Syllabus

M.Sc. Course in Zoology

(Four Semester course)

(With effect from the session 2021–2022)

[CHOICE BASED CREDIT SYSTEM]

The M.Sc. (PG) syllabus in Zoology under CBCS system (2021-2022) has been placed in the meeting of Board of Postgraduate Studies (PGBOS) in Zoology held on 02.07.2021 and 27.10.2021. The members of PGBOS restructured and recommended the syllabus and the same was subsequently submitted to the Dean, Faculty of Science, University of Kalyani, for approval from the Faculty Council and Executive Council of the University. The Faculty Council of the University of Kalyani approved the syllabus on 29.10.2021. The approved syllabus will be placed in the subsequent meeting of the Executive Council of the University for final approval.

Head of the Department & Chairman,
PGBOS, Department of Zoology
University of Kalyani,
Kalyani, W.B.
India

CBCS - M.Sc. (PG) Zoology, University of Kalyani

Preamble

“Zoology", a prime branch of biological science, emphasizes on the study of animals both living and extinct. In this beneficial science subject, a person learns the basic fundamentals of life forms, particularly animal life, and simultaneously understands the key concepts including the molecules, genes and cells. The subject enfolds all the fascinating biological processes starting from formation of the first cell to organization and evolution of complex multi-cellular organism.

In a more descriptive sense, the subject helps in understanding the classification of animals, their anatomy, physiology and metabolic processes, formation of embryo and further development, structure of genetic materials and their role in various life processes, ecology and dynamics of ecosystem functioning, evolution and the driving forces, behaviour and distribution of animals, and finally conservation and economic zoology.

The entire post graduate course in Zoology of this University is designed to impart knowledge about the subject in a phased manner. The students learn the basics first e.g., chordate and non-chordate biology, parasitology, developmental biology, systematics and taxonomy, fish biology in the first two semesters and then advances to six different specializations in the last two semesters. The course offers Core, Ability Enhancement Compulsory, Discipline Specific Elective (Major), and Discipline Specific Elective (Minor) papers including practical for Core and Discipline Specific Elective (Major) papers, along with one Generic Elective paper for students of other disciplines.

With the advancement of knowledge in this branch of science, augmented with phenomenal discoveries directly associated with human welfare, the subject is gaining tremendous attraction from the society and wide range of students.

In a nutshell, this entire curriculum is a holistic approach to establish a better teaching-learning platform in animal science for the students, the teachers, and the society.

Programme Objectives:

The programme **M.Sc. in Zoology** aims to equip students with recent advances in Zoology from organismic to reductionist biology. It also aims to empower students to understand the challenges of society and the country that falls into the realms of Zoology, such as Non-Chordata, Chordata, Parasitology, Fish biology, Reproductive health, Behavior and Biological time keeping, Cancer biology, Molecular biology, Environmental biology and microbiome, Toxicology and pesticides etc. It also offers students to a series of elective courses so that they can choose to specialize in the specific area of their interests in Zoology.

Keeping the true spirit of choice-based credit system scheme, close to 25% of the total credits are offered as elective courses. First and second semester courses are offered as Core and Ability Enhancement Compulsory courses. In third and fourth semester, the students are offered to choose two Discipline Specific Elective (Minor) and one Discipline Specific Elective (Major) papers out of a bouquet of six papers in the syllabus. One Generic Elective paper is also offered in Semester-II for students from diverse multidisciplinary areas of science and other disciplines, such as Botany, Physiology, Chemistry, Physics, Environmental studies, Library science, Bengali, History etc. The postgraduate course is designed to ignite the inquisitive minds about learning the basics as well as the advances in the subject Zoology and is open for admission to students who have studied Zoology (Hons.) in their undergraduate course with CBCS curriculum.

Programme Specific Outcomes:

It is expected that a student after successfully completing four semesters of M.Sc. in Zoology programme would sufficiently be skilled and empowered to solve the problems in the realms of Zoology and its allied areas. They would have plethora of job opportunities in the education, environment, agriculture-based, and health related sectors. The bright and ignited mind may enter into research in the contemporary areas of Zoological and/or Biological Sciences. The broad skills and the deeper knowledge in the field would make them highly successful and excellent researcher in advanced areas of research in the Biological sciences.

CHOICE BASED CREDIT SYSTEM (CBCS)

Department of Zoology, University of Kalyani

Effective from 2021-2022Session

Semester wise Details of M.Sc. (Zoology) Course & Course Credit

SEMESTER-I

Course Name	Paper	Points	Credit	Hours /Week
Theory (Core)				
ZCORT-101	Non-Chordate Biology and Insect Organization	75	6	4
ZCORT-102	Parasitology, Ecology, Environment and Wildlife Biology	75	6	4
ZCORT-103	Developmental Biology and Cytogenetics	75	6	4
ZCORT-104	Animal Physiology, Biochemistry and Metabolic Processes	75	6	4
Theory (Ability Enhancement compulsory course)				
ZAECCT-101	Basic principles of methods used in animal biology	25	2	1
Practical (Core)				
ZCORL-101	Non-Chordate Biology and Insect Organization	25	2	3
ZCORL-102	Parasitology, Ecology, Environment and Wildlife Biology	25	2	3
ZCORL-103	Developmental Biology and Cytogenetics	25	2	3
ZCORL-104	Animal Physiology and Biochemistry and Metabolic Processes	25	2	3
Library/Field Work/ Class Test				1
Total points & Credits in Semester I		425	34	30

SEMESTER-II

Course Name	Paper	Points	Credit	Hours /Week
Theory (Core)				
ZCORT-205	Chordate Biology, Biosystematics and Taxonomy	75	6	4
ZCORT-206	Advanced Parasitology, Vector Biology and Fish Biology	75	6	4

ZCORT-207	Immunobiology, Human Genetics & Biostatistics	75	6	4
Theory (Generic Elective)				
ZGECT-201	Applied Zoology (For students other than Department of Zoology)	50	4	4
Practical (Core)				
ZCORL-205	Chordate Biology, Biosystematics and Taxonomy	25	2	3
ZCORL-206	Advanced Parasitology, Vector Biology and Fish Biology	25	2	3
ZCORL-207	Immunobiology, Human Genetics & Biostatistics	25	2	3
Library/Field Work/Class Test				5
Total points & Credits in Semester-II		350	28	30

SEMESTER-III

Course Name	**Paper**	Points	Credit	Hours /Week
Theory (Core)				
ZCORT-309	Arthropod of Economic Importance, Concept of Biodiversity and Evolution	75	6	4
ZCORT-310	Environmental Toxicology and Endocrinology	75	6	4
Theory (Discipline Specific Elective - Minor) (any two)				
ZDSE(MN)T-301	Applied Ichthyology	25	2	1
ZDSE(MN)T-302	Developmental Dynamics	25	2	1
ZDSE(MN)T-303	Human Molecular Genetics	25	2	1
ZDSE(MN)T-304	Forest Entomology	25	2	1
ZDSE(MN)T-305	Medical & Veterinary Parasitology	25	2	1
ZDSE(MN)T-306	Reproductive Biotechnology	25	2	1
Theory (Discipline Specific Elective - Major) (any one)				
ZDSE(MJ)T-301	Fish and Fisheries, Cytogenetics & Mol. Biology, Endocrinology & Rep. Biology, Parasitology & Immunology, Entomology, Cell & Dev. Biology	50	4	3
ZDSE(MJ)T-302	Fish and Fisheries, Cytogenetics & Mol. Biology, Endocrinology & Rep. Biology, Parasitology & Immunology, Entomology, Cell & Dev. Biology	50	4	3

Theory (Skill Enhancement Course)				
ZSECT-301	Industrial/Economic Zoology	25	2	1
Practical (Core)				
ZCORL-309	Arthropod of Economic Importance, Concept of Biodiversity and Evolution	25	2	3
ZCORL-310	Environmental Toxicology and Endocrinology	25	2	3
Practical (Discipline Specific Elective - Major)				
ZDSE(MJ)L-301	Discipline Specific Elective - Major (Lab)	50	4	3
Total points & Credits in Semester III		425	34	30

SEMESTER–IV

Course Name	Paper	Points	Credit	Hours /Week
Theory (Core)				
ZCORT-411	Animal Behaviour and Microbiology	75	6	4
ZCORT-412	Molecular Biology, Biotechnology, Tools and Technique	75	6	4
Theory (Discipline Specific Elective - Minor) (any two)				
ZDSE(MN)T-407	Agricultural Entomology	25	2	1
ZDSE(MN)T-408	Cancer Biology and Medical Genetics	25	2	1
ZDSE(MN)T-409	Medical Embryology	25	2	1
ZDSE(MN)T-410	Aquaculture Technology	25	2	1
ZDSE(MN)T-411	Hormone and Signal Transduction	25	2	1
ZDSE(MN)T-412	Parasites and Diseases	25	2	1
Theory (Discipline Specific Elective - Major) (any one)				
ZDSE(MJ)T-403	Fish and Fisheries, Cytogenetics & Mol. Biology, Endocrinology & Rep. Biology, Parasitology &Immunology, Entomology, Cell & Development Biology	50	4	3
ZDSE(MJ)T-404	Fish and Fisheries, Cytogenetics & Mol. Biology, Endocrinology & Rep. Biology, Parasitology & Immunology, Entomology, Cell & Development Biology	50	4	3
Practical (Core)				
ZCORL-411	Animal Behaviour and Microbiology	25	2	3

ZCORL-412	Molecular Biology, Biotechnology, Tools and Technique	25	2	3
Practical (Discipline Specific Elective - Major)				
ZDSE(MJ)L-402	Discipline Specific Elective - Major (Lab)	50	4	3
	Project/ Dissertation			
ZDSEP-402	Project/ Review work/ Dissertation	100	8	1
Total points & Credits in Semester IV		500	40	30

Abbreviations used in the syllabus:

ZCORT – Zoology Core Course Theory

ZCORL – Zoology Core Course Lab

ZAECCT – Zoology Ability Enhancement Compulsory Course Theory

ZGECT – Zoology Generic Elective Course Theory

ZDSE(MN)T – Zoology Discipline Specific Elective (Minor) Theory

ZDSE(MJ)T – Zoology Discipline Specific Elective (Major) Theory

ZDSE(MJ)L – Zoology Discipline Specific Elective (Major) Lab

ZDSEP – Zoology Discipline Specific Project

Examination Pattern

Course	In-Semester (20%)	End Term (80%)	Total Points
Theory (Core)	15 Attendance (2.5+2.5) Internal Assessment (5+5)	60	**75**
Practical (Core)	5 Attendance (2) * Lab. Report (3)	20 Practical + Viva Voce (15 + 5)	**25**
Theory (Generic Elective)	10	40	**50**
Theory (Ability enhancement compulsory course, skill enhancement course & discipline specific elective course - minor)	5 Internal Assessment (5)	20	**25**
Theory (Discipline Specific Elective - major)	10 Internal Assessment (5+5)	40	**50**
Practical (Discipline Specific Elective - major)		50	**50**
Project/ Review work/ Dissertation		100	**100**

*Attendance: 90-100% = 5, 80-89% = 4; 70-79% = 3; 60-69% = 2; Less than 60% = 1

Question Pattern

In-Semester	End Term Examination
For written test only For 10 points: 2Pt. × 5(out of 6) For 5 points: 1Pt. × 5 (out of 6) =5	**For 20 Points:** $2^{1/2}$pt x 2 (out of 3) = 5 3pt x 3(out of 4) = 9 6pt x 1(out of 2) = 6
	For 40 Points: $2^{1/2}$ pt x 2 (out of 3) = 5 3 pt x 3 (out of 4) = 9 5 pt x 2 (out of 3) = 10 8 pt x 2 (out of 3) =16

	For 60 Points: **(for each section in each paper) 30×2=60** $2^{1/2}$ pt x 2 (out of 3) = 5 5 pt x 3 (out of 5) =15 10 pt x 1 (out of 2) =10

SEMESTER–I

THEORY (CORE)

Course Objectives:

The non-chordate biology and insect organizationmust be taught to every student of life science. This section starts with metazoan evolution and the course is highly updated and tailor-made to make a PG student strong enough in the most fundamental aspect of the biological sciences.

