant characters in drosophila.
2. Drosophila crossing experiments using various mutants with normal flies helps in understanding the Mendelian principles of inheritance of characters.
3. Drosophila crossing experiments are included to understand the pattern of character inheritance, where the students on their own conduct different crosses using normal and mutant flies.
4. Students will be trained to breed small laboratory animals and aquarium fish.
5. Visit to animal farm facility will help the students to gain knowledge on husbandry practices and its advantage and limitations.

Experiments:

1. Preparation of culture media and maintenance of *Drosophila.*
2. S*tudy the* l i f e cycle and morphological features of *Drosophila.*
3. Mounting of genital plate and sex comb of drosophila species.
4. Study the drosophila mutants.
5. Study of polytene chromosome of *Drosophila.*
6. Experiments to demonstrate the pattern of inheritance of characters in *Drosophila* and *Chi*-square test - To demonstrate Mendel's law of segregation.
7. Genetic problems.
8. Demonstration of mouse breeding submission of report.
9. Demonstration of fish breeding techniques- aquarium fishes' submission of reports.
10. Study the defects in eggs and their grading.
11. Judging of sheep by score card method & computation of sire index
12. Study the breeds of farm animals- Cattle, Swine, Poultry, Piggery etc.
13. Study the breeds of dogs and cats- record few breeds kept as pet animals in region.
14. Field visit to dairy, piggery and poultry farm and submission of report.

ZOH 452 : TOXICOLOGY AND FORENSIC SCIENCE
Teaching 10 hours /Unit

COURSE OUTCOMES:

- Understand the fundamentals, scope, and testing methods of toxicology, including dose-response, xenobiotic metabolism, and the impact of various toxicants on health and the environment.
- Learn toxicological testing techniques and specific organ toxicity, along with national and international safety regulations and antidote therapies.
- Gain knowledge of forensic science principles, crime scene investigation protocols, evidence handling, and the role of forensic experts in legal systems.
- Explore forensic toxicology methods, identification of biological fluids, wildlife forensics, and DNA profiling applications in criminal investigations.
- Develop skills in detecting toxic substances and analysing forensic evidence such as poisons, explosives, and trace materials, along with understanding legal procedures and expert testimony

UNIT- I: Definition, scope, and branches of toxicology. Dose-response relationships and their significance. Factors that influence the toxicity. OECD and EPA guidelines- toxicological testing protocols. General and rodent and non-rodent species, strains used in toxicity studies Identification of biomarkers for toxic exposure. Toxicity of pesticides, heavy metals, nanomaterials, microplastics and their impacts on human health and ecosystems. Mechanisms and effects of endocrine-disrupting chemicals (e.g., bisphenol a).

UNIT- II: Toxicological testing methods, -Acute, sub-acute and chronic toxicity tests, LD_{50}, LC_{50} and ED_{50} and special toxicity tests. Tissue/organ specific toxicity-hepatotoxicity, neurotoxicity, nephrotoxicity, cardio toxicity and reproductive toxicity. Ethical considerations. Indian and international regulations on chemical safety. Xenobiotic metabolism. Algal toxins, microbial toxins, animal toxins and fungal toxins. A brief account ecotoxicology, Principles and procedures of antidote therapy.

UNIT -III: History, scope, and application of forensic science. The role of forensic science in criminal investigations. Types of forensic science disciplines (forensic biology, chemistry, physics).Crime Scene Investigation-Crime scene protocols- Documentation, evidence collection, and preservation. Chain of custody, evidence handling, and legal considerations. Role of forensic investigators and expert witnesses in legal proceedings. Types of forensic evidence - Tool marks, firearms, and ballistics. Blood, semen, hair, and tissue.

UNIT- IV: Foundations of forensic toxicology. Drugs abuse, Bloodstain pattern analysis- Interpretation of blood spatter at crime scenes. Identification of biological fluids (e.g., semen, saliva). Techniques for identifying illegal wildlife trade and species protection. Techniques for extracting DNA from biological samples. Applications of DNA profiling- criminal investigations, paternity testing, and cold cases.

UNIT- V: Techniques for detecting alcohol, narcotics, and other toxic substances in biological fluids. Detection of poisons like cyanide, arsenic, and organophosphates. Notable poisoning cases. Analysis of fibres, paint, glass, and explosives. Identification of accelerants and explosives in fire investigations. Admissibility, chain of custody, and expert testimony. The role of forensic science in criminal law and legal proceedings.

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ZOP 454: TOXICOLOGY AND FORENSIC SCIENCE -LABORATORY
4 hours/week

COURSE OUT COME :

1. Students will develop skills in culturing Drosophila, studying its life cycle, identifying wild-type and mutant strains (e.g., yellow body, ebony, vestigial wings, white eye, apterous), and performing genetic crosses to demonstrate Mendelian inheritance patterns.
2. Students will gain practical knowledge in breeding laboratory animals (e.g., mice) and aquarium fish, including setting up breeding pairs, monitoring reproductive cycles, and maintaining breeding records.
3. Students will apply statistical methods, such as the Chi-square test, to analyze genetic data from Drosophila crosses, enabling them to interpret inheritance patterns and validate Mendelian laws.
4. Students will study various breeds of farm animals (cattle, swine, poultry) and companion animals (dogs, cats), including their characteristics, care requirements, and roles in agriculture and society.
5. Through field visits to dairy, piggery, and poultry farms, students will observe and report on livestock management practices, gaining insights into the operations and challenges of animal husbandry.

Experiments :

1. Detection of organophosphates by paper chromatography technique.
2. Detection of heavy metals by enzyme inhibition technique.
3. Detection of LC_{50} /LD_{50}.
4. Determination of adulteration in food/drugs/commodities/cosmetic products.
5. To separate the dyes and inks/plant pigments/body fluids/explosives by thin layer chromatography.
6. Identification of salts and metals by simple color test in case of metallic poisoning.
7. Use of breath analyzer for measuring blood alcohol concentration.
8. Forensic entomology analysis of routine practice for estimating PMI in the early and late post-mortem periods.
9. Forensic identification of class and individual characteristics of handwriting.
10. Analysis of signature forgery.
11. Recovery of data, copying and imaging
12. Tracking of IP address/Audio, video and image authentication.
13. Collection and Identification of Pollen Grains
14. Collection and identification of planktons of forensic importance
15. Field visits: The students are supposed to prepare a report of the field visits to crime scenes, police stations, FSLs, court rooms etc. and submit a specific report on the same for the evaluation**.**

ZOS 453: MOLECULAR CELL BIOLOGY AND CANCER BIOLOGY
Teaching 10 hours /Unit

COURSE OUTCOME:

- Understand the structural organization and functions of viruses, bacteria, and eukaryotic cells, including membranes, organelles, cytoskeleton, and cell signaling mechanisms.
- Learn the molecular details of DNA/RNA structure, chromatin organization, gene expression, replication, transcription, translation, and their regulation in prokaryotes and eukaryotes.
- Gain insights into the molecular mechanisms of cell cycle regulation, mitosis, meiosis, apoptosis, and the biology of cancer and ageing.
- Explore cancer biology at the molecular level, including tumor development, oncogenes, tumor suppressors, metastasis, and the tumor microenvironment.
- Examine current and emerging cancer therapies and technologies, including immunotherapy, targeted treatments, CRISPR, cancer databases, and bioinformatics tools for cancer research

UNIT- I : Structural organization of virus, bacteria and eukaryotic cell- ultra structure of animal cell. Bio-membranes: chemical composition and molecular arrangement, models of membranes (Davison– Danieli model, fluid mosaic model). Cytoskeleton-microtubules, microfilaments and their dynamics. Centrosome, cilia, flagella. Cell surface receptors, Cell adhesion molecules, Cell junctions, Membrane transport. Cell signaling- from plasma membrane to nucleus, signal transduction. DNA as a data storage medium, C-value paradox. Structure of DNA and RNA,

UNIT - II : Structural organization of nucleus -components, nuclear pore complex, export and import of proteins. Morphology and functional elements of eukaryotic chromosomes-Centromere and telomere, nuclear organizers, heterochromatin and euchromatin. Molecular organization of chromatin, nucleosome model. Replication of DNA in prokaryotes and eukaryotes. Transcription in prokaryotes and eukaryotes. RNA processing, spliceosomes, catalytic RNA. Translation in prokaryotes and eukaryotes. Effect of antibiotics on protein synthesis. Post translational modifications.

UNIT - III: Molecular mechanism of cell division cycle- cyclins and cyclin dependent kinases. Mitotic apparatus and movement of chromosomes. Mitotic poisons. Meiotic division and genetic recombination. Overview of cancer- types, classification, and cancer statistics. Causes of cancer – carcinogenic agents – physical, chemical and biological agents, environmental causes. Oncogenes, tumour suppressor genes. Apoptosis–definition, mechanism and significance. Cell cycle regulation and apoptosis in cancer. Biology of ageing.

UNIT – IV : Hallmarks of cancer- molecular and cellular perspectives. Genetic mutations and epigenetic modifications in cancer. Viral oncogenes- role of retroviruses in cancers. Cancer stem cells- concept and significance. Mechanisms of tumor invasion and metastasis. Growth characteristics of transformed cell. Angiogenesis and its regulation. Tumor microenvironment and immune evasion. Cancer metabolism- Warburg effect and beyond. Cancer biomarkers- Diagnostic and prognostic applications.