ZCORT-101: Non-Chordate Biology and Insect Organization	**Points 75**
Non-Chordate Biology	**Points 37** **Lectures**
1.Origin & Evolution of Metazoans.	3
2. Cell organelles in Protozoa: Golgi, Mitochondria, Kinetoplast, Pellicle and Cuticle.	4
3. Cell association and cellular differentiation in Protozoa.	4
4.Osmoregulation in Protozoa and Nematodes.	4
5. Sense organs and their importance - Chemoreception, photoreception and mechanoreception; sensory organelles and reaction for stimuli in protozoa.	3
6. Organs and process of reproduction in major invertebrate groups.	
7. Structural organization of respiratory organs in major invertebrate groups; factors affecting respiration.	4
8. Photogenic organs in insects: structure, mechanism and significance of light production.	4
9. a) Trochophore larva: Structure and evolutionary significance. b) Evolutionary significance of minor invertebrate phyla.	3
10. Insect flight: types; structure concerned; functional mechanism; evolution of flight patterns in different insect groups.	4
	4
Insect Organization	**Points 38** **Lectures**
1. Modern classification of insects.	3
2. General organization, segmentation, division of body: i) Head and mouth-parts in general ii) Thorax and thoracic appendages. Modification of legs and wings. iii) Abdomen and abdominal appendages.	4
3. Integument: Basic structure and functions; modification in different insect groups.	4

4. Digestive organs: Structure and functions; Peritrophic membrane, Filter chamber.	4
5. Structure and functions of the central nervous system in insects.	4
6. Insect visual organs, their structure and functional mechanisms.	4
7. Insect blood: composition, functions, morphology of circulatory system.	4
8. Structure and function of sound producing organs in insects; types of insect sound; significance of sound production.	4
9.Exocrine glands: Lac gland, Wax gland, Silk gland, Labial gland.	
10.Metamorphosis in insects: hormonal regulation; factors affecting metamorphosis; diapause.	4 3

Suggested Literature:

1. Barnes: Invertebrate Zoology (Holt-Saunders International, 4th edition, 1980)
2. Barnes: The Invertebrates – A synthesis, 3rd edition, Blackwell, 2001
3. Hunter: Life of Invertebrates, Collier Macmillan Pub. 1979
4. Marshall: Parker & Haswell Text Book of Zoology, Vol. I, 7th edition, Macmillan, 1972
5. Moore: An Introduction to the Invertebrates, Cambridge University Press, 2001
6. Kudo: Hand Book of Protozoology, Charles C Thomas Publishers, 1931.

Course Learning Outcomes:

The course is designed to prepare the students with knowledge and skills of non-chordate physiology for exploring and assessing biodiversity and ecosystem health. There are emerging scopes of jobs as biologist and ecologists with good taxonomic knowledge in India and abroad.

Course Objectives:

To introduce the students to various pathogens causing diseases and the reactions of the body against them.

The objective of this course to make awareness among the young students about the surrounding environment, the impact of climate change and its mitigation, and biodiversity.

To educate the students about the basic environmental phenomena like pollution, ecosystem, etc. and to educate the students about the importance of wild life conservation.

ZCORT-102: Parasitology, Ecology, Environment and Wildlife Biology	**Points 75**
Parasitology	**Points 37** **Lectures**
1. Concept of parasitism, symbiosis commensalism and mutualism.	4
2. Host-parasite interaction: immunopathological consequences in parasitic infections.	4
3. Classification of Protozoa and Helminths.	3
4. *Entamoeba* and Blood Flukes in Humans.	4
5. Microspora: Structure and life history of *Nosema bombycis* -impact on	

sericulture.	3
6. Mode of transmission of *Plasmodium*, *Trypanosoma* and Piroplasm.	6
7. Zoonosis with particular reference to *Toxoplasma and Schistosoma.*	5
8.Life cycle, biology, pathogenesis, epidemiology and control of medically important helminths – *Diphyllobothrium latum, Paragonimus westermani, Trichinella spiralis* and *Wuchereria bancrofti.*	5
9.Salient features of plant parasitic nematodes and life cycle patterns of i) *Meloidogyne hapla*, ii) *Anguina tritici*.	3
Ecology, Environment and Wildlife Biology	Points 38 Lectures
1. The Ecosystem: Gaia hypothesis, cybernetic nature and stability of the ecosystem, ecosystem management and optimization. Macroecology: concept and consequences. Principles of Thermodynamics, energy flow and ecological energetics.	4
2. Niche theory: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. (Lotka-Volterra model, Isoclines, Niche prediction).	3
3. Community: Structure and Gradient analysis, Structure of biotic community. Community patterns: diversity and stability. Community boundary: Ecotone and edge types, Edge effect and edge species, Leibig's Law of the minimum.	4
4. Population attributes: Growth forms and mathematics of growth, Life Table - (Cohort and Static); survivorship curves, generation time, net reproductive rate, gross reproductive rate, vital index. Life history strategies: Evolution of life history traits, strategies related to longevity; clutch size; life history optimization.	5
5. Metapopulation: Concept, models, structure and dynamics	2
6. Major terrestrial biomes: Theory of island biogeography, Biogeographical zones of India	3
Environment and Wildlife Biology	
7. Concept of Environment: Structure, radiation balance, UN movements on environment.	2
8.Theory and analysis of conservation: Stochastic perturbations, population viability analysis, recovery strategy for threatened species: Different approaches for conservation – in-situ and ex-situ, In-situ conservation-problems and prospects; Sanctuaries, National parks, Community Reserves and Conservation Reserves; Biosphere Reserve, EIA and EIS.	5
9. Conservation biology of important wild animals: Conservation status, habit & habitat, threats and conservation management of the following animals: Olive Ridley Turtle / Greater one-horned *Rhinoceros*/ Ganges river dolphin.	6
10. Basic Concept of Wildlife Biology: Wildlife wealth of India; Threatened	

wildlife and IUCN status - Concept of Extinct, Critically Endangered, Endangered, Vulnerable and rare species; concept of corridor.	4

Suggested Literature:

1. Cheng, T. C. (1986). General Parasitology. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
2. Noble, E. R. and Noble G. A. (1989). Parasitology. The Biology of animal Parasites. 6th ed.
3. Roberts, L. S., Janovy, J. and Nadler S. (2013) Gerald D. Schmidt & Lary S. Roberts'Foundation of Parasitology. 9th ed. McGraw-Hill International.
4. Begon, M., Harper, J. L. and Townsend, C. R. (2006). Ecology: Individuals, Populations and communities. 4 th ed. Blackwell science.
5. Enger, E. D. and Smith, B. F. (2008). Environmental Science: A study of Interrelationships. 11th ed. McGraw-Hill Higher Education.
6. Kormondy, E. J. (2002). Concepts of Ecology. 4th Indian Reprint, Pearson Education.
7. Odum, E. P. and Barret, G. W. (2005). Fundamentals of Ecology. 5th ed. Thompson Brooks/Cole.
8. Smith, T. M and Smith, R. L. (2006). Elements of Ecology. 6thed. Pearson Education.

Course Learning Outcomes:

The course will provide information of the diversity and biology of parasites, epidemiology and mode of transmission of parasitic diseases and preventive measures. Students will be exposed to the fundamental aspects of ecology. They will get idea about the impact of anthropogenic activities on the environment. Students will get idea about the natural resources and their conservation.

Course Objectives:

The topic covered under Developmental Biology aims to provide a multi-dimensional platform to the students for understanding the basics patterns and process of embryonic development and thereby emphasizing a deep insight into molecular and genetic aspects of the developmental process in different biological specimen.

The curriculum of Cytogenetics intends to effectively inculcate in them the desire for deeper understanding of molecular genetics and molecular cell biology in order to manifest creativity and thought-provoking ideas with regards to the rapidly changing field of advance molecular biology across animal kingdom.

ZCORT 103: Developmental Biology and Cytogenetics	**Points 75**
Developmental Biology	**Points 37** **Lectures**
1. Overview of early embryonic development and morphogenesis.	2
2. Basic concepts in Developmental Biology: potency, induction, germ cell migration, competence, commitment: specification, determination and differentiation, morphogenetic gradient and fate map.	6
3. Axis specification in *Drosophila*: role of maternal effect genes, patterning of early embryo by zygotic genes, gap genes, pair– rule genes,	

segment polarity genes, homeotic selector genes- bithorax and antennapedia complex.	6
4. Axis specification in vertebrates: Early patterning in vertebrates - Symmetry breaking, Nieuwkoop center. Wnt and cadherin signaling, TGFβ signaling in early developmental process, asymmetric gene expression.	6
5. General concepts of organogenesis: Development and patterning of vertebrate limb, homeobox genes in patterning, signaling in patterning of the limb; Insect imaginal discs–organizing center in patterning of the leg and wing, the homeotic selector genes for segmental identity; insect compound eye.	6
6. Postembryonic development: growth, cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence	4
7. Regeneration– Epimorphic regeneration of reptile (salamander) limb; Morphollaxis regeneration in *Hydra*.	4
8. Programmed cell death: apoptosis, autophagy and necrosis.	3
Cytogenetics	**Points 38 Lectures**
1. Organization and Structure of Genomes: Organization and nature of eukaryotic nuclear DNA, Size and complexity of eukaryotic genome; transposable elements, retrotransposons, SINE, LINE, Alu and other repeat elements, pseudogenes, segmental duplications; super coiling of DNA; Classes of DNA, Giant chromosomes: study model for chromosome organization and gene expression; Virus and Bacterial genomes, Mitochondrial genome.	13
2. Cell cycle, Apoptosis and Cancer: Phases of Cell cycle, Check Points, Regulation of cell cycle; MPF, cyclins and cyclin-dependent kinases; Concepts of Apoptosis: Regulators of Apoptosis, Caspases, Pathways of apoptosis; Cell Senescence, Necrosis; Cancer-Types and Stages, Carcinogens, Tumor suppressor genes and Proto-oncogenes induction to oncogenes.	13
3.DNA Replication and Recombination: Topology, Variations and Nature of Replication; Replicon, Replicator, Fidelity and Processivity of replication; "Hayflick limit" and Telomerase activity; Regulation of Replication-Cell Cycle synchronization, Origin Firing, Licensing, DNA damage response; Drugs and Inhibitors targeting replication-antibacterial, antiviral and anticancer; Extrachromosomal Replicons; Homologous Recombination and DNA Repair.	12
Suggested Literature: 1. Developmental Biology: Scott F Gilbert. 2. Principles of Development: Louis Wolpert.	

3. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., Blackwell Publishing, West Sussex, UK.
4. The Cell: A molecular Approach. Geoffrey M. Cooper and Robert E. Hausman. 3rd Ed. ASM Press Washington, DC.
5. Molecular Cell Biology- 4th Ed. James E. Darnell, Harvey Lodish, Arnold Berk, Lawrence Zipursky, Paul Matsudaira, David BaltimoreMolecular Biology of the Cell. 4th Ed.
6. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter.
7. Genetics: A molecular approach. Peter J. Russell. Benjamin Cummings publishers.
8. Principles of Genetics. D.P. Snustad and M.J. Simmons., John Wiley & Sons, Inc.
9. Genes IX- Benjamin Lewin. Jones and Bartlet Publishers.

Course Learning Outcomes:

Developmental Biology enquires about the fundamental processes that underpin the fertilization of an egg cell and its step-by-step transformation into the fascinating complexity of a whole organism. After completing the course, the students should gain ample knowledge and understanding in the factual basis of embryonic development and its relevancy with differential gene expression in various model organisms which would strive them with immense opportunity to take up active research in molecular embryology in future.

Successful completion of the curriculum of Cytogenetics, the students should have a comprehensive idea on structural and functional aspects of biological macromolecules and genome which would help them to embark and reach new avenues in the field of molecular biology and cytogenetics in their future research.

Course Objectives:

Animal physiology is the study of structural and functional plan in animals. Animal Physiology helps to understand how animals work at all levels as a whole integrated organism from cells to tissues to organs. The scope of physiology includes elucidation of the function of all cells in all organs and all animals related to nervous, respiratory, circulatory, muscular, cellular communication, cellular transport and other physiological systems. This course especially focuses on the different physiological systems of organisms across the animal kingdom with special emphasis on humans. This course focuses not only on the functioning of the different physiological system, but on the molecular basis of the functioning of the physiological systems.

Biochemistry and Metabolic Processes course is designed as an advance course for understanding the thermodynamics, interplay, energetics, catalysis in living systems, how cellular reactions are possible in the living systems, certain important metabolic pathways: regulation and inter-dependence of the pathways on one another their roles in health and diseases. The course also deals with the importance of enzymes, enzyme kinetics of first order reactions, second order reactions, inhibitions, regulations. Moreover, students who have an exposure to Biochemistry in their undergraduate studies will get exposure to advanced

subject topics like free radicles and their roles in living systems, vitamins and minerals: their biochemistry. It is designed for students who have already taken up the courses and elementary biochemistry at the undergraduate level to have in depth knowledge of the same at an advanced level.	
ZCORT 104: Animal Physiology, Biochemistry and Metabolic Processes	**Points 75**
Animal Physiology	**Points 37 Lectures**
1.Respiratory function of blood: Respiratory pigments –types, distribution and brief chemistry. Structure and function of haemoglobin- i) in adult and ii) during embryonic life. Transport of oxygen and carbon dioxide in blood and body fluids, Regulation of respiration.	8
2. Physiology of muscle contraction and proteins associated with muscle contraction: Physiology of muscle contraction, Chemical nature of contractile elements, actin nucleation, actin treadmilling, myosin types, structure, Role of structural and regulatory proteins in muscular contraction (profilin, cofilin, thymosin, troponin, tropomysin, Arp 2/3 complex), ATP and signal molecules in muscular contraction, neuromuscular junction and its functioning.	6
3. Physiology of excretion: Formation of urine: Physiology of ultrafiltration, reabsorption, tubular secretion Counter current theory of urine concentration, Regulation of urine formation, Renal regulation of acid- base balance.	6
4.Synaptictransmission; types of synapses, Pre- and postsynaptic structure and function, Steps in Synaptic Transmission, chemistry and modes of neurotransmitter release, proteins in synaptic transmission: SNARE hypothesis: synapsins, synaptobrevin, synaptotagmin, SNAP and NSF, synaptic plasticity, toxins in synaptic transmission.	6
5. Cytoskeleton, Extracellular matrix, gap junctions, integrins, cell adhesion molecules and their functions.	6
6. Intracellular protein trafficking for secretory and non-secretory cells: Protein synthesis, Protein sorting and targeting to organelles; signal sequences, vesicle transport, packaging, storage and release, Targeting of proteins to lysosomes for degradation; Receptor mediated endocytosis.	5
Biochemistry and Metabolic Processes	**Points 38 Lectures**
1. Proteins: Protein folding and protein stability.	4
2. Bioenergetics (anaerobic and aerobic respiration, oxidative and substrate level phosphorylation) basic concept of ETC and ATP synthesis, uncouplers. Spontaneous reaction (concept of -vedel G). Thermodynamic principles and steady-state conditions of living organism.	4
3. Amino acid metabolism: Amino acid classification, Urea cycle.	

4. Carbohydrate metabolism: Carbohydrates of physiologic significance Glycolysis, Gluconeogenesis, Hexose monophosphate Shunt, Glycogenesis and glycogenolysis, Control and regulation of carbohydrate metabolism	3 3
5. Biosynthesis of cholesterol, control of cholesterol biosynthesis, lipoproteins and types of cholesterol transport	6
6. Enzymes: Kinetic analysis of enzyme-catalyzed reaction, Michaelis-Menten Equation, Lineweaver-Burk's plot, Eadie–Hofste plot, Bi-substrate Reactions, enzyme inhibitions, Regulation of enzyme activity, Allosteric control of enzyme activity	4
7. Chemistry of free radicals and antioxidants.	6
8. Vitamins and minerals: Role of vitamins as coenzymes.	4 4

Suggested Literature:

1. Animal Physiology: Adaptation and Environmental, Nelson K. S. (ed.) Cambridge University Press, Cambridge, UK.
2. Comparative Animal Physiology, Prosser,C.L. & Brown Jr.,F.A.(ed.), Saunders.
3. Eckert: Animal Physiology 5th Ed by Randall, David, Burggern, Warren, French, Kathleen (2001)
4. Guyton and Hall Textbook of Medical Physiology, Latest Edition
5. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition,
6. W.H. Freeman and Co., New York.
7. Berg, J.M., Tymoczko, J.L. and Stryer, L.(2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
8. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.

Course Learning Outcomes:

After going through this course, the students will understand how systems in animals work and how these animals' biology is influenced by the different environments. The students will be able to explore an original query in animal physiology. The students will appreciate the molecular makeup of the physiological systems and will understand what forms the systems and allows them to function.

After going through this course of Biochemistry and Metabolic Processes, the student would be able to understand the inter-relationships between different metabolic pathways that play important roles in the living systems. Also, the students will be able to predict and understand which particular pathway will function under a specific condition. They will be able to predict the futuristic outcome of failure of metabolic pathways. Consequently, a scheme of intervention for metabolic failure can be predicted and this course may encourage students to find molecules that modulate the metabolic pathways eventually resulting into design of drugs.

THEORY (ABILITY ENHANCEMENT COMPULSORY COURSE)

Course Objectives:

Major objective of this ability enhancement compulsory paper is to impart knowledge to the students on contemporary molecular techniques for genetic manipulation that could help them in better understanding of biological processes in broad range of host organisms. Lectures will specifically address the historical standard techniques with emphasis on principles of various methods used in biological research.

ZAECCT-101: Basic principles of methods used in animal biology	**Points 25 Lectures**
1. Microscopy: Basic concepts of light and electron microscopy (magnification, resolution, limit of resolution, chromatic aberrations).	5
2. Histochemical and immunological techniques: Tissue processing, microtomy, fixatives (types and function), staining, and immunohistochemistry. Antibody generation and antigen-antibody interaction.	5
3. Biophysical methods: Common spectroscopic methods, Electromagnetic radiation, Principle of spectroscopy.	5
4. Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.	5
5. Methods in field biology: Methods of estimating population density of animals, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization-ground and remote sensing methods.	5
Suggested Literature:	
1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA[Latest edition].	
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK.	
3. DeRobertis and De Robertis Cell and Molecular Biology. Lea and Febiger.	
4. Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition, ISBN-13: 9780136043027	
5. Immunology Kuby W.H. Freeman and Company.	
6. Murphy, K and Casey W. (2016). *Janeway's Immunobiology*. 8thed.Garland Science.	
7. Roitt, I. M. and Delves, P. J. (2017). *Roitt's Essential Immunology*. 13th ed. Blackwell Science Ltd.	

8. Wilson and Walker's (2018). *Principles and Techniques of Biochemistry and Molecular Biology.8th ed.* Cambridge University Press.	
Course Learning Outcomes: The students will be able to gain a comprehensive knowledge on techniques widely used in biological research and clinical understanding. On completion of the course, they would be able to understand and analyse the basic principles of methods and experiments used in understanding the molecular mechanisms of cellular processes.	

PRACTICAL (CORE)

Course Objectives: This lab course is intended to introduce the students to different non-chordate species in order to give them a hands-on training to explain the anatomy and physiology of the specimen.	
ZCORL 101: Non-Chordate Biology and Insect Organization	**Points 25**
Anatomical analysis (Non-Chordate) 1. Grasshopper: Reproductive; Air sacs. 2. Cockroach: Male reproductive. 3. Crab: Digestive and Nervous. **Anatomical analysis (Insect Organization)** 4. Honey bee: Poison apparatus, Pollen basket. 5. Mosquito: Head-mouth parts and wing. 6. Housefly: Head, mouth parts and wing. 7. Drosophila: Arista. 8. Laboratory note book &Viva voce.	
Course Learning Outcome: The section will provide fundamental ideas about the body organization of non-chordates.	
Course Objectives: Course objective is to provide hands on training on Parasitology, Ecological and environmental knowledge.	
ZCORL 102: Parasitology, Ecology, Environment and Wildlife Biology	**Points 25**
Parasitology 1. Collection, fixation, staining and preservation of protozoa by wet and dry method. 2. Staining of ciliate parasites by Kelin's silver impregnation technique. 3. Collection, fixation, preservation and staining of endoparasitc helminths of vertebrates. **Ecology, Environment and Wildlife Biology** 4. Determination of Primary Productivity of water. 5. Determination of orthophosphate of water. 6. Determination of organic carbon of soil. 7.BOD and COD analysis of water sample.	

8. Heavy metal analysis from water and soil sample. 9.Wildlife census techniques: Line transact method, Pug mark analysis (basic knowledge). 10. Laboratory note book & viva voce.	
Course Learning Outcomes: The students will adapt with practical knowledge of parasitology, ecology, environment and wild life biology.	
Course Objectives: The practical course has been designed to enrich the basics of developmental biology and cytogenetics in the students by giving them an opportunity of performing different techniques on their own accomplishes their in-depth theoretical understanding.	
ZCORL 103: Developmental Biology & Cytogenetics	**Points 25**
Developmental Biology 1. Preparation of Whole mounts of 24, 48 and 72 hours of Chick embryos. 2. Study of serial section of chick embryo of 48 & 72 hours (emphasis to be given on brain, eye, heart, gut, limb and tail bud regions). 3. Study of life cycle stages of *Drosophila*. 4.Identification of different developmental stages of fish. 5. Effect of teratogens during development of *Drosophila/* Tilapia. **Cytogenetics** 6. Study of mutant phenotypes of Drosophila. 7. Demonstration of law of segregation using Drosophila mutants. 8. Study of meiosis in grasshopper testes by squashing method. 9. Temporary squash preparation of polytene chromosomes from salivary glands of Drosophila larvae/Chironomous larvae. 10. DNA isolation and visualization. 11. Laboratory note book & Viva voce.	
Course Learning Outcomes: The practical training would assist in proper understanding of the theoretical knowledge and equip them with hands on experience in the areas of developmental biology and cytogenetics.	
Course Objectives: The course is designed to make the students understand various physiological and biochemical processes.	
ZCORL 104: Animal Physiology, Biochemistry & Metabolic Processes	**Points 25**
Animal physiology 1. Blood pressure and pulse rate - Effect of exercise. 2.Estimation of rate of O_2 consumption, CO_2 release and RQ in cockroach/mice. **Biochemistry & Metabolic Processes** 3. Determination of Acid Number of Fatty Acid. 4. Kinetic study of an enzyme - urease/ catalase.	

5. Laboratory note book &Viva voce.	

Course Learning Outcomes:

This course will help in advancing our knowledge on physiology and biochemistry. Further, course will equip the students to know how different changes in the environment can bring changes to the physiology of the animals and how different factors can modulate the biochemical processes.

SEMESTER II

THEORY (CORE)

Course Objectives:

Variation is most important rule of nature. The splendid characteristic of life is its diversity and uniqueness of its components and processes. No two sexually reproducing organisms are the same, nor are any two populations, species or higher taxa.

With the term "Taxonomy" coined by A.P. de Candolle in 1813, the entire life form on earth is under investigation and the process will continue until we reach a reasonable answer to the quest regarding the total number of living organisms inhabiting the planet Earth.

It is with this background, the course is carefully drafted and tailor made to better understand the diversity of chordates, their structure, physiology and metabolic processes and to gain knowledge on the techniques of naming, classifying, and diagnosis of this diverse life form.

ZCORT-205: Chordate Biology, Biosystematics and Taxonomy	**Points 75**
Chordate Biology	**Points 37** **Lectures**
.1. Blood and cardiovascular system: Blood pressure and baroreceptors, blood volume regulation; cardiac cycle, myogenic and neurogenic heart, origin and conduction of heart beat, ECG and its implications, neural and chemical regulation of functions of heart.	**8**
2. Respiratory system: Comparative account of respiratory pigments; transport and exchange of gases.	**6**
3. Nervous system: Gross anatomy of brain and spinal cord; cranial nerves, neural control of muscle tone.	**4**
4. Thermoregulation: Importance of body temperature in animal physiology, heat exchange interactions between animals and environment, thermoregulation in ectotherms and endotherms, physical, chemical, neural regulation of body temperature; acclimation and acclimatization.	**6**
5. Circulatory systems: General plan, Hemodynamics. Cardiovascular response to extreme conditions like exercise, diving and hemorrhage. Neural control of cardiovascular system. Immune responses.	**6**
6. Digestive system: Acquisition of Energy: Types of feeding, Digestion (motility and Secretions), Metabolism, and absorption, Physiology of gastrointestinal system (mammals) including neural and hormonal regulatory mechanisms.	**7**

Biosystematics and Taxonomy	**Pointss 38 Lectures**
1. Species concept: a. Biological species concept, difficulties in application of biological species concept. b. Nomenclature rules, ICZN: The code; amendments and applications c. Concept of Type.	
2. Character and character states in taxonomy: a. Types of character: primitive and advanced, missing, polymorphic, micro, cryptic and internal. b. Character state transition, environmental effect and their significances, artifacts and special characters. c. Taxonomic key: types and their role in classification.	6 8
3. Phenetic method of classification- a. Numerical phenetics and numerical taxonomy. b. Preparation of data matrix and similarity matrix using distance method (Manhattan distance and Euclidian distance). c. Cluster analysis (different methods)	 8
4. Cladistic method of classification – a. Cladistics and cladogram, terminologies in cladistics. b. Methods of measuring evolutionary transitions c) Homoplasy, parsimony and character conflict.	
5. Polyphasic concept in biosystematics – a. Biochemical taxonomy, cytotaxonomy and molecular taxonomy. b. DNA barcoding. **c.** Phylogenetic trees: construction and analysis; types.	 8 8

Course Learning Outcomes:

Knowledge on the diversity, morphology, anatomy, and physiology of different chordate groups will be of immense help for students in understanding the animal world and to pursue further studies and research directly linked to human welfare such as disease control, animal husbandry, and functional studies.

By learning basic principles of biosystematics and taxonomy, the most important discipline of biological science, students will better understand the diversity of all life forms and will be able to identify unknown taxa and make new discoveries. Thus, the students can make significant contribution to science and society in their future ventures as researcher, entrepreneur, and teacher.

Suggested Literature:

1. Anonymous [International Commission on Zoological Nomenclature] (1999). *International Code of Zoological Nomenclature*. 4th edition. International Trust for Zoological Nomenclature, London, xxix + 306 p.

2. Futuyma, D. J. (1986). *Evolution*, Sinauer Associates, Inc., Sunderland, USA
3. Hennig, W. (1966). *Phylogenetic Systematics.* University of Illinois Press, Urbana, Chicago, London, vii + 263 p.
4. Kapoor, V. C. and Kapoor, M. (2012). *Theory and Practice of Animal Taxonomy*. Oxford and IBH. 7th ed.
5. Kitching, I. J., Forey, P. L., Humphries, C. J. and Williams, D. (1998). *Cladistics: Theory and Practice of Parsimony Analysis* (*Systematics Association Special Volumes*). 2nd ed. OUP Oxford.
6. Mayr, E. and Ashlock, P. D. (1991). *Principles of Systematic Zoology*. 2nd ed. McGraw-Hill.
7. Quicke, D. L. J. (1993). *Principles and Techniques of Contemporary Taxonomy*. Blackie Academic and Professional.
8. Randall, D., Burggren, W. and French, K. (2002). *Eckert's Animal Physiology – Mechanisms and Adaptation*. 5th ed. W. H. Freeman.
9. Schmidt Nielsen, K. (1994). *Animal Physiology: Adaptation and Environment*. Low Price Cambridge Edition.
10. Kardong, K.V. (2010). *Vertebrates: Comparative Anatomy, Function, Evolution*. 4th Edition. Tata McGraw Hill.

Course Objectives:

The course aims to give an overview of basic ideas of parasitism and parasitic lifestyles including host responses and parasite evasion. It will enable students to explore a number of important diseases, along with the diverse protozoans and worms responsible for them. The students learn about transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment and control of major parasites.

Various biological aspects of fish viz. Respiratory organs, Excretion, Electroreception, Reproduction in fish, migration etc. are in this paper, Fish biology.

ZCORT 206: Advanced Parasitology, Vector biology and Fish Biology	**Points 75**
Advanced Parasitology and Vector biology	**Points 37** **Lectures**
1.Protozoans as parasites and causal agents of diseases.	5
2. Physiology and metabolism of Haemo flagellates.	4
3. Physiology and immunopathogenesis of *Plasmodium vivax* and *P. falciparum*.	5
4. Physiology of cestodes, trematodes and nematodes.	5
5. Fish parasites and its control.	4
6. Parasites of edible oysters.	4
7. Mode of transmission, pathogenicity and prevention of tuberculosis, cholera, tetanus, rabies and dengue.	5
8.Life cycle, medical importance and control of disease-causing vectors: i. *Anopheles* sp., *Culex* sp., *Aedes* sp.	5

ii. Black fly	
Fish Biology	**Points 38 Lectures**
1. Respiratory organs: Water breathing, Air-breathing, Swim bladder	6
2. Excretion and osmoregulation in fish.	4
3. Reproduction in fish: reproductive strategies, oviparity, viviparity, ovo-viviparity, parental care, maturity stages, breeding cycle	8
4. Structure and physiology of endocrine glands in fishes	4
5. Electroreception in fish, Electric organs	4
6. Determination of age of fish by scale and hard parts.	4
7. Poisonous and venomous fish.	4
8. Fish migration: Types, Theories and Significances	4

Suggested Literature:

1. Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley and Sons Inc.
2. Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando.U.S.A. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
3. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed.
4. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts'Foundation of Parasitology*. 9th ed. McGraw-Hill International.
5. Bond, C. E. (1996). *Biology of Fishes*. 2nd ed. Saunders Pub.
6. Evans, D. H. (1998). *The Physiology of Fishes*. CRC Press.
7. Hoar and Randall. *Fish Physiology,* Volumes I-XV (1969-onwards, Academic Press)
8. Encyclopedia of Fish Physiology. 2011. Anthony P. Farrell, E.D. Stevens, J.J. Cech&
9. J.G. Richards (Eds). Academic Press, UK.
10. Fish Physiology. (Series) W.S.Hoar and D.J. Randall (Series Eds). Academic Press, UK.
11. The Physiology of Fishes. 2013. Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK.