UNIT - V: Conventional cancer therapies: Surgery, chemotherapy and radiotherapy. Targeted therapies: Monoclonal antibodies, tyrosine kinase inhibitors. Immunotherapies: Immune checkpoint inhibitors and CAR-T cells. Advances in cancer research: Liquid biopsies, CRISPR in cancer research and nanotechnology. Prevention and public health strategies for cancer control. Cancer bioinformatics - Overview of the TCGA and GTEx database, the database of Genotype and Phenotype (dbGaP), GEO database, Structural variation in Cancer Genomes, Gene expression profiling interactive analysis of cancer datasets.

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6. Robert A. Weinberg., (2013): *The Biology of Cancer,* 2nd Edition, Pages: 960,Publisher: Garland Science,Place of Publication: New York, NY, USA,DOI: 10.1201/9781315735368
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8. Roger J.B. King and Mike W. Robins,.(2020); *Cancer Biology.,* 5th Edition, Pages: 360, Oxford University Press, Oxford, UK.

ZOP 455 : MOLECUALR CELL BIOLOGY AND CANCER BIOLOGY – LABORATORY
4 hours /week

COURSE OUT COME:

- Students will gain practical experience in studying cell divisions cycle .
- Students will learn to isolate DNA and RNA from rodent tissues and yeast, respectively, and perform DNA sequencing, enhancing their ability to analyse genetic material and understand gene expression.
- Students will acquire skills in inducing tumours in mice models, assessing drug efficacy, and studying systemic effects of cancer by analysing blood and serum parameters, providing insights into cancer progression and treatment evaluation.
- Students will study tumour tissues through histopathological examination of permanent slides and evaluate metastasis using lung colonization assays, gaining an understanding of cancer spread and tissue alterations.
- They will investigate apoptosis using DNA fragmentation assays and assess cell proliferation in cancer cell lines, enhancing their comprehension of cell death mechanisms and tumour growth dynamics.

Experiments :

1. Study of mitosis in *Allium cepa* (colchicine treated).
2. Preparation of mitotic chromosomes from bone marrow cells of rodents.
3. Meiosis in Grasshoppers (preparations /permanent slides)
4. Isolation of RNA from yeast.
5. Isolation of DNA from liver/spleen, thymus of rodents.
6. Reading of DNA sequence from autoradiogram
7. Methyl-pyronin staining of nucleic acids
8. Tumour induction and monitoring in mice model.
9. Assessment of drug efficacy in tumour- bearing mice.
10. Study systemic effects of cancer by analysing blood and serum parameters.
11. Grass tumour examination.
12. Histopathological examination of tumor tissue (Permanent slides)
13. Evaluation of metastasis using a Lung colonization assay/Liver.
14. To evaluate the migratory behaviour of cancer cells in vitro/ assess cell proliferation in cancer cell lines using.
15. To study apoptosis using techniques -DNA fragmentation assay (gel electrophoresis).

ZOS 454 : ENVIRONMENTAL BIOLOGY AND CHEMICAL ECOLOGY
Teaching 10 hours /Unit

COURSE OUTCOME :

- Understand ecosystem structure, types, energy flow, population dynamics, ecological succession, and climax communities.
- Learn about key biogeochemical cycles, microbial ecology, and the interaction of microbes with various environments.
- Gain insights into marine ecosystems, environmental pollution, conservation strategies, and principles of sustainable development.
- Explore chemical ecology, including communication through hormones and pheromones in animals and plants.
- Study natural bioactive compounds, their chemical structures, biological significance, and methods of chemical analysis and discovery.

UNIT–I: Ecosystems- structure, function and types of ecosystems- terrestrial, fresh water, marine and estuarine. Abiotic and biotic components, basic laws of energy flow, food chain, food web, ecological pyramids. Population ecology, population dynamics, stochastic and time lag models of population growth, population characteristics- mortality, fecundity, density, age distribution, population explosion. Ecological succession- its mechanism and type. Ecological climax. Ecotone and edge effect.

UNIT–II: Biogeochemical cycles- carbon, nitrogen and phosphorus. Community ecology-Species interactions - prey- predator interactions. Host -parasite interactions. Microbial distribution in nature, interaction within microbial communities, with man and animals, dispersal of microorganisms in different environments.

UNIT–III: Marine ecosystem – coastal ecosystem- inter-tidal ecosystem, rocky - zonation pattern - physical and biological factors, sandy shores and protected sand flats – physical and biological factors. Exclusive Economic Zones (EEZ). Environmental pollution, control and its effect on biological systems. Conservation management of natural resources. Environmental impact assessment. Sustainable development. Coastal Regulation Zone (CRZ)- coastal zone management plan and its functions

UNIT–IV: Introduction to chemical ecology. Chemical communication in biology- cell-cell and organism - organism communication. Fungus farming termites. Explosive secretory discharge of bombardier beetle (Brachinus). Foraging behavior in bees. Chemical diversity in biology. Chemical effectors- hormones and pheromones (volatile). Sex pheromone of the silk moth. Fish fear factor. Diverse chemicals (non-volatile). Sensory perception and signal transduction.

UNIT-V: Chemical analysis in biology- natural products/molecules found in nature – cholesterol, strychnine, erythromycin, alkaloids (nicotine, caffeine, cocaine, morphine), curcumin, chondroitin, capsaicin. The discovery of artemisinin (qinghaosu) and its applications. Methods used for the structural determination of the natural products. Marine conopeptide characterization.

REFERENCES :

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4. Krebs, C.J. (1972). Ecology: the Experimental Analysis of Distribution and Abundance. Harper & Row, New York.
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6. Odum, E.P. (1971) Fundamentals of ecology, W.B. Saunders, Philadelphia.
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8. Saha, T. K. (2013) Ecology and environmental biology, 1st edition, Books and Allied (P) Ltd.
9. Sharma, P. D. (2014) Ecology and environment. 12th edition, Rastogi Publication.
10. Sharma, P. D. (2013) Environmental biology and toxicology, 3rd Rev edition, Rastogi Publication.

ZOP 456: ENVIRONMENTAL BIOLOGY AND CHEMICAL ECOLOGY -LABORATORY
4 hours/week

COURSE OUTCOME :

- Students acquire practical skill in ecological and environmental assessments.
- They will gain practical experience in assessing ecological productivity.
- Study the mutualistic interactions
- The impact of pollution on aquatic animals and food chain will be analyzed
- Estimation of carbon emission and its impact on environment will be analyzed.

Experiments :

1. Construction of ecological pyramids of different ecosystems- Aquatic , terrestrial and arboreal. etc.
2. Productivity of aquatic ecosystem by plankton study.
3. Study of faunal diversity of the lentic water bodies.
4. Study of faunal diversity of mangrove ecosystem.
5. Study of habitat structure and faunal diversity of intertidal region.
6. Physico-chemical properties of polluted water and its impact on plankton diversity.
7. Estimation of carbon emission
8. Study of aphid-ant mutualistic interactions
9. Study the structure of honey bee colony and foraging behavior
10. Study the food preference by drosophila.
11. Visit to costal ecosystem and recording of human impact on costal environment and submission of report.

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ZOS 455 : DEVELOPMENTAL BIOLOGY AND CLINICAL EMBRYOLOGY
Teaching 10 hours/Unit

COURSE OUTCOME:

- Understand the cellular, molecular, and physiological processes involved in gametogenesis, fertilization, cleavage, and early embryonic development.
- Learn about germ layer differentiation, organogenesis, congenital anomalies, and key concepts of evolutionary developmental biology (Evo-Devo).
- Gain insights into embryonic body plan formation, regeneration, early development across vertebrates and invertebrates, and the evolution of multicellularity.
- Explore human reproductive anatomy, hormonal regulation, gamete maturation, and assisted reproductive technologies (ART) including IVF and embryo culture.
- Acquire knowledge on infertility diagnostics, embryo transfer techniques, and emerging technologies like AI in embryo selection and reproductive genetics.

UNIT- I : Gametogenesis and early development- physiological, chemical and molecular events during - oogenesis, spermatogenesis, fertilization and cleavage. Competence and induction- primary, secondary and abnormal inductions. Mesoderm induction in amphibians. Totipotency and nuclear transplantation experiments. Fertilization- sperm-egg interaction, acrosome reaction. Zona pellucida binding. Early embryogenesis (cleavage, blastulation, gastrulation). Signalling pathways (Wnt Pathway, BMP Pathway, FGF Pathway).

UNIT-II: Germ layer differentiation: ectoderm development- nervous system. Mesoderm development- cardiovascular, musculoskeletal, urogenital systems. Endoderm development- gastrointestinal, respiratory systems). Organogenesis- **l**imb development, craniofacial development. Evolutionary developmental **b**iology (Evo-Devo**)** (Hox Genes, Conserved genetic pathways**).** Congenital anomalies (neural tube defects, cleft lip/palate, limb malformations, chromosomal disorders).

UNIT-III: Embryonic and body plan- embryonic polarity –drosophila and amphibia. Gastrulation in amphibia and mammal. Epithelial morphogenesis- cytoskeleton components, microtubules, microfilaments and intermediate filaments. Regeneration-physiological changes during regeneration in planarians and amphibians. Life cycles and evolution of developmental pattern- Life cycle of frog and zebra fish. Developmental pattern of metazoan. Multicellularity – evolution of differentiation. Early development in vertebrates- fish, birds and mammals. Early development in invertebrates- sea urchin, snails, tunicates and nematodes.

UNIT-IV: Reproductive anatomy - male and female reproductive system. Endocrinology of reproduction. Hormonal regulation - FSH, LH, oestrogen, progesterone, testosterone. Gamete maturation- **c**apacitation, acrosome reaction. Assisted Reproductive Techniques **(**ART) -In - vitro fertilization. Intra-cytoplasmic sperm injection. Embryo culture-embryo grading, embryo selection. Cryopreservation techniques-vitrification, slow-freezing protocols**.** Preimplantation genetic testing (PGT). **E**mbryo biopsy. Chromosomal screening.