Course Learning Outcome:

Upon successful completion of this course the students would be able to learn about transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment and control of major parasites. The student would be able to understand about the fish biology and their importance. The course has been structured in a way that the students assimilate the classroom knowledge for applied aspects of parasitology, public health and fish biology.

Course Objectives:

The course has been developed to provide the basics of immunology and understanding the structure, components and function of an immune system so that necessary skills are provided

for the critical analysis of contemporary literature on topics related to health and disease and the role of immune system. The course will also enable the students to learn broad knowledge on the structural and functional aspects of human chromosomes and enhance the understandings on human genetics and related human genetic disorders, thereby paving the way for possible treatment and management. The biostatistics topics have been designed to learn traditional numerical methods of biological science. The topics included are expected to help the students in designing experiments or surveys, scientific data collection and management, as well as statistical interpretations from the collected data.	
ZCORT 207: Immunobiology, Human Genetics& Biostatistics	**Points 75**
Immunobiology	**Points 37** **Lectures**
1. Basic concepts of Immune System; Primary and Secondary Lymphoid Organs, Cells, Tissues and molecules of Immune System.	4
2. Innate immunity: Overview, features, epithelial barrier, neutrophils, macrophage functions, inflammation, NK cells, cross talk with adaptive immune system.	4
3. Humoral immune system: Structure and class switching of antibodies, B cell function, maturation and development.	
4. Complement system and diseases.	4
5. Antigen presentation: Concept of haptens, determinants, conditions of antigenicity, superantigen, Dendritic cell, MHC, role of APCs.	4
6. Antigen Recognition: Antigen Receptor: T and B cell Receptor, Structure of Immunoglobulin and T-cell receptor, Antigen Receptor Diversity-Mechanism, Antigen Receptor Maturation and selection.	4
7. Vaccination and immunization: natural and artificial immunization; active immunization, vaccines.	4
8. Immuno-techniques: Antigen-Antibody Reaction Analysis-Agglutination, Diffusion etc. Isolation and culture of Immune cells, Antigen-Antibody reaction-RIA, ELISA, Visualization of Immune reaction In vivo and vitro- Immunofluorescence, FISH, GISH, immunohistochemistry.	4 **9**
Human Genetics and Biostatistics	**Points 38** **Lectures**
1. Basic concept of human genetics: introduction to the structure of human genome; human genome and mapping.	3
2. Human karyotype; karyotype and nomenclature of metaphase chromosome bands.	3
3. Chromosome anomalies and Structural Variants.	3
4. Molecular Pathology: Loss of function, Gain of function; Mitochondrial disorders.	3
5. Genetic analysis of complex traits and disease.	3 3

6. Human genetics and society: genetic testing; human rights; genetic counseling. 7. Quantitative genetics; variance; heritability and its measurement; inbreeding and cross breeding; QTL.	3
Biostatistics:	
1. Measures of Central Tendency and dispersal.	2
2. Measures of Variation.	2
3. Concept of Probability and significant test, Probability Distribution (Binomial, Poisson and normal).	2
4. Graphical representation of biological data: Box plot analysis, leaf and stem diagram.	2
5. Test of Hypothesis, Students' *t*-test and z-test and their application.	2
6. Analysis of Variance (ANOVA).	2
7. Nonparametric tests: Chi-square test and Wilcoxon sign-rank test.	2
8. Linear Regression, Correlation analysis and rank Correlation analysis.	3

Suggested Literature:

1. Delves, J.P., Martin, J.S., Burton, R.D. and Roitt, M.I. (Latest Edition) Roitt's Essential Immunology.
2. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (Latest Edition) Immunology
3. Strachan, T and Read, A (2018) Human Molecular Genetics
4. Jorde, L.B., Carey, J.C. and Bamshad, M.J. (2015) Medical Genetics.
5. Zar, J.H. (2013) Biostatistical Analysis
6. Pagano M., Gauvreau, K, (2000), Principles of Biostatistics.

Course Learning Outcomes:

Upon completion of the course, the students will have a good knowledge of the essential elements of the immune system, preparing them to engage further in this rapidly evolving field. Human genetics will impart knowledge about the human chromosome constitution that would help in applying basic principles of chromosome behaviour to disease context. The course also expected to give application-based learning of biostatistics, or the use of numerical techniques to extract information from data and facts. The students can apply this knowledge in their fields of research and higher education.

THEORY (GENERIC ELECTIVE)

Course Objectives: We are living in a golden age of biology. There is a vast domain of knowledge to teach and learn about biology especially zoology and its applications for the welfare of society. This optional paper caters to a wide domain including applied zoology, wild life ecosystem, ecology and medical zoology which have a significant contribution in recent times.	
ZGECT 201: Applied Zoology (For students other than Department of Zoology)	**Points 50**
Wildlife and Conservation	**Points 15** **Lectures**
Concept of Wildlife and its Conservation	
1. Categories of wild life.	3
2. Wild life and wild life habitat in India: Wild life wealth of India.	3
3. Wild life management: Distribution, status, habitat utilization pattern, threats and survival of – Royal Bengal Tiger, *Rhinoceros*, Olive Ridley Turtle.	3
4. National and International efforts for conservation: CITES, IUCN, CBD, Protected area concept.	3
5.Conservation of natural enemies of insect pest.	3
Ecological Principles and Application	**Points 15** **Lectures**
1. Concept of habitat and niche	2
2. Ecological principles.	2
3. Community ecology: nature of communities; levels of species diversity and its measurements.	3
4. Biogeographical zones of India.	2
5. Environmental management: Solid waste management; Bioremediation; Bioreactors in Environment monitoring.	2
6. Organic farming and vermicomposting.	2
7. Insect pollinators: Types and role in agriculture.	2
Medical Zoology	**Points 20**
1. Genetics of Human Diseases. Nutrigenomics, Pharmacogenomics and their applications.	5
2. Preliminary knowledge on zoonotic diseases.	5
3. Immunodiagnostics: Concepts of Innate and Humoral Immunity, Antigen Presentation, Antigen-antibody interactions, its application in medical diagnosis (Western Blot, ELISA, RIA, Elispot, FACS, Immunofluorescence.	10

Suggested Literature:

1. The Wisdom of the Hive. Thomas D. Seeley, Harvard University Press, 1995
2. Review articles published in various journals.
3. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons.
4. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd.
5. Bond, C. E. (1996). *Biology of Fishes*.2nd ed. Saunders Pub.
6. Pillay, T. V. R. and Kutty, M. N. (2005). *Aquaculture: Principles and Practices*. 2nd ed. Blackwell Publishing Ltd.
7. Parker, R. (2012). *Aquaculture Science*. 3rd ed. Delmar, Cengage Learning, USA.
8. Cunningham, W. P. and Cunningham, M. A., (2007). *Principles of Environmental Science: Inquiry and Applications*. 4th ed. Tata McGraw-Hill Company.
9. Dash, M. C., (2001). *Fundamental of Ecology*. 2nded. Tata McGraw-Hill Company.
10. Kormondy, E. J. (2002). *Concepts of Ecology*. 4th Indian Reprint, Pearson Education.
11. Odum, E. P. and Barret, G. W. (2005). *Fundamentals of Ecology*. 5th ed. Thompson Brooks/Cole.
12. Santra, S. (2005). E*nvironmental Science*. New Central Book Agency (P) Ltd.
13. Smith, T. M and Smith, R. L. (2006). *Elements of Ecology*. 6thed. Pearson Education.

Course Learning Outcomes: This part is a culmination of basic and applied skill-based zoology that has emerging scopes of jobs as biologist.

PRACTICAL (CORE)

Course Objectives:

The course is designed in such a way that the students will practically learn one or two anatomical features of a model chordate animal and will be able to explore the anatomy of various chordate groups in their future studies and research.

They will also be able to practically identify unknown taxa through taxonomic keys and will be able to erect new species/genus/family and make significant contribution to science in their future research and study.

ZCORL 205: Chordate Biology, Biosystematics and Taxonomy	**Points 25**
Anatomy of Chordates 1. Cranial nerves, arterial and venous system of teleosts. 2. Accessory respiratory organs of fish, dissection of carp showing interrelationship between gas (swim/ air) bladder and Weberian Ossicles. 3. Recording of a 12 lead ECG-its analysis and interpretation. **Biosystematics and Taxonomy** 4. Preparation of materials for taxonomic study; Identification of nematodes. 5. Identification, preparation of taxonomic keys and taxonomic studies of insects. 6. Collection, fixation and staining of protozoa for taxonomic studies.	

7. Identification from prepared slides. 8.Laboratory note book &Viva voce. **Excursion and collection of specimens**.	

Suggested Literature:

1. Mayr, E. and Ashlock, P. D. (1991). *Principles of Systematic Zoology*. 2nd ed. McGraw-Hill.
2. Quicke, D. L. J. (1993). *Principles and Techniques of Contemporary Taxonomy*. Blackie Academic and Professional.
3. Schmidt Nielsen, K. (1994). *Animal Physiology: Adaptation and Environment*. Low Price Cambridge Edition.
4. Kardong, K.V. (2010). *Vertebrates: Comparative Anatomy, Function, Evolution*. 4th Edition. Tata McGraw Hill.

Course Learning Outcomes:

Knowledge on the anatomy of any model chordate animal, particularly fish, will be of immense help for students in pursuing research and study in any field of animal science.

By learning the basic principles of taxonomic keys, the students can make significant contribution to science and society by discovering new taxa and also to explore the faunal diversity of any ecosystem.

Course Objectives:

Lab Course is intended to familiarize students with basic biochemical techniques to plan and carry out experiments. In addition, the course will also provide students with knowledge of identification of parasites and fish physiology which can facilitate.

ZCORL 206: Advanced Parasitology and Fish Biology	**Points 25**
Advanced Parasitology 1. Staining and mounting of platyhelminth parasites. 2. Protozoan parasites of freshwater fish and Insects of economic importance. 3. Identification of parasitic protozoans. **Fish Biology** 4. Urinogenital system of teleost. 5. Study of scales and otolith in fish age determination. 6. Display of pituitary gland of fish. 7. Histological study of pituitary glands, gills, kidney, liver, intestine, testis and ovary of fish (from prepared slides). 8. Study of museum specimens of fishes having electric organs and venomous organs. 9.Laboratory note book &Viva voce.	

Course Learning Outcomes:

Upon successful completion of this lab content students would be able to trained to diagnose, identify and detect some important parasites and also different fish physiological organs.

Course Objective:

This Laboratory course content comprises the items for hands on training of the students on

different techniques on Immunobiology, Human Genetics and Biostatistics.	
ZCORL 207: Immunobiology, Human Genetics and Biostatistics	**Points 25**
Immunobiology 1.Analysis of blood group A, B, AB, O and Rh factor. 2.Antigen antibody reaction; immunodiffusion. 3.Raising of antibody. 4.Identification of lymphoid organs. 5.Absolute eosinophil count (AEC)- immunological perspective. **Human Genetics and Biostatistics** 6. Demonstration of human chromosomes and preparation of karyotypes. 7.Study of chromosomal aberrations with respect to number, translocation, deletion etc. from the images provided. 8.Study of Micronuclei and sperm head anomaly. 9. Solving problems on linkage and chromosomal mapping; population genetics 10. Paired T-test on experimental data. 11. Chi square test for goodness of fit with a Mendelian frequency distribution. 12. Laboratory note book &Viva voce.	
Suggested Literature: 1. Daniel, W.W. 1983. Biostatistics: A Foundation for analysis in the Health Sciences. John Wiley and Sons, New York. 2. Dunn, O.J. and V.A. Clark. 2001. Basic Statistics: A primer for Biomedical Science. John Wilety and Sons, New York. 3. Goon, A.M., M.K. Gupta and B. Dasgupta. 1983. Fundamentals of Statistics. Vol.I.	
Course Learning Outcomes: The students are expected to gather practical knowledge on Antigen-antibody interactions, antibody generations and blood grouping factors and detection mechanism in human at the end of this course. The course will also deliver sound understandings on human chromosome groups, chromosomal aberrations and mapping of genes. Further, the course should help students on using the statistical principles choose suitable tools and techniques in collecting data, summarizing, analyzing, and interpreting them, at the same feel confident about facing questions and problems in medicine, public health or biology.	

SEMESTER-III

THEORY (CORE)

Course Objectives: Arthropods, the largest group of animals with approximately 1.3 million species on earth, play significant role in maintaining ecosystem balance. Together, they constitute the most important animal group in the form pests, pollinators, nutrient recyclers and vectors of many diseases. Moreover, it is immensely important to understand the vast diversity of animals and their evolution through course of time and also to understand the patterns and driving forces of such evolution. It is with this background, the course has been carefully designed for better understanding of the economically important arthropods, levels and threats of species diversity, and dynamics of organic evolution.	
ZCORT-309: Arthropod of Economic Importance, Concept of Biodiversity and Evolution	**Points 75**
Arthropod of Economic Importance	**Points 37** **Lectures**
1. Insect pests: Morphology, bionomics and control of- i) Stored grains: Stored rice grain moth (*Corcyra cephalonica*) and stored pulse beetle (*Callosobruchus chinensis*) ii) Field insect pests: Fall army worm (*Spodoptera frugiperda*), cardamom capsule borer (*Conoganthes punctiferalis*), jute semilooper (*Anomis sabulifera*).	**8**
2. Pest management: Mechanical; Chemical; Biological; Integrated.	
3. Lac culture: Life history of lac insect, culture method, lacprocessing, lac products, natural enemies of lac insect and their control.	**4**
4. Sericulture: Indigenous races, pure races and commercial races of mulberry silk moth; rearing of mulberry silk moth.	**8**
5. Parasitic insects and Acarines: a) General remarks on *Phlebotomous*, *Glossina*, *Tabanus* and head louse in relation to morphology, habit, habitat, life cycle and disease caused by them, mode of transmission.	**8**
b) General remarks on mites and ticks in relation to morphology, habit, habitat, life cycle and diseases caused by them.	**9**
Concept of Biodiversity and Evolution	**Points 38** **Lectures**
1. Levels of species diversity and relationship; geographic distribution of biological diversity; biological hotspots; measuring biodiversity; interrelationship between diversity measures; pattern of local and regional biodiversity.	5

2. Threats to species diversity; natural and human induced threats and vulnerability of species extinction; Red data book; rarity, endemism, effective and minimum viable population, fragmentation of population; problems of genetic diversity; bottleneck; genetic drifts; inbreeding depression.	
3. Biodiversity Resource Management, values and uses of biological diversity as source of foods, drugs and medicines.	5
4. Theories on relation between biodiversity and ecosystem function i. Species Complementarity ii. Sampling effect iii. Redundancy.	4
5. The economics of biodiversity and ecosystem function.	4
6. Landscape Ecology: a) Theories in landscape ecology. Hierarchy theory and the structure of the landscape, Percolation theory, The systems source sink, b) Scale and landscape, Scaling the landscape, Change of scale perception. Importance of parameters at different scales, c) Processes in the landscape: Disturbance, Fragmentation, Landscape connectivity, Corridors, d) Methods in landscape ecology, Spatial data processing, fractal geometry approach, urban ecology.	4 8
7. Remote sensing in landscape ecology, Geographic Information System, Spatially explicit population models (SEPM).	
8. Organic evolution: concept and evidences (comparative anatomy, embryology, biogeography, palaeontology, genetics, biochemistry and physiology).	4 4

Suggested Literature:

1. Atwal, A. S. and Dhaliwal, G.S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi.
2. David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.
3. Futuyma, D. J. (1986). *Evolution*, Sinauer Associates, Inc., Sunderland, USA
4. Hennig, W. (1966). *Phylogenetic Systematics.* University of Illinois Press, Urbana, Chicago, London, vii + 263 p.
5. Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.
6. Kitching, I. J., Forey, P. L., Humphries, C. J. and Williams, D. (1998). *Cladistics: Theory and Practice of Parsimony Analysis* (*Systematics Association Special Volumes*). 2nd ed. OUP Oxford.
7. Lull, R.S. (1917). *Organic evolution*. The Mcmillan company, New York.
8. Mullen, G.R. and Durden, L.A. (2009). *Medical and Veterinary Entomology*. 2nd ed. Academic Press.
9. Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological control of Insect pests.* Lewis Publishers.

Course Learning Outcomes:

Knowledge on the morphology, bionomics, and control measures of various economically

important arthropods, particularly insect pests and vectors, will be beneficial in planning better pest control strategies, economic growth, and management of insect vector borne diseases. Additionally, the knowledge on culture techniques like Apiculture, Sericulture, Lac culture will assist in the development of entrepreneurship. By learning the basic concepts of animal diversity and evolution, the students will better understand the fundaments of life processes and will be able to undertake advance research and study in the field of organic evolution, particularly microbes of human interest, and will be able to make significant contribution to science through new findings and discoveries.

Course Objectives: The course is designed not only to provide knowledge about various toxicants in our environment but also to know about its fate and interactions in our body. The course will provide detailed knowledge about various types of hormones and their receptors.	
ZCORT-310: Environmental Toxicology and Endocrinology	**Points 75**
Environmental Toxicology	**Points 37** **Lectures**
1. Toxicology of pesticides: Scope, division, toxicants and toxicity, LD50, LC 50 and ED50, Dose-response relationship; Carcinogenic, Mutagenic and Teratogenic effects, Method of testing chemicals on insect and evaluation of toxicity.	4
2. Group Characteristics and function of pesticides: Organochlorines, Organophosphates insecticides, Carbamates, Pyrethroids, other plant origin bio-insecticides, neonicotinoids and nitrogenous insecticides; fumigants; IGRs, attractants, repellents and anti-feedants. Properties of few individual insecticides i.e. DDT, HCH (BHC), Lindane, Endosulfan, Parathion, Malathion, Carbaryl, Cypermethrin, etc.	6
3. Toxicants of public health hazards: Pesticides, Heavy metals, Radiation, food and additives.	4
4. Toxicokinetics and toxicodynamics: Absorption, distribution, Metabolism, elimination, organ toxicity.	4
5. Mode of action: Central Nervous system, Acetylcholinesterase and unknown modes of action. Metabolism of insecticides: Phase I and Phase II reactions and metabolism of other pesticides.	4
6. Toxicological symptoms of Organochlorines, Organophosphorus, Carbamates, Pyrethroids, plant origin insecticides and other bio-insecticides.	4
7. Safer pesticides: Next generation molecules to be used as pesticides for plant protection and their chemistry.	3
8. Plant Allelochemicals: Types and its role in insect-plant interaction.	3

9. Plant secondary metabolites in insect response.	5
Endocrinology	**Points 38 Lectures**
1.Classification of hormones; general principles, nature of hormone receptors (cell surface receptors and intracellular receptors), and hormone signalling pathways (G-protein coupled receptors, Receptor Tyrosine Kinases, and steroid hormone signalling).	6
2. Biosynthesis, secretion and regulation of hormones: biosynthesis of Insulin, Post-Translational event and release.	6
3.Biosynthesis and function of steroid and thyroid hormones (T_3 and T_4) and their regulations.	5
4. Neuroendocrine system and neuro-secretion: neural control of glandular secretion; hypothalamic pituitary unit, neuroendocrine feedback	5
5. Physiological role of hormones: hormonal regulation of mineral metabolism and fluid volume	4
6. GI tract hormones: source, composition and function	4
7. Molecular basis of endocrinopathies: Disorders of pituitary hormone axis-thyrotoxicosis, hypothyroidism, Hashimoto's thyroiditis metabolic bone diseases, Cushing syndrome, Addison's diseases, androgen deficiency syndromes- testicular neoplasm, hormone-related cancers.	8

Suggested Literature:

1. Ernest Hodgson – A text book of modern toxicology, Wiley-Blackwell (latest edition).
2. Lindsay Murray, Mark Little, Ovidiu Pascu and Kerry Hoggett- Toxicology handbook, Churchill Livingstone, Australia, (Latest edition.
3. David A. Wright and Pamela Welbourn- Environmental toxicology, Cambridge University Press, (Latest edition).
4. Endocrinology- Fox T, Brooks A, Baidya B. JP Medical London (latest edition).
5. Jameson JL. Harrison's Endocrinology. McGraw Hill Education (latest edition).
6. Goodendocr man HM. Basic Medical endocrinology. Academic press (latest edition).
7. Endocrinology-Mac E Hadley and Jon E Levine. Pearson (latest edition).
8. Introduction to endocrinology- Chandra S Negi. PHI (latest edition).
9. General endocrinogy-Turmer CD and Bagnara JT. East-West press Pvt. Ltd. (latest edition).
10. Vertebrate endocrinology-Norris DO. Elsevier academic press (latest edition).
11. Basic endocrinology, an interactive approach-Neal JM. Blackwell Science (latest edition).
12. Endocrine physiology-Molina PE. McGraw Hill Lange (latest edition).

Course Learning Outcomes:

At the end of the course the students will be able to-

Understand basic concepts of toxicants, know different toxicological testing procedures. gather knowledge about fate and interaction of toxicants in our body, learn toxicants-induced damage of organs, develop the ability of critical thinking about plant allelochemicals, gather

concept of various hormones (neurohormones, local hormones etc.) & their receptors. Be able to understand deep knowledge about biosynthesis, structure & function of hormones and their mechanism of action.