UNIT- V: Infertility diagnostics -male and female infertility evaluation. Ovarian stimulation protocols - controlled ovarian hyperstimulation and monitoring strategies. Embryo transfer techniques- fresh and frozen embryo transfer. Endometrial receptivity. Emerging technologies- artificial intelligence in embryo selection. Advances in reproductive genetics.

REFERENCES :

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4. Bruce M. Carlson (2023):*Human Embryology and Developmental Biology* (7th Edition). Elsevier.
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ZOP 457: DEVELOPMENTAL BIOLOGY AND CLINICAL EMBRYOLOGY-LABORATORY
4 hours/week

COURSE OUTCOME:

- Students will observe and analyse various developmental stages of animals
- Students will gain hands-on experience in preparing chick blastoderm mounts, conducting fertilization experiments, and observing morphogenetic movements in vitro, enhancing their practical skills in embryology.
- They will study the gross anatomy of male and female reproductive systems, perform semen analysis to assess concentration and motility, and examine sperm morphology and function tests, providing insights into reproductive physiology.
- They will learn to set up and operate instruments in andrology and embryology laboratories, including media preparation and maintenance of cultures, to support research in reproductive health and developmental biology.
- They will study regeneration processes and gene expression patterns during embryogenesis contributing to the understanding of developmental processes and abnormalities.

Experiments:

1. Observation of slides of the early development of fish, frog and chick.
2. Preparation of whole mount of chick blastoderm.
3. Fertilization of check embryos.
4. Morphogenetic movements of cells in-vitro during development of chick.
5. Observations of sections of testis and ovary of fish, frog and rat.
6. Organogenesis in chick and pig – observation of sections.
7. Demonstration of live observation of drosophila embryo.
8. Male and female reproductive system – gross anatomy demonstration
9. Semen analysis (concentration & motility)
10. Study of sperm morphology and sperm function tests.
11. Setting up of andrology laboratory -Instrumentation and media in andrology laboratory.
12. Instrumentation in embryology laboratory.
13. Study of regeneration in *Hydra.*
14. Influence of temperature and teratogens on animal development.
15. Study of embryogenesis in *Drosophila* and pattern of gene expression in embryogenesis by *in situ* hybridization technique.
16. Grading of human embryos.

ZOE 456: PUBLIC HEALTH ENTAMOLOGY
Teaching 8 hours/Unit

COURSE OUTCOME:

- Student will understand the taxonomy, classification, and collection methods of medically important insects and arthropods.
- They gain knowledge of key blood-feeding arthropods and their role as vectors of human diseases.
- They study the biology, life cycle, and epidemiology of malaria parasites and other vector-borne diseases.
- They learn fundamental epidemiological concepts, including disease patterns, causation, and emerging infections.
- They develop skills to analyse disease control strategies, modes of transmission, and research study designs in public health.

UNIT- I : Taxonomic hierarchy: Phylum, Class, Order, Family, Genus and Species. Concept of species. Infraspecific categories– sibling species, subspecies and variants within populations. Classification of Insecta. Characteristics of Orders- Diptera, Siphonaptera, Anoplura, Hemiptera, Dictyoptera. Collection and preservation techniques-mosquitoes– sand flies – fleas – lice – ticks – flies- adult collection methods - traps - larval collection methods – wet preservation – dry preservation. Mosquito taxonomic inventory.

UNIT- II: Introduction to Arthropods of public health, Salient features and distribution of arthropod vectors of human diseases – zoonotic diseases – public health nuisance. Biology of blood feeding arthropods of public health importance Life history of importance vector mosquitoes: Anopheles (*An. stephensi*, *An. culicifacies*, *An. fluviatilis*), Aedes (*Ae. aegypti*, *Ae. albopictus*), Culex (*Cx. quinquefasciatus, Cx. tritaeniorhynchus*), Mansonia (*Ma. annulifera, Ma. uniformis*), Sandflies (*Phlebotomus argentipes*), Black flies (*Simulium damnosum*).

UNIT- III: Malarial parasites- history and geographic distribution of human malaria (Global and India) – Taxonomic position of different malarial parasites. Distinguishing characters of different species of human malarial parasites. Zoonotic malarial parasites. Life cycle and host-parasite interactions. Pathogenesis and clinical manifestations. Diagnosis and control. Vector borne diseases. Indices malaria- basic reproduction rate, vectorial capacity, vector competence, inoculation rate, stability index. Human Blood Index (HBI). Parasite indices.

UNIT-IV: Introduction to epidemiology - definition -scope and applications-endemic, epidemic, pandemic, epidemic curve. Types of epidemics. Concept of disease concept of causation, epidemiologic triad. Pathogen/parasite factors- vector factors, environmental factors, cyclic and secular trend of diseases. Emerging and re-emerging vector borne diseases.

UNIT- V: Concept of disease control - elimination/eradication. Concept of disease prevention. Modes of disease transmission. Source & reservoir of infection - source and sink sites. Biological and mechanical transmission- intermediate and definite hosts. Inter-seasonal maintenance. Descriptive studies - case reports/case series. Analytical studies - ecological/cross sectional study/case control/cohort. Concept of bias - experimental study- clinical/community trials - association and causation. Criteria for judging causality. Introduction to qualitative research.

REFERENCES :

1. Annual Review of Eco, Evo & Systematics (2011). Annual Reviews Inc.
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ZOE 457: ORNAMENTAL FISH PRODUCTION AND MANAGEMENT
Teaching 8 hours/Unit

COURSE OUTCOME :

- Understand the basics of ornamental fish species, their classification, breeding methods, and their role in conservation and ecotourism.
- Learn how to set up and maintain aquariums, including tank construction, equipment use, and managing water quality and fish health.
- Gain knowledge on pond fish keeping, including pond design, species selection, and indoor rearing facilities like cement and FRP tanks.
- Understand the nutritional needs of ornamental fish, live feed culture, and advanced feeding and color enhancement techniques.
- Explore fish packing, transportation, global and Indian ornamental fish trade, regulations, and opportunities for entrepreneurship and education.

UNIT-I: Introduction ornamental fishes, definition, classification, varieties, relevance. Breeding: Brood stock development, Breeding, larval rearing, induced breeding, environmental manipulation, water quality parameters, feeding, harvesting and conditioning. Commercially important- indigenous, exotic (egg –layers and live bears) ornamental fishes. Breeding of live bearers and egg layers. Types of breeding, selective breeding and cross-breeding and hormonal induction and sex-reversal. Contribution to conservation and ecotourism.

UNIT-II: Principles of setting up and maintenance of aquaria different types fish tanks, requirements, construction, and fabrication of glass tanks, Steps of aquarium fabrication, Aquarium accessories for small and large-scale units. Aeration and filtration. Latest trends in aquarium tanks. Uses of aquarium plants, Use of test kits for regular monitoring water quality. Common diseases and parasites of freshwater and marine ornamental fish. Fish diseases and their prophylactic measures.

UNIT-III: Pond fish keeping, sitting a pond, size of ponds, equipment's, stocking of pond with plants, Pond construction fish production facilities, Permission from the competent authority, resources of water, water quality management, selection of suitable species of ornamental fishes. Construction of cement cisterns for indoor-facility, FRP Tanks, and water re-circulation facility.

UNIT-IV: Feeding and nutrition of ornamental fishes. Nutritional requirements of aquarium fish. Larval feeding. Live feed culture. Artemia culture, infusoria, Brachinus culture, development of live feed culture lab. Formulated feeds. Preparation of aquarium fish food. Colour enhancement techniques. Feeding frequency. Feeding fry, feeding of young ones, feeding of adults. Emerging technologies in breeding, nutrition, and disease management.

UNIT-V: Fish packing systems, steps to be taken while transporting, condition of fish for packing, ornamental fish trade-supply - demand situation in India. Quality control, prices, demand. Global trade of ornamental fishes, contribution of culture and capture; marketing strategies; Green certification. Indian laws, and export-import regulations. Role of ornamental fisheries in aquaponics, education, and public awareness programs and entrepreneurship.

REFERENCES:

1. Andrews, C., Exell, A., & Carrington, N. (1988**).** The manual of fish health. Tetra Press. ISBN: 978-3923880082.
2. **A**xelrod, H.R. (2001). Encyclopaedia of exotic tropical fishes for freshwater aquariums. T.F.H. Publications. ISBN: 978-1890087986.
3. C.D. Wester 2015: Nutrient requirements and feeding of finishes for aquaculture
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SEMESTER - III

ZOH 501: ANIMAL CELL BIOTECHNOLOGY
Teaching 10 hours/Unit

COURSE OUTCOME:

- Students will understand the principles, history, and applications of animal tissue culture techniques.
- They will gain practical knowledge of cell isolation, culture maintenance, and contamination control.
- Learners will explore the use of stem cells and hybridoma technology in medical and pharmaceutical research.
- They will be introduced to genetic engineering tools and methods, including cloning and gene transfer techniques.
- Students will understand the ethical, legal, and biosafety issues related to genetic modification and biotechnology.