THEORY (DISCIPLINE SPECIFIC ELECTIVE - MINOR)

Course Objectives: To acquaint the students with the Origin, Evolution and Distribution of major groups of fishes, Ornamental fish culture, Nutrition of fish and Aquaculture methods.	
ZDSE(MN)T 301: Applied Ichthyology	**Points 25** **Lectures**
1.Origin, Evolution and Distribution of major groups of fishes, Methods employed in Phylogenetic Studies and Fish Identification. 2.Ornamental fish culture: Background, classification, breeding of ornamental fish, common diseases and control. 3. Biology and culture of some: Blue green algae, diatoms, rotifers, chironomids, tubifex, brine shrimps. 4. Nutrition offish: Anatomical modification in relation to feeding habits, natural foods, prepared feed, types of feed, feed storage, energy and growth, food conversion ratio and food conversion efficiency, feed additives: Probiotics, prebiotics. 5. Aquaculture methods: concept and significance, Different systems of aquaculture for carps and shrimps: Extensive, Semi-intensive, Intensive.	5 5 5 5 5
Suggested Literature: 1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons. 2. Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed. industhanPub.Corp. John Wiley and Sons. 3. Lowe, H. (2005). *Beginner's Guide to Aquarium Fish and Fish Care*. Abhishek Press, New Delhi. 4. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd. 5. De Silva, S. S. and Anderson, T. A. (1995). *Fish Nutrition in Aquaculture*. Chapman and Hall, London. 6. Merrifield, D. L. and Ringø, E. (2014). *Aquaculture Nutrition: Gut Health, Probiotics and Prebiotics.* Wiley-Blackwell. 7. Srivastava, C. B. L. (1999). *Fish Biology*.Narendra Publishing House. New Delhi.	
Course Learning Outcomes: Students will be exposed to the Origin, Evolution and Distribution of the fishes. They will get idea about the Ornamental fish culture, fish nutrition and aquaculture methods.	

Course Objectives: To inculcate the essence of developmental biology with special emphasis for point to point understanding of the application of subject core in advance biological intervention.	
ZDSE(MN)T 302: Developmental Dynamics	**Points 25** **Lectures**
1. Common features of development: Genomic equivalence; cytoplasmic determinants; imprinting, Cloning of animals.	7
2. Techniques for the study of development: i) Cell labeling and tagging ii) Cell sorting.	8
3. Model organism *Xenopus*/ Zebra fish/ *C. elegans*: early embryonic development and major classes of molecules expressed, regional and genetic specification.	6
4. Stem cells: Application of Adult Stem Cells, iPS Cells; Stem cell niches; Trans-differentiation.	4
Suggested Literature: 1. Developmental Biology: Michael J.F. Barresi Scott F. Gilbert, (12 th Ed). 2. Principles of Development: Lewis Wolpert and Cheryll Tickle (4th Ed.).	
Course Learning Outcomes: After completing the course the students shall be able to elucidate the relationship of developmental biology strategies and their applicability in different forms of biology.	
Course Objectives: This course is designed to provide an invaluable foundation of human genome and genetic diseases at the molecular and biochemical level. The course aims to provide comprehensive look at the human genome through evolutionary studies and forensic science by learning concepts of Polymorphism, molecular phylogenetics, RFLPs and Bioinformatics etc.	
ZDSE(MN)T 303: Human Molecular Genetics	**Points 25** **Lectures**
1. Human population genetics and evolution: Basic attributes and polymorphic structures in human protein coding genes. Mitochondrial DNA polymorphism. Y-chromosome polymorphism and Single nucleotide polymorphism (SNP), Regulatory sequence evolution and transposon origin of functional sequences, Basic concept in molecular phylogenetics.	6
2. Genetics in forensic science: Protein comparisons, DNA comparisons, RFLPs, genetic fingerprinting, VNTRs, Genetic profiles. Unique correlation, Sociobiology, Altruism, Kin selection and inclusive fitness, Haplodiploidy, Imprinting phenomena.	6
3. Molecular and biochemical basis of genetic diseases: Autosomal (cystic fibrosis), X-linked (hemophilia A), Metabolic disorders (phenylketonuria); Mapping and identifying genes for monogenetic disorders; Investigation of complex diseases: Epidemiological	7

approaches, Linkage and association approach. 4. Human Genome: Human genome project and the age of genomics, Structure of Human Genome, Concepts and application of Bioinformatics.	6
Suggested Literature: 1. Strachan, T and Read, A (2018) Human Molecular Genetics 2. Strachan, T., Goodship, J. and Chinnery, P. (2014) Genetics and Genomics in Medicine. 3. Jorde, L.B., Carey, J.C. and Bamshad, M.J. (2015) Medical Genetics. 4. Mount, D. W. (2001), Bioinformatics: Sequence and Genome Analysis	
Course Learning Outcomes: This course is expected to deliver knowledge of how organisms, populations and species evolve, besides providing answer some of the most fundamental questions on human genome, disease and functions of gene.	
Course Objectives: The Forest Entomology course describes the importance of forest, types and distribution of forest in India, the interaction of nature, plants and insects in order to understand the seriousness of pest problem on forest plants and timber yielding plants, highlights various control methods to ensure plant protection by controlling soil and plant insect pests of important timber yielding trees and plants.	
ZDSE(MN)T 304: Forest Entomology	**Points 25** **Lectures**
1. Indian forest types, their distribution and importance, forest insects (pests) - damage and sign categories. 2. Insect pests of timber yielding trees (Sal – *Shorea robusta*; Teak –*Tectona grandis*; Mahogony- *Swietenia macrophylla*). Bionomics and nature of damage of Borers – *Hoplocerambyx spinicornis*, Defoliators – *Hapalia machaeralis*. 3. Soil insects and their damage to forest plants and their management. Role of insects in tropical forest ecosystem. 4. General issues in forest entomology: a) Insect damages in plantation vs natural forest, b) Pest problems in plantation of indigenous vs exotic species. c) Pest problems in monoculture and mixed plantations. 5. Management of tropical insect forest pests.	5 5 5 5 5
Suggested Literature: 1. Forests and Forestry, K.P. Sagreiya, (First edition 1 January 1967), National Book Trust, India. 2. Indian Forestry, K. Manikandan S. Prabhu, (7th edition 1 February 2021); Jain Brothers-New Delhi; Jain Brothers.	
Course Learning Outcome: Forest Entomology plays a major role in training students in understanding the importance of	

forest plants including timber yielding trees and their interaction with nature and different types of forest insect in contrast to manage forest vegetation from nuisance, invasive alien species seriously threaten forestry ecosystems, biodiversity, and cause significant economic losses.

Course Objectives:

The course examines the general biology, life cycles, modes of transmission, and pathogenesis of major parasites on global human health. The students are exposed to parasites that not only infect humans but also those of cattle animals.

ZDSE(MN)T 305: Medical and Veterinary Parasitology	**Points 25 Lectures**
1.*Leishmania donovani* and Leishmaniasis.	3
2.Structure, pathobiology prophylaxis and diagnosis of *Babesia* sp. *Anaplasma* sp. And *Theileria* sp.	4
3. *Trypanosoma cruzi* and Chagas disease	3
4. *Trichomonas foetus* in cattle.	3
5. Outline structure and life cycle of *Plasmodium* spp.	3
6. *Trichuris trichiura*– biology, epidemiology, pathogenesis, diagnosis and treatment.	3
7. Life cycle, biology, pathogenesis, epidemiology and control of *Loa loa*, *Dracunculus medinensis, Haemonchus contortus, Sarcoptes scabiei*.	6

Suggested Literature:

1. Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
2. Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata.
3. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed.
4. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts'Foundation of Parasitology*. 9th ed. McGraw-Hill International.

Course Learning Outcomes:

Upon successful completion of this course the students would be able to learn pathological changes associated with parasite infections and achieved a analytical view on the role of vectors and intermediate hosts in parasite transmission.

Course Objectives:

The course is planned to give comprehensive understanding of the technologies that are applicable to make better options as far as reproductive successes are concerned. This course will provide an overview of the reproductive health, the problems associated and the technologies that might be applied to overcome the problems.

ZDSE(MN)T 306: Reproductive Biotechnology	**Points 25 Lectures**
1.Cell culture laboratory design and equipments, media and reagents, animal cell culture techniques, concept of organoid culture.	7
2. Assisted Reproductive Technology and IVF.	6
3. An overview of cloning techniques, Nuclear transfer technology.	6
4. Gene Replacement and Transgeic Technology.	6

Suggested Literature:

1. Peer reviewed journal articles, monographs and reviews as and when recommended.
2. Endocrine and reproductive physiology, 4th edition, edited by Bruce A. White and Susan P. Porterfied, Copyright © 2013 Elsevier Inc.
3. Progress in Molecular Biology and translational science, Vol.143 gonadotropins from benchside to bedside, edited by T. Rajendra Kumar, 2016 ISBN: 978-0-12- 801058-7, Elsevier Inc.2018
4. Fertility and Assisted Reproductive Technology (ART), 7th Edition Theory, Research, Policy, and Practice for Health Care Practitioners Edited by: Stevenson, Eleanor L., PhD, RN | Hershberger, Patricia E., Published: January 2016
5. Animal Cell Culture: Essential Methods Editor(s): John M. Davis First published:31 March 2011Print
6. Introduction to Cell and Tissue Culture Theory and Technique. Authors: Mather, Jennie P., Roberts, Penelope E. Springer Publication

Course Learning Outcomes:

Students of this class will be able to understand the importance of technology in the maintenance and upgradation of reproductive health in human and animals. This course will make them suitably knowledgeable about cell culture techniques, cloning techniques, preservation of eggs and sperms, artificial reproductive technologies to undertake the therapeutic research jobs in various pharmaceutical companies as well as in hospitals in addition to the IVF centres.