UNIT - I : Introduction, historical perspective, advantages and limitations of animal tissue culture. Major differences in vivo and in vitro methods. Types of tissue culture. Biology of cultured cells – culture environment, cell adhesion, cell proliferation, differentiation, initiation of culture, cell senescence. Design and layout of laboratory, - construction, sterile handling area, incubation room, service bench, Preparation, wash up, maintenance of sterile condition. Equipment's – Essential, beneficial and useful equipment's, consumable items. Culture medium- physico-chemical properties, complete media, serum, serum free media, balanced salt solutions, selection of medium and serum. Preparation and sterilization – Apparatus, Reagents and media, storage, Contamination- source and types of contamination.

UNIT- II : Primary culture- types of primary culture, Isolation of tissues – mouse and chick embryos, human biopsy material, explant culture, primary cell culture, disaggregation- enzymatic, mechanical. Suspension culture. Cell lines: Definition, Evolution of cell lines, continuous cell lines, cell line designation, maintenance, subculture, maintenance records. Cell line banking, cryopreservation, cell viability assays. Culture of tumor cells, application in cancer research, Lymphocyte culture technique and its applications.

UNIT- III: Culture and maintenance of human and mouse embryonic stem cells. Stem cells in gene therapies, stem cell-based therapies for autoimmune diseases. Hybridoma technology – Cell hybrids, Production and Application of Monoclonal antibodies. Use of animal cells as replacement for whole animal in toxicity testing. Commercial application of animal tissue culture – Uses of animal cells in vaccine production. Cell cultures in the production of medicinally important compounds –pharmaceuticals, enzymes, hormones etc.

UNIT-IV: Genetic engineering- general introduction and concept. Transduction and transfection. cDNA. Recombinant DNA techniques, Restriction enzymes, Salient features of cloning vectors. Different types of cloning vectors- plasmids, cosmids, phagemids, shuttle vectors, viral vector. Outline of gene cloning, gene cloning procedures, C-DNA cloning, Gene libraries, Chromosome walking and jumping, Recombinant selection and screening – genetic methods, immunochemical methods, South-western screening, nucleic acid hybridization, product recovery. Application of recombinant DNA technique in medicine and industry. Use of genetically engineered microorganisms in the environment. Genetic engineering approach to detoxification.

UNIT -V: Methods to introduce genes into animal cells- electroporation, viral vectors, retroviruses, lipofection, calcium phosphate co-precipitation. Transgenic animals- transferring genes into animal oocytes, eggs and embryos. Uses of transgenic technology in research. Knockout mice. Production of human disease equivalents in the mouse. Novel therapies for human diseases. Transgenic technology in the improvement of farm animals. Transgenesis in animal cloning. Genetically modified (GM) plants and animals. Regulation of genetic engineering – biosafety regulations. Risk versus benefits. Ethics involved in animal cloning and stem cell research. Ethics of xenotransplantation. Intellectual property rights, Patenting of living organisms, Ethical issues.

REFERENCES :

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2. Cartwright T(1994) Animal cells as bioreactors, Vol.VI, CU Publishers, Cambridge.
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ZOP 508: ANIMAL CELL BIOTECHNOLOGY- LABORATORY
4 hours/week

COURSE OUTCOME :

- Students will learn to establish primary and secondary cultures from various tissues, including chick embryos and mouse organs, and maintain them under sterile conditions.
- Students will acquire skills in assessing cell viability using the trypan blue dye exclusion test and evaluate cell proliferation through assays such as the MTT assay.
- Students will practice isolating peripheral blood mononuclear cells (PBMCs) using density gradient centrifugation and culture mouse macrophages and lymphocytes.
- They will be introduced to molecular techniques including restriction enzyme digestion of λ DNA and Western blotting for protein analysis.
- Students will understand the general requirements for an animal tissue culture laboratory, including cleaning, sterilization methods, and handling contamination to maintain aseptic conditions.
- These outcomes ensure that students are well-equipped with the practical skills and theoretical knowledge necessary for advanced studies and professional work in animal tissue culture and related fields.

Experiments :

1. Introduction to general requirements of animal tissue culture laboratory.
2. Cleaning, washing, preparation and sterilization methods for tissue culture work.
3. Contamination of cultures
4. Preparation of media, serum, BSS, PBS, trypsin etc.,
5. Trypan blue dye exclusion test for cell viability
6. Growth and maintenance of tumour cell lines.
7. Cell proliferation test using MTT assay
8. Separation of peripheral blood mononuclear cells (PBMCs) - Histopaque method.
9. Mouse macrophage and lymphocyte culture
10. Primary explant culture of mouse pup/adult/ chick embryo organs
11. Mouse bone marrow/hemopoietic cell cultures
12. Study of restriction sites in λ DNA – Demonstration
13. Western blot technique -Demonstration.

ZOH 502 : AQUATIC BIOLOGY AND FISHERIES
Teaching 10 hours/ Unit

COURSE OUTCOME :

- Students will understand the classification and physical-chemical characteristics of various aquatic ecosystems and their biogeochemical cycles.
- They will learn about plankton dynamics, benthic communities, and their role in aquatic food webs and productivity.
- Learners will study fish biology, behavior, reproduction, and global fisheries management principles.
- They will gain practical knowledge of aquaculture techniques, fish diseases, and fisheries technology relevant to India.
- Students will understand aquatic pollution types, their environmental impacts, and methods for pollution control and habitat conservation

UNIT - I: Classification of aquatic ecosystems- Lentic, lotic, estuarine, and marine systems. Light, temperature, pH, dissolved oxygen, salinity, and nutrients. Hydrological cycle and its role in shaping aquatic habitats. Biogeochemical cycles- carbon, nitrogen, and phosphorus cycles in aquatic systems. Seaweeds and sea grasses. Management and conservation of aquatic habitats. Management of lakes - eutrophication, control of nutrient and macrophyte biomass. Methods of water analysis.

UNIT- II: Planktons - classification, distribution and migration, phyton and zooplankton. Methods of collection of plankton and estimation of primary, secondary and tertiary productivity. Factors affecting productivity. Regional differences and seasonal variations. Phytoplankton and zooplankton inter-relations. Benthos- animal communities in lakes, streams and reservoirs. Biological zonation.

UNIT- III: Morphology, physiology, and behavior of commercially important fish species. Classification of fishes. Food and feeding habits. Methods for determining fish age, growth, and mortality. Length-weight relationships. Reproduction, spawning behavior and fecundity. Global fishery zones and their productivity. Trends in marine capture fisheries and aquaculture production. Code of conduct for responsible fisheries.

UNIT-IV: Aquaculture practices in India. Freshwater carps and lacustrine fish culture. Advances in mariculture and hatchery techniques. Setting up and maintenance of an aquarium. Hybridization and cryopreservation. Fish and shell fish diseases, prophylaxis and therapy. Fishery technology and fishery economics .Fishing gears and crafts. Fishing industry in India (including preservation and processing). Fishery research Institutes in India. Economic importance and nutritional value of fishes. Marine nutraceuticals. Biofloc technology and RAS.

UNIT- V: Major pollutants, sources, dynamics, transport paths and agents. Sewage, industrial and agricultural discharges, composition, disposal systems. Nutrients- detergents, heavy metals and pesticides composition and fate in the marine environment, biological concern, and toxicity and treatment methods. Thermal pollution: thermal stratification, effects of thermal pollution and management of heat. Radioactive pollution. Oil pollution - biological effects biodegradation, bio monitoring, bacterial pollution and seafood poisoning. Micro plastics- sources, distribution and impact.

REFERENCES:

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ZOP 509: AQUATIC BIOLOGY AND FISHERIES- LABORATORY
Teaching 4 hours /week

COURSE OUTCOME:

- Students will learn to assess the physicochemical parameters of aquatic environments, including turbidity, dissolved oxygen, pH, hardness, and biological oxygen demand, using standard laboratory techniques.
- They will identify and analyze various aquatic species, such as planktons, macrophytes, benthos, and commercially important fishes, and study their morphometric and meristic traits.
- Students will examine fish scales for age determination and study the food and feeding habits, gonadosomatic index, and fecundity of commercially important fishes.
- They will gain practical experience in induced breeding methods, preparation of artificial and live feeds, and the use of hydrological equipment like Secchi discs and plankton nets.
- Students will conduct field surveys to collect data on aquatic fauna and visit aquaculture farms and processing industries to analyse and report on industry practices.

Experiments :

1. Measurement of physicochemical parameters aquatic samples.
2. Qualitative and quantitative analyses of planktons.
3. Identification of key aquatic species (e.g., macrophytes, fishes, and benthos).
4. Study the morphometric and meristic traits in fishes.
5. Examination of fish scales for age determination.
6. Study the food and feeding habits/ GSI /Fecundity **of** commercially important fishes.
7. Demonstration of hormone injection methods for induced breeding.
8. Observation of gametes and embryonic stages under a microscope.
9. Preparation of artificial feed/live feed.
10. Identification of parasites of common fishes.
11. Collection and analysis of water/fish samples for microplastics.
12. Quantitative and qualitative study of the fauna of rocky, sandy and muddy shores.
13. Identification of fishing gears and fish byproducts.
14. Use of hydrological equipment's-- Sacchi disc. Ekman's grab, Water sampling bottle. Plankton net, Sedgwick rafter counting cell etc.
15. Visit the aqua farming and processing /marketing industries and submit the report.

ZOS 503: HUMAN GENETICS AND DISEASES
Teaching 10 hours/Unit

COURSE OUTCOME:

- Students will understand human chromosome structure, inheritance patterns, and the basics of human karyotyping.
- They will learn principles of population genetics, including Hardy-Weinberg equilibrium and genetic polymorphisms in humans.
- Learners will study chromosomal and single-gene disorders, their causes, and examples of human genetic diseases.
- They will explore complex genetic phenomena like genomic imprinting, dynamic mutations, and genetic instability linked to diseases and cancer.
- Students will gain knowledge of genetic counseling, diagnostic screening methods, gene therapy, and associated ethical considerations.

UNIT- I: Human chromosomes- historical account on understanding human chromosomes. Human lymphocyte culture and chromosome analysis. Human karyotype and International System for Human Chromosome Nomenclature (ISCN). Sex-influenced and Sex-limited genes and traits. Mendelian inheritance in humans- simple autosomal inheritance (Dominant and Recessive), Sex linked inheritance (X and Y linked). Polygenic traits inheritance. Penetrance and expressivity. Multiple alleles- genetics of human blood group inheritance. Pedigree analysis . Human genome project.

UNIT-II : Mendelian population and scope of population genetics- gene and genotype frequencies. Twins in genetic studies. Mating equilibrium, random and non-random matin. Hardy-Weinberg principle- extension of Hardy Weinberg principle to multiple alleles. Factors influencing H-W equilibrium. Inbreeding- endogamy, consanguineous marriage. Inbreeding coefficient. Types of genetic polymorphisms with examples. Human races – a genetics and evolutionary perspective. Application of population genetics in human races and ethnic group.

UNIT-III: Human chromosomal anomalies- Structural chromosomal abnormalities- causes and types of abnormalities. Genetic disorders caused by structural chromosomal abnormalities- Martin-Bell syndrome, DiGeorge syndrome, Cry-du-chat syndrome, Retinoblastoma. Genetic disorders caused by a single gene- Tay-Sachs disease, Marfan syndrome, Thalassaemia, haemophilia, Cystic fibrosis, Muscular dystrophy. Numerical chromosomal abnormalities- non-disjunctions & aneuploidy. Genetic disorders caused by aneuploidy - Down’s syndrome, Patau syndrome, Edward syndrome, Klinefelter syndrome, Turner syndrome.

UNIT-IV: Genome imprinting and pattern of disease inheritance- Prader William and Angelman Syndrome, Beckwith Wiedeman Syndrome. Dynamic mutations, Triplet repeat expansion and disorders. Genomic instability and human diseases- Progeroid syndromes. Chromosome breakage syndromes. Ataxia telangiectasia, Xeroderma pigmentosa, Fanconi anaemia and Bloom syndrome. Cancers caused by genetic changes. Hereditary cancer syndromes. Genetic tests for hereditary cancer syndromes. Identification of genetic changes in the development of cancer.

UNIT - V: Genetic counselling and genetic screening test for disease diagnosis- pre-natal diagnosis- Amniocentesis, Chorionic villus sampling, Cordocentesis (PUBS). Neonatal screening and adult screening. Biopsy. Ultra sound, fetoscopy, maternal serum screening, carrier screening. Blood pressure test, Blood screening - Cholesterol measurement, Urine analysis, Faecal occult blood test, Colonoscopy, Liver function test, Pulmonary tests. Diabetes test, Prostate specific antigen (PSA), Pap test, mammography. Dermatoglyphics. Gene therapy- somatic and germ line gene therapy. DNA drugs and vaccines. Biosafety and ethical considerations

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ZOP 510: HUMAN GENETICS AND DISEASES -LABORATORY
4 hours/week

COURSE OUTCOME:

- Students will acquire skills in performing ABO and Rh blood grouping, preparing Barr bodies from buccal smear cells, and analyzing human karyotypes to understand chromosomal variations and inheritance patterns.
- Students will learn to isolate genomic DNA from various tissues, culture human lymphocytes, and apply molecular techniques like PCR and RFLP analysis to study genetic variations and mutations.
- Students will investigate Mendelian and non-Mendelian inheritance patterns, calculate genotype frequencies using Hardy-Weinberg equilibrium, and assess the genetic basis of diseases through pedigree analysis.
- They will utilize bioinformatics tools such as BLAST and FASTA to analyse nucleotide and protein sequences, and interpret data from genome-wide association studies (GWAS) to identify disease-associated variants.
- They will develop proficiency in laboratory techniques including DNA extraction, gel electrophoresis, lymphocyte culture, and DNA damage assessment using comet assays, preparing them for advanced research in genetics and molecular biology.
- These outcomes ensure that students are well-equipped with the practical skills and theoretical knowledge necessary for advanced studies and professional work in human genetics and molecular biology.

Experiments:

1. Demonstration and preparation of ABO blood grouping & Rh- groups
2. Study of human blood group genetics and estimation of allelic frequencies- pedigree analysis from different families.
3. Preparation of Barr body from buccal smear cells.
4. Demonstration of human blood lymphocyte culture.
5. Demonstration and preparation of human normal & abnormal karyotypes (male / female).
6. Study the dermatoglyphic (palmar & finger print) patterns of the families.
7. Primer design, identification of enzymes for RFLP analysis using NEB cutter software, Gene fragment amplification using PCR and agarose gel electrophoresis technique. Determination of Alu marker.
8. Demonstration and preparation of DNA damage comet assay using Single cell Gel electrophoresis.
9. Determine the frequency of phenotypic traits.
10. Calculate genotype frequencies for genetic diseases using the Hardy-Weinberg equation.
11. Computer simulation of the inheritance patterns of genetic disorders.

12. Use online databases (e.g., dbSNP, ClinVar) to search for specific genetic variants associated with diseases.
13. Assess the risk of genetic disorders based on inheritance patterns.
14. Genotype phenotype association using Odds ratio.
15. Virtual PCR simulation to study Polymerase Chain Reaction.
16. Interpreting the GWAS(Genome wide association study)- Manhattan plot .
17. Survey exercise to study the genetic basis of drug response related to medications.

ZOS 504 : BIOSTATISTICS, BIOINFORMATICS AND COMPUTATIONAL BIOLOGY
Teaching 10 hours/Unit

COURSE OUTCOMES:

- Students will understand fundamental statistical concepts and experimental design used in biological research.
- They will learn about bioinformatics databases, sequence analysis tools, and the basics of molecular biology data.
- They will gain programming skills in languages like Python and R to manipulate and analyse biological data.
- They will study genome sequencing technologies and methods for genomic data analysis related to phylogeny and disease genetics.
- Students will be introduced to machine learning techniques for biological data and understand their applications and ethical considerations

UNIT- I: Fundamentals of statistics and experimental design in biological research. - Descriptive and inferential statistics – Measures of central tendency and measures of dispersion – standard deviation. Probability and probability distributions. Correlation & Regression analysis. Hypothesis testing. Chi-square test, t-tests, test of significance and level of significance. Degree of freedom and confidence intervals. Analysis of variance (ANOVA). Statistical software tools (R, SPSS).

UNIT- II : Overview of bioinformatics, its importance in modern biology, and key areas such as genomics, proteomics, and metabolomics. Biological databases and data types: metadata, and data formats (FASTA, PLINK, VCF etc.) - Sequence alignment - BLAST and other search tools GenBank, UniProt - Introduction to molecular biology.

UNIT- III: Introduction to programming languages commonly used in bioinformatics (linux, Python, R).- Basic programming concepts: Basic syntax, control structures (loops, conditionals), and functions. - Data structures: Lists, arrays, dictionaries, data frames. Algorithms: Sorting and searching algorithms- Data manipulation and visualization - Writing scripts (bash, perl, awk etc.) for biological data analysis.

UNIT- IV: Genome sequencing technologies: Sanger sequencing, NGS platforms (Illumina, PacBio, Oxford Nanopore) Trimming, filtering, and assessing read quality with tools like FastQC. Alignment techniques (BWA, Bowtie), variant calling (GATK). Genomic data analysis for molecular phylogeny, population and disease genetics. SNPs, variants, and disease association studies.

UNIT- V: Machine learning (ML)/Artificial Intelligence (AI) for biological data- Introduction to machine learning concepts. Supervised vs unsupervised learning. Examples of classification algorithms (e.g., logistic regression, support vector machines) and clustering (e.g., k-means, hierarchical). Importance of ML in bioinformatics, and the difference between ML and traditional statistics. Applications of machine learning in biology (e.g., classification, clustering). Evaluation metrics: Precision, recall, F1 score, ROC curves for model assessment. Ethical considerations and policies related to bioinformatics research and data usage.

REFERENCES:

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ZOP 511: BIOSTATISTICS, BIOINFORMATICS AND COMPUTATIONAL BIOLOGY-LABORATORY

4 hours/week

COURSE OUTCOMES:

- Students will acquire skills in performing ABO and Rh blood grouping, preparing Barr bodies from buccal smear cells, and analyzing human karyotypes to understand chromosomal variations and inheritance patterns.
- They will learn to isolate genomic DNA from various tissues, culture human lymphocytes, and apply molecular techniques like PCR and RFLP analysis to study genetic variations and mutations.
- Students will investigate Mendelian and non-Mendelian inheritance patterns, calculate genotype frequencies using Hardy-Weinberg equilibrium, and assess the genetic basis of diseases through pedigree analysis.
- They will utilize bioinformatics tools such as BLAST and FASTA to analyze nucleotide and protein sequences, and interpret data from genome-wide association studies (GWAS) to identify disease-associated variants.
- Students will develop proficiency in laboratory techniques including DNA extraction, gel electrophoresis, lymphocyte culture, and DNA damage assessment using comet assays, preparing them for advanced research in genetics and molecular biology.
- These outcomes ensure that students are well-equipped with the practical skills and theoretical knowledge necessary for advanced studies and professional work in human genetics and molecular biology.

Experiments:

1. Measures of central tendency and measures of dispersion – problem solving
2. Probability and probability distributions – problem solving and representation of data.
3. Chi-square test and t-test - problem solving.
4. Data/file handling in linux
5. Preparation of DNA sequence data using linux
6. Multiple sequence alignment using UI based software
7. Multiple sequence alignment using command line software
8. Perform molecular phylogenetic analysis using mitochondrial genomes
9. Visualizing the data using ggplot2 package in R
10. Visualizing the data using matplotlib in Python
11. Handling of SNP array data using plink
12. Plotting Fst based heatmap in R
13. Perform PCA using plink
14. Perform linear regression using biological data
15. Creating a map of sampling locations and frequency data using QGIS.

ZOS 505 - WILDLIFE CONSERVATION AND MANAGEMENT
Teaching 10 hours /Unit

COURSE OUTCOME :

- Students will understand the different levels and types of biodiversity and methods for its assessment and monitoring.
- They will learn about India's ecological zones, biodiversity hotspots, and major biomes with their unique flora and fauna.
- Learners will study species interactions, population analysis techniques, and modern tools like GPS and GIS used in wildlife research.
- They will identify major threats to biodiversity, conservation strategies including in-situ and ex-situ methods, and the role of protected areas.
- Students will gain knowledge of national and international biodiversity laws, conventions, and important conservation projects in India

UNIT-I: Biodiversity concepts- ecosystem diversity, genetic diversity, species diversity. Biodiversity from ecological, taxonomical and evolutionary prospective (Alpha, Beta and Gamma diversity). Biodiversity assessment- Inventorying and monitoring biodiversity- sources of information, data collection and management. WCMC and IGCMC. Taxon data sheet. Biodiversity indices.

UNIT-II : Ecological subdivisions of India. Biodiversity hotspots. Biome essays- ecology and biodiversity of Tropical and Temperate forests, Tundra forests, Boreal forests, Caves and Mountains, Coastal ecosystems, Mangroves and Estuaries, Coral reefs, Lakes and Rivers. Unique Indian animals- diversity and distribution.

UNIT-III: Endemic species. Species interaction and Keystone species. Concept of niche, home range and territory. Population analysis- territory mapping. Capturing and marking techniques- capture-recapture method, entrapment, darting, tagging and banding., line transects, pellet count, pug mark, call track count. Radio telemetry. GPS, GIS, Still and Video photography techniques in wildlife studies.

UNIT-IV : Threats to biodiversity- habitat destruction, climate change, exotic species introduction, over exploitation. Wildlife diseases and their control. Species extinction- Extinction vertex. IUCN Red list criterions and categories. Biodiversity conservation- Prioritizing choices in conservation. In-situ conservation methods- National parks and Sanctuaries of India. Ex-situ conservation methods- captive breeding program- role of Zoos and Botanical gardens. Gene bank/ seed bank. Role of museums in the conservation of biological diversity.

UNIT-V: Legal aspects- Earth summit and Ramsar convention. National and International conventions- Convention on Biological diversity (CBD)-1992. CITES, TRAFFIC. Indian biodiversity laws. Wildlife laws- Wildlife (Protection) Act-1972. Biological Diversity Act-2002. Special projects- Project Tiger, Gir Lion project, Project Elephant, Crocodile breeding project. Project Great Indian Bustard, Project Dolphin. Important dates of celebrations on biodiversity and its conservation at national and international level.

REFERENCES :

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ZOP 512: WILDLIFE CONSERVATION AND MANAGEMENT - LABORATORY
4 hours/week

COURSE OUTCOME:

- Students will be trained in the collection, preservation and identification of important groups of regional fauna.
- The data on diversity, richness, population structure of animal groups in the study area will be assessed using appropriate methods and documentation will be done. This will help the students to know the current conservation status of the species and in the implementation of possible step in saving the regionally threatened species.
- The data the ecological role of the species by studying their feeding behavior will help in understanding their interaction in the sustainable manner.
- Bird species identification will be done indirectly by using audio-visual methods, so that the animal s is not disturbed in their natural habitat.
- The students will be trained by using the appropriate statistical methods to know the diversity and abundance of species
- Various ecosystems will be visited to understand the nature, distribution, ecological functions of species. Threats to species and the possible conservation strategies adopted, their impact will be studied.
- These outcomes ensure that students are equipped with practical skills and theoretical knowledge necessary for advanced studies and professional work in habitat ecology and biodiversity conservation.

Experiments:

1. Aquatic habitat- water quality analysis- salinity, EC, pH, Temp. etc
2. Terrestrial habitat- Soil faunal diversity analysis.
3. GPS and GIS – Land Use Land Cover (LULC) study.
4. Identification of bird species by audio- visual methods.
5. Study the nesting activity in birds, spiders, ants and wasps -submission of report.
6. Identification of frogs using their calls.
7. Pitfall trap, beat sheet, sweep nets methods of faunal collection- submission of report.
8. Study the paw prints (Pet dogs and cats), hoof mark (Horse /Deer's/ Cattle) and Pug mark - submission of report.
9. Photographic and videographic techniques in biodiversity study- Demonstration
10. Population estimation techniques - Line transect, Quadrate and Biomass analysis.
11. Preparation of 'Taxon Data Sheet' any one local invertebrate & vertebrate species.
12. Food habit analysis of insectivorous animals- Lizards / Bats etc.
13. Biodiversity indices- calculation and interpretation. - Simpson's index ii) Evenness iii) Morishita Horn.
14. Recording of bird's species of the campus during an annual "***Campus Bird Counts***" – submission of checklist and a report.
15. Visit to observe and record types of ecosystems and associated flora and fauna (Protected and unprotected areas, biological parks etc.).

ZOE 506: INFECTIOUS DISEASES AND MANAGEMENT
Teaching 3 hours/week

COURSE OUTCOMES:

- Understand the types, transmission, and control principles of infectious diseases, along with hygiene, sterilization, and public health practices.
- Learn about bacterial and viral infections, mechanisms of antibiotic and antiviral action, and resistance development.
- Gain knowledge of fungal, protozoan, and helminthic infections, including treatment strategies and the role of disease vectors.
- Explore host immune responses, hospital-acquired infections, outbreak investigations, and bioterrorism threats.
- Study infectious diseases in vulnerable populations, vaccine development, and the challenges of emerging and re-emerging infections.

UNIT - I: Infectious Diseases and its prevalence, Historical perspectives, Disease transmission - Water borne, Food borne and Air borne diseases. Hand hygiene and personal protective equipment's. Sterilisation and disinfection. Principles of infection control. Epidemiology and public health.

UNIT - II: Gram-positive bacterial infections (e.g., *Staphylococcus, Streptococcus*), Gram-negative bacterial infections (e.g., *Escherichia, Klebsiella*). Tuberculosis and other mycobacterial infections, Mechanism of antibiotics and antibiotic resistance. RNA viruses (e.g., HIV, SARS COV2). DNA viruses (e.g., herpes simplex). Viral haemorrhagic fevers (e.g., Ebola). Antiviral therapy and resistance.

UNIT- III: Fungal infections (e.g., Candidiasis). Parasitic infections - Protozoan (e.g., malaria, toxoplasmosis). Helminthic infections (eg. Ascariasis). Antifungal and antiparasitic therapy. Morphology, life history and medical importance of disease transmitting vectors.

UNIT- IV: Infectious diseases and host defence. Hospital-acquired infections and prevention strategies. Infection control in outpatient settings. case studies- disease outbreaks, investigation and management. Types of outbreaks (sporadic, endemic, epidemic, pandemic), Bioterrorism (e.g., anthrax)

UNIT -V: Infectious diseases in immunocompromised patients. Paediatric infectious diseases. Infectious diseases in pregnancy and childbirth. Emerging and re-emerging infectious diseases. Immunisation. Vaccine development and its types.

REFERENCES :

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ZOE 507: WASTE MANAGEMENT AND VERMITECHNOLOGY

Teaching 3 hours /week

COURSE OUTCOME :

- Understand the types, sources, and characteristics of solid and liquid waste, along with current waste management practices and challenges in India and globally.
- Learn about waste collection, transportation, and disposal methods such as landfilling, incineration, composting, and recycling, including their advantages and limitations.
- Explore waste processing techniques, waste minimization strategies (3Rs), and planning and implementation of effective recycling programs.
- Gain knowledge of vermitechnology, including earthworm biology, vermicomposting methods, and the use of vermicompost in agriculture and land restoration.
- Understand the role of earthworms and microbes in waste decomposition, vermifiltration for wastewater treatment, and the policies, marketing, and financial support related to organic waste management

UNIT- I: Objectives and scope of the waste management. Types of solid waste: municipal solid waste, agricultural waste, biomedical waste, and industrial waste. Waste generation, sampling and analysis- waste characteristics: Physical & Chemical characteristics. Liquid waste – types & source. Solid waste management practices in India and elsewhere-Municipal solid waste management. e-waste- its management in India and abroad. Waste management- current status, challenges and solutions- Integrated waste management.

UNIT -II: Waste collection, storage and transport- collection components, storage-containers/collection vehicles, collection operation, transfer station, waste collection system design, record keeping, control, inventory and monitoring, implementing collection and transfer system. Waste management strategies- Various techniques, applications, uses and their drawbacks- land fill, incineration, recycling, composting, source reduction, anaerobic digestion. etc.

UNIT -III: Waste processing techniques- waste minimization- reduce, recycle, reuse sources. -purpose of processing. Mechanical volume and size reduction. Component separation. Drying and dewatering. Source reduction, product recovery and recycling- basics, purpose, implementation monitoring and evaluation of source reduction. Significance of recycling. Planning of a recycling program and recycling program elements. Commonly recycled materials and processes. Marketing recycled products and limitations.

UNIT-IV: Introduction to vermitechnology. General characters of earthworms. The habitat, diversity and distribution of earthworms. Earthworm as farmer's friend- role of earthworms in soil fertility and waste management. Selection of earthworm species for vermitechnology. Methods of vermicomposting. Factors affecting $-P^H$, moisture, temperature. Chemical fertilizers and vermicompost – advantages and disadvantages. Earthworms' bioreactors. Worm casts, vermi-wash production and its applications. Nutritional status of vermicompost. Use of vermicompost for crop production, in land improvement and reclamation.

UNIT- V: Earthworms and microorganisms-role of intestinal microbes of earthworms on the decomposition of organic wastes. Vermi-filtration for waste water treatment -Vermifilter. By-products of Vermi-filtration. Influence of chemical inputs on earthworm activity. Pest & parasites affecting earthworms and their control. Packaging and marketing of vermicompost products. Financial support by governments and NGOs for vermitechnology – Various schemes for organic farming. Policy and guidelines on waste management in India.

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SEMESTER - IV

ZOH 551- IMMUNOLOGY
Teaching 10 hours /Unit

COURSE OUTCOME:

- Students will understand the organization and function of the immune system, including innate and adaptive immunity.
- They will learn about antigen properties, MHC molecules, and antigen processing and presentation pathways.
- Learners will study antibody structure, B-cell development, activation, and the generation of antibody diversity.
- They will explore T-cell development, activation, immune responses, and regulatory mechanisms.
- Students will gain knowledge about immune tolerance, autoimmune diseases, infectious disease immunity, vaccines, and transplantation immunology.

UNIT - I : Historical perspectives and important concepts of immune system. Cells of immune system. Primary, secondary, and tertiary lymphoid organs. Components of innate immunity. Interactions between innate and adaptive immunity systems. Major pathways of complement activation. Diverse functions. Regulation of complement activation. Complement deficiencies and microbial evasion strategies.

UNIT-II : Antigens and Immunogens. Immunogens and immunogenicity. Properties of immunogens. Epitopes and their characteristic properties. Adjuvants and haptens. Structure and function of MHC molecules. General organization and inheritance of the MHC. Role of MHC and expression patterns. Immune responsiveness. MHC alleles and susceptibility to diseases. Endogenous and exogenous pathway of antigen processing. Presentation of antigens. Cross presentation of exogenous antigens. Presentation of nonpeptide antigens.

UNIT-III: Structure of antibodies. Antibody binding site. Antibody mediated effector functions. Antibody classes and biological activities. Antigenic determinants on antibodies. B-Cell receptor. Immunoglobulin super family and monoclonal antibodies. Abzymes . B–Cell development in bone marrow. Development of B-1 and marginal- zone B cells. B cell activation, differentiation and memory generation. Mechanism of generation of antibody diversity. Receptor ligand interactions. Common strategies used in many signalling pathways. Signal transduction in B cells.

UNIT-IV: Early thymocyte (T cell) development. T-cell activation, differentiation and memory generation. T-cell receptor and co-receptor complex. Accessory molecules and signalling. Cell mediated effector responses. Experimental assessment of cell–mediated cytotoxicity. T-cell responses to tumours. Regulatory T-cell responses and memory.

UNIT- V: Establishment and maintenance of tolerance. Immunosuppression and its induction. Autoimmune diseases. Factors responsible for induction. Mechanisms of induction and treatment. Infectious diseases- bacterial, viral, protozoan and fungal infections. Evasive mechanisms developed by microbes. Vaccines- active and passive immunization. Vaccine strategies. Types of vaccines, advantages and challenges. Types of transplants. Graft rejection. Tissue typing. Immune tolerance to allografts. Clinical transplantations. Hypersensitivity-types of reactions and allergy.

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ZOP 556: IMMUNOLOGY - LABORATORY
4 hours/week

COURSE OUTCOME :

- Students will identify and understand the roles of various immune cells (e.g., B cells, T cells, macrophages) and organs (e.g., thymus, spleen, lymph nodes) in immune responses.
- Students will perform and interpret various immunological assays, including agglutination and precipitation reactions, to detect and quantify antigens and antibodies.
- Students will conduct immunoelectrophoresis, rocket immunoelectrophoresis, and counter current immunoelectrophoresis to analyse antigen-antibody interactions and protein profiles.
- Students will prepare antisera, precipitate immunoglobulins using ammonium sulfate, and isolate and purify immunoglobulin G to understand antibody purification methods.
- Students will perform standard and dot ELISA to detect specific antigens or antibodies, gaining practical experience in immunoassay techniques.
- These outcomes ensure that students acquire both theoretical knowledge and practical skills in immunology, preparing them for advanced research and applications in the field.

Experiments:

1. Study the cells of immune system.
2. Study the organs of immune system.
3. Study the agglutination reactions.
4. Study the precipitation reactions
5. Quantitative precipitation assay.
6. Immunoelectrophoresis.
7. Rocket immunoelectrophoresis.
8. Counter current immunoelectrophoresis.
9. Preparation of antisera.
10. Precipitation of immunoglobulins by ammonium sulphate method.
11. Isolation and purification of immunoglobulin G.
12. Enzyme Linked Immno- Sorbent Assay (ELISA)
13. Dot ELISA.
14. Hapten conjugation method.
15. Scale grafting in fish.

ZOP --552 : PROJECT WORK

4 hours (Field /laboratory work)

ZOS 553- NEUROBIOLOGY AND BEHAVIOUR
Teaching 10 hours /Unit

COURSE OUTCOME:

- Students will understand the structural organization and functions of vertebrate and invertebrate brains, along with neuron and glial cell physiology.
- They will learn the mechanisms of resting membrane potential, action potential generation, and synaptic transmission including neuromuscular junction function.
- Learners will study types of learning and memory, their neuronal regulation, and molecular mechanisms in animals.
- They will explore animal communication through pheromones, insect dance language, auditory signalling, and reproductive strategies.
- Students will gain knowledge of classical and modern neuroanatomical, electrophysiological, and immunohistochemical tools used in neuroscience research.

UNIT-I: Structural organization of vertebrate brain (human, mouse and zebra fish) and invertebrate brain (Aplysia and *Drosophila*). Structure and functions of neuron and glia cells. Resting membrane potential- Na and K ions across the neural membrane. Role of Na and K channels in maintaining resting membrane potential. Action potential- Axon hillock and generation of action potential.

UNIT-II : Neural transmission- chemical and electrical synapses. Excitatory and inhibitory neurotransmitters. Neuromuscular junction- synaptic connection between neurons and muscles. Molecular basis of synaptic transmission across the neuromuscular junction. Muscle contraction- types and functions of muscle fibers. Molecular mechanism of muscle contraction. Neuro-muscular disorders- Etiology of amyotrophic lateral sclerosis (ALS), Multiple sclerosis and Muscular dystrophy.

UNIT-III: Associative learning- types of associative learning (Classical and Operant conditioning). Neuronal regulations of classical and operant conditioning. Non-Associative learning- types of non-associative learning (Habituation and Sensitization). Molecular mechanisms of habituation and sensitization. Memory in animals- types of memory (sensory, short-term and long-term memory). Memory storage sites in vertebrates (hippocampus) and insects (mushroom bodies). Molecular mechanisms of short-term and long-term memory.

UNIT-IV: Pheromones-types, chemistry and significance of pheromones in animal communications. Neural circuits regulating pheromone communications in insects and mammals. Dance language in honeybee- types and significance of dance language in honeybee. Auditory communication in insects- types and significance of sound production in insects. Different types of sound producing organs in insects. Reproductive strategies and mating system in animals- polygamy, monogamy and polygyny.

UNIT -V: Classical neuroanatomical tools- Golgi-silver staining and cobalt filling of neurons in vertebrate and insect nervous system. Camillo Golgi and Ramon Cajal. Transgenic tools- Gal4-UAS system for labelling neurons in insects and zebra fish. BRAIBOW in mouse brain. Electrophysiological tools- Patch-clamp techniques (voltage and current clamp). Immuno-histochemical methods- antibody staining for localization of different neurotransmitters (GABA, Acetyl Choline, Glutamate Dopamine and Serotonin) and its receptors.

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ZOP 557: NEUROBIOLOGY AND BEHAVIOUR- LABORATORY
4 hours/week

COURSE OUTCOME

- Students will differentiate between mechanoreceptors (e.g., campaniform sensilla) and chemoreceptors, exploring their roles in detecting mechanical strain and chemical signals, respectively.
- Students will master Golgi staining and fluorescent labelling methods, such as the Gal4-UAS system, to visualize and trace neural circuits in insects, facilitating the study of brain structure and function.
- Students will design and conduct behavioural assays, including geotaxis and T-maze tests, to assess learning, memory, and sensory processing in insects and rodents.
- Students will apply immunohistochemical techniques to examine synaptic structures and neurotransmitter levels, enhancing understanding of neural plasticity and synaptic function.
- Students will observe and analyse complex behaviours in insects, such as courtship, feeding preferences, and olfactory discrimination, contributing to the field of neuroethology

Experiment :

1. Differentiation of mechanoreceptors and chemoreceptors in Insects.
2. Golgi-staining technique
3. Study of campaniform sensilla /slit sensilla in arthropod.
4. Study of olfactory discrimination in insects.
5. Study of insect colonies- Social insects.
6. Study of Gal4-UAS system to label neural circuits.
7. Geotaxis assay in insects.
8. Study of feeding preferences in insects.
9. Study of courtship behavior in insects.
10. Study of spectral sensitivity in insects.
11. Estimation of neurotransmitter acetyl choline.
12. Demonstration of nuclear staining in brain tissues.
13. Immuno-staining of chemical synapses.
14. T-maze learning in mice.

ZOS 554: ECONOMIC ZOOLOGY

COURSE OUTCOMES:

- Students will understand the biology, cultivation methods, and environmental benefits of earthworms and vermiculture technology.
- They will learn about the mulberry plant, silkworm biology, rearing techniques, and disease management in sericulture.
- Students will study honeybee species, colony management, product processing, and pollination's ecological role in apiculture.
- They will explore lac insect biology, cultivation, product processing, and natural enemy management in lac culture.
- Students will gain skills in experimental design, molecular tools, and sustainable practices for improving economically important bio-culture industries.

UNIT-I: ***VERMICULTURE***: Introduction to Vermitechnology. General characters and classification of Annelida. The habitat of earthworm- soil-major types (red soil, black soil, alluvial soil). Earthworm as farmer's friend-role of earthworms in soil fertility. The selection of earthworms (endemic and exotic species) for vermitechnology. Methods of vermicomposting and factors affecting vermiculture. Large scale manufacture of vermicompost. Worm casts. Vermiwash - production and its applications. Role of earthworms in waste management. Recycling of food and agricultural wastes. Packaging and marketing of vermicompost products and financial support by governments and NGOs for vermiculture. Potentiality of vermi-biotechnology in India.

UNIT- II : ***SERICULTURE*** **:** History and scope of Sericulture. Moriculture – origin, distribution and morphology of mulberry plant. Nutritional value of mulberry leaves. Planting system – irrigation, manuring ,weeding, Interalteration ,mulching, pruning and harvesting. Vegetative propagation– cutting ,layering and grafting . Diseases and pest of mulberry plant. Origin , distribution, morphology and classification of silk worm. Life cycle of silkworm - morphology of egg , larva, pupa and adult. Silkworm rearing – prerequisite for rearing, egg handling, incubation & chawki rearing. Late age silkworm rearing. Silkworm seed technology. Silk technology- silk gland. Pests of silk worm – Uzi fly and Dermestid beetle. Diseases of silk worm – viral, bacterial, fungal, protozoan. Causative agents and mode of infections. Prevention and control of diseases. Sericulture organization and economics.

UNIT- III: ***APICULTURE*** **:** History, scope, and importance of beekeeping. Species of honeybees. Characteristics and distribution. Anatomy and lifecycle of honeybees. Role differentiation in a bee colony- queen, workers, and drones. Establishment and maintenance of an apiary. Bee keeping equipment and seasonal management practices. Honey, wax, royal jelly, pollen, and propolis. Collection, processing and uses honey. Medicinal and economic value of bee products. Breeding programs for disease resistance and high productivity. Effects of temperature, humidity, and flora changes on bee populations. Challenges in queen rearing and artificial insemination of bees. Common pests (e.g., Varroa mite) and diseases (e.g., foulbrood). Preventive and curative measures, including organic practices. Role of honeybees in pollination and ecosystem services. Impact of pesticide use and habitat loss on pollinators. Adaptation strategies for climate-resilient beekeeping.

UNIT- IV: *LAC CULTURE* – History, scope and importance of lac cultivation. Lac insect- Species and distribution . Biology of lac insect – morphology of male and female. Life cycle .Types of lac insects- Kusumi and Rangini. Host plants for lac insects. Lac production technology- lac secretions and processing of lac. Commercial cultivation . Lac insect products and their uses. Natural enemies of lac insects- predators and parasites. Lac culture in India and abroad.

UNIT - V : Experimental design and statistical analysis in economically important animals- Field survey techniques and sample collections. Application of molecular markers in research- Genomic tools for improving economically important traits . Development of disease-resistant strains. Success stories in bio-culture program. aquaculture (e.g., IMTA, RAS) and apiculture (e.g., urban beekeeping). Sustainable technologies- eco-friendly approach in bio-culture practices. Global trends and challenges in bio-culture research.

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ZOP 558 : ECONOMIC ZOOLOGY - LABORATORY

4 hours/week

COURSE OUTCOME :

- The students will get to know bio-resource management through hands-on experience with vermiculture, sericulture, and apiculture.
- Skill in handling and analyzing biological systems and products**,** including compost quality, nutrient analysis, and bee product testing.
- The field-based exposure to sustainable practices and entrepreneurship opportunities in organic farming, silk production, and honeybee management

Experiments :

1. Collection and identification of earthworms
2. Organic waste management using earthworms- experimental setup (Pot culture method) and submission of report on the quality of the compost.
3. Analysis of vermi-wash for its nutrient contents.
4. Study the morphology and life cycle of silkworm -*Bombyx mori* – visit to silkworm rearing center and submission of report on set up and its functioning.
5. Study the structure of cocoon and various types silk.
6. Study the external morphology and dissection of a honeybee to examine internal structures.
7. Demonstration of apiary setup, including hive arrangement and safety precautions.
8. Extract honey using a honey extractor/Test honey for purity by analyzing moisture content, sugar content, and adulterants- biochemical analysis
9. Collect and process wax, royal jelly, and propolis/Study the medicinal properties of bee products.
10. Arrange field visits to apiculture/sericulture/vermiculture units to provide practical exposure/Use live demonstrations and videos for activities that require advanced setups (e.g., honey extraction)

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ZOS 555- RADIATION BIOLOGY
Teaching 10 hours /Unit

COURSE OUTCOME:

- Students will understand atomic and nuclear structures, radioactivity laws, and high-energy electromagnetic radiation properties.
- They will learn the principles, design, and functioning of various radiation detectors and dosimeters.
- Students will study radiation interaction with biological systems, including molecular and cellular effects.
- They will gain knowledge of radiation safety protocols, dose limits, hazard evaluation, and regulatory measures.
- Students will explore practical applications of radioisotopes in biology, agriculture, medicine, and research techniques like radioimmunoassay and tracer studies.

UNIT- I: Radiological physics- **a**tomic structure models. Constituents of atomic nuclei. Isotopes and Isobars. Radioactivity and laws of radioactivity. High energy electromagnetic radiation and its properties. Space radiation. Units of radioactivity. Modes of interaction of X-ray & gamma rays- Photoelectric, Compton effect & pair production.

UNIT-II: Principles of radiation detection and measurement- Basic principles, design & working of physical dosimeters. Ionization chamber- Proportional counters, GM- counter. Concepts of Gas amplification. Resolving time & dead time. Scintillation detectors, Thermo-luminescent. Dosimeter. Semiconductor. Lithium detectors. Area survey meter. Film badge. Chemical dosimeters- Salient features of chemical dosimeter. Fricke dosimeter, methyl orange, FBX dosimeter, Free radical dosimeter, Ceric sulphate dosimeter, chlorobenzene dosimeter. High & low dose indicators.

UNIT- III: Radiolysis of water, G-value, direct and indirect action. Interaction of radiation with living system – viruses, prokaryotic & eukaryotic cells. Effect of radiation on nucleic acids, proteins, enzymes & carbohydrates. Cellular effects of radiation- Mitotic delay, Inhibition of mitosis, Giant cell formation, Cell death. Cell recovery & modification of radiation damage. Genetic effects. Chromosomal breakage and aberrations. Somatic effects of radiation.

UNIT-IV: Radiation safety measures- natural & man-made radiation exposures. Maximum Permissible Dose (MPD). Evaluation of external & internal radiation hazards. Radiation protection- measures in Industrial establishments, Radioisotope laboratories, Diagnostic & therapeutic installations & during transportation of radioactive substances. Disposal of radioactive wastes. Administrative & legislative aspect of radiation protection.

UNIT- V: Applications of radioactivity - radioisotopes in biology, agriculture, plant breeding, soil plant relationship & plant physiology, medicine, (Therapy & diagnosis). Radiation hormesis. Radioimmunoassay. Radio tracer techniques with illustrative examples.

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ZOP 559: RADIATION BIOLOGY - LABORATORY
4 hours/week

COURSE OUTCOME:

- Students will gain proficiency in using various dosimeters—such as Fricke, alanine, FBX, and ferric sulphate—to accurately measure radiation doses, understanding their principles, applications, and limitations.
- Students will investigate the impact of UV and gamma radiation on *E. coli* survival, enzyme activity, protein integrity, and DNA structure, elucidating the mechanisms of radiation-induced cellular damage.
- Students will observe and analyse how exposure to UV and gamma rays affects cell division processes, contributing to the understanding of radiation's effects on mitotic and meiotic activities.
- Students will examine the influence of gamma radiation on cell membrane integrity, utilizing various assays to detect alterations in membrane permeability and function.
- Students will employ spectroscopic techniques, including UV-Vis spectroscopy and viscometry, to assess the biochemical and physical changes in biological macromolecules induced by radiation exposure.
- These outcomes ensure that students acquire both theoretical knowledge and practical skills essential for understanding radiation dosimetry and its biological implications.

Experiments :

1. Study of Fricke dosimeter.
2. Study Free Radical dosimeter (Alanine and Glutamine)
3. Study of FBX dosimeter.
4. Study of Ferric Sulphate dosimeter.
5. To determine the effect of UV and Gamma rays on *E. coli* and elucidate cell survival curve.
6. To demonstrate the effect of Gamma rays on Enzymes, Proteins and DNA, using spectroscopic method and viscometer.
7. To demonstrate the effect of UV and Gamma rays on cell division.
8. To demonstrate the effect of gamma rays on cell membrane.

END