THEORY (DISCIPLINE SPECIFIC ELECTIVE – MAJOR I)

Course Objectives: Fisheries Resources of Indiaintroduces the young students about the Indian fish diversity. The paper fisheries Resources and aquatic organism gives information about the various aquatic resources viz. rivers, lakes, reservoirs. Various physiological aspects of fish viz. Swimming and Buoyancy, homeostatis, Growth and Metabolism, stress and Sensory Physiology etc. are in this paper, Fish Physiology.	
ZDSE(MJ)T 301: Fish and Fisheries	**Points 50** **Lectures**
Unit-I **Inland Capture Fisheries Resources of India, Limnology & Aquatic Organisms**	
1. Fisheries of Lakes and Reservoirs: Distribution, commercial exploitation of major freshwater lakes and reservoirs, brackish water lakes. Major threats to freshwater systems, including pollution and sand mining. Impact of large dams and fragmentation on river ecology and fishery. River continuum concept. Environmental flow. Pollution and eutrophication. Climate change implications on freshwater systems. Biomonitoring.	**10**
2. Cold water fisheries: Definition, principal zones of cold water fisheries of India, important cold water fisheries of India, food and feeding habit.	**2**
3. Limnological characteristics of lentic and lotic water systems, morphoedaphic index.	**3**
4. Aquatic Organisms: Distribution patterns of planktonic organisms. Phytoplankton-zooplankton relationships. Adaptations of planktonic organisms to different aquatic habitats. Periphytic communities. Benthos. Bio-indicators and Biomonitoring.	**10**
Unit-II **Fish Physiology**	
1. Swimming and Buoyancy: Propulsive systems, swimming modes, strategies for buoyancy regulation.	**5**
2. Internal Transport and Homeostasis: Gas exchange, cardiovascular physiology, osmoionic regulation, Acid-base balance.	**5**
3. Growth and Metabolism: Regulation of food intake by neuropeptides and hormones, environmental factors and feed intake, digestive physiology and nutrient digestibility in fishes.	**5**
4. Sensory Physiology and Coordination: Photoreception, Olfaction, Perception of mechanical and electrical stimuli, neuroendocrine coordination.	**5**
5. Stress Physiology: Effect of abiotic, biotic and xenobiotic stresses on fish	**5**

immunesystem, Adaptation to extreme temperature, Hypoxia.	

Suggested Literature:

1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons.
2. Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed. HindusthanPub.Corp. John Wiley and Sons.
3. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd.
4. Bond, C. E. (1996). *Biology of Fishes*. 2nd ed. Saunders Pub.
5. Hoar and Randall. *Fish Physiology,* Volumes I-XV (1969-onwards, Academic Press)
6. Jayaram, K. C. (1999). *The Freshwater Fishes of the Indian Region*.Narendra Publishing House, New Delhi.
7. Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed., HindusthanPub.Corp. John Wiley and Sons.
8. Fish Physiology. (Series) W.S.Hoar and D.J. Randall (Series Eds). Academic Press, UK.
9. The Physiology of Fishes. 2013. Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK.

Course Learning Outcomes:

Students will learn about the Fisheries Resources of India, aquactic organism, cold water fisheries and limnology. And the information about the various aquatic resources viz. rivers, lakes, reservoirs. The knowledge of physiology equips the young generation for the propagation of fish.

Course Objectives:

This course is prepared to provide knowledge about the complex organization in the eukaryotic cell and the molecular mechanisms of the cellular processes that exist in all cell types. The course is designed to impart knowledge and understanding of this rapidly changing field of modern biology and fast evolving tools for whole genome analysis, high throughput genome, transcriptome and proteome sequencing. Further the students will be able to learn insight into the cell signalling mechanisms, cell-cell and cell-matrix interactions and the organizations of microbial genomes to their genetic expressions mechanisms.

ZDSE(MJ)T 301: Cytogenetics and Molecular Biology	**Points 50 Lectures**
Unit I **Genomics, Transcriptomics and Proteomics**	
1. Eukaryotic chromosome organization: Packaging of DNA in eukaryotic cell; chromatin structure; histones and non-histones; nucleosome; higher order structure of chromatin; domains and scaffold; organization of active chromatin and assembly of chromatin during replication. 2. Mapping genomes: Cytogenetics mapping, Physical mapping, Molecular marker and map, In situ hybridization, Optical mapping, Sequencing genomes: high-throughput sequencing, strategies of sequencing,	**7**

recognition of coding and non-coding regions and annotation of genes, quality of genome-sequence data, base calling and sequence accuracy. 3. Transcriptomics and Proteomics: Transcriptome, Transcriptome analysis, DNA microarray expression profiling, data processing and presentation, RNA sequencing; Proteomics – Proteomes, expression analysis, Post-translational modification, 2D Electrophoresis, Protein Sequencing, Biomarkers, protein structure analysis, protein-protein interaction, Protein-DNA interaction. 4. Protein folding and processing Chaperones and folding; enzymes and protein folding, protein cleavage, glycosylation, attachment of lipids.	**7** **7** **7**
Unit II **Microbial Genome and Cell Signalling**	
1. Microbial genetics: organization of prokaryotic genome; single stranded DNA phages; RNA phages; cycle and gene expression in SV40 virus; Lytic and lysogenic phage morphogenesis in λ Phage; bacterial conjugation, transduction and transformation. 2. Cell signalling and gene regulation: Modes of cell communications; Signalling molecules and receptors; Signal transduction and amplification; Response to signals-Gene expression, Cellular growth and metabolism, Cell death; DNA damage and repair signalling; Extracellular matrix and cell signalling; Signalling crosstalk. 3. Signalling defects, disease and therapeutic drugs: Signalling defects in human disease-Alzheimer's disease, Diabetes mellitus and Cystic fibrosis; Pathogens (bacteria, virus) target of host signalling, Human disease and therapeutic drugs targeting GPCR, JAK-STAT, and TLR signalling pathways.	**7** **7** **7**
Suggested Literature: 1. Strachan, T and Read, A (2018) Human Molecular Genetics 2. Geoffrey M. Cooper (2019) The Cell-A Molecular Approach 3. James D. Watson,Tania A. Baker, Stephen P. Bell (2018) Molecular Biology of Gene 4. Harvey F Lodish (2018) Molecular Cell Biology 5. Joanne Willey, Kathleen Sandman, Dorothy Wood (2019) Prescott's Microbiology	
Course Learning Outcomes: The student would be able to understand genetic organisation and underscore the importance through genomics, transcriptomics and proteomics. The students are expected to appreciate the importance of cell-cell adhesion and the extracellular matrix in cellular organizations. The course will enhance the students' understanding about the genome composition and the functions of microbes.	

Learning Objectives:

This course is meant to impart advanced knowledge of hormones, hormone receptor interactions, different signalling cascades initiated by hormones and their diverse mechanisms of actions. The roles of special categories of hormones like pheromones, prostaglandins etc can stress upon the diverse actions of hormones starting from invertebrates to vertebrates. The course also intent to deal with the growth hormones, hormones associated with stress, calcium homeostasis and metabolism in great detail. In a nutshell, this course aims at providing the students a holistic knowledge about endocrine ligands, receptors, signalling and various different types of hormones and their functioning.

ZDSE(MJ)T 301: Endocrinology and Reproductive Biology	**Points 50 Lectures**
Unit-I **Hormone & Hormone Receptors**	
1. Chemical nature of hormones, Identification, quantification and purification and characterization of hormone receptors: cell surface receptors, intracellular receptors and orphan receptors	**6**
2. Hormone-receptors interactions: Saturation binding curve, reversibility of hormone-receptor interaction and Scatchard plot.	**6**
3. Posterior pituitary hormones and neuroendocrine modulation.	**6**
4. Pheromones: Chemical nature, production, use.	**6**
Unit-II **Endocrine Physiology & Metabolism**	
1. Physiological action of GH, growth factors, Chemical nature, function and mechanism of action of EGF, IGFs, FGF, TGFα and TGFβ.	**5**
2. Hormonal regulation of calcium and phosphate metabolism: Parathyroid gland, related to kidney, bone and intestine; mechanism of action of PTH, thyroid gland and calcitonin, mechanism of action of calcitonin, Vitamin D_3 in bone mineral metabolism, PTHrP, mechanism of action of PTHrP.	**5**
3. Hormonal regulation of energy metabolism	**5**
4. Adrenocorticotropic hormones: biosynthesis, structure and function	**4**
5. Adrenomedullary hormones biosynthesis structure and functions	**4**
6. Prostaglandin type, chemical nature, biosynthesis and major action.	**5**

Suggested Literature:

1.The course is designed to develop deep understanding on evolution of endocrine physiology, Endocrinology by L.J. De Groot, 5th ed., 2006.

2. Vertebrate Endocrinology by David O. Norris Elsevier Academic press, 2007.

3. Hand Book of Physiology published by American physiological Society by Oxford University Press, Section 7: Multiple volumes set, 1998.

Course Learning Outcomes:

This course will help in advancing knowledge on endocrine systems employing the hormone-receptor interactions. Further, Endocrine Physiology during stress, calcium homeostasis,

growth will equip the students to know how residue of pharmaceuticals, estrogenic compounds coming from indiscriminate use of polythene and other pollutants present in the ecosystems are severely affecting the hormone secretion and leading to various endocrine disorders.

Course Objectives:

The course aims to give an overview basic idea of parasitic protozoans and its evolutionary significance with emphasize on origin of parasitic protozoans. It enlightens on the evolutionary aspect of host-pathogen interactions leading to host specificity. It will enable students to explore a number of important diseases, along with the diverse protozoans and arthropods responsible for them.

ZDSE(MJ)T 301: Parasitology and Immunology	**Points 50** **Lectures**
Unit-I **Classification and General Organization**	
1. Classification of Apicomplexa with examples.	6
2. Origin of parasitic protozoa.	6
3. Some general consideration of protozoan parasites: a) Population & Communities b) Ecological niche c) Temperature and Climate d) Mutualistic intestinal Protozoa.	7
4. Arthropods as blood suckers and disease transmitters.	6
Unit-II **Protozoology & Host-parasite Interaction**	
1. Parasite-host specificity with reference to protozoan parasites.	6
2. Genome organization in *Plasmodium*.	6
3. Molecular adaptation of antigenetic variation in *Plasmodium.*	7
4. Host parasite interaction.	6

Suggested Literature:

1. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
2. Eric S. Loker, Bruce V. Hofkin Parasitology: A Conceptual Approach,
3. Kuby Immunology, Richard, Thomas, Barbara, Janis , W. H. Freeman and Company [Latest edition].
4. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed.Lea and Febiger, Philadelphia.
5. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts'Foundation of Parasitology*. 9th ed. McGraw-Hill International.
6. Smyth, J. D. (1994). *Animal Parasitology*. 3rd ed. Cambridge University Press.
7. William E. Paul, Lippincott Williams & Wilkins. Fundamentals of Immunology, Publishing.
8.

Course Learning Outcomes:

Upon successful completion of this course the students assimilate the classroom knowledge for applied aspects of parasitology and public health. The course will provide an understanding of the diversity and biology of parasites, besides the epidemiological aspects of different parasitic diseases would be explored and students will able to gain knowledge regarding the mode of transmission of parasitic diseases and preventive measures.

Course Objectives:

Insects form the most important component of our ecosystem, both terrestrial and aquatic. They perform some indispensible ecological functions such as nutrient recycle, pollination, seed dispersal, enhancement of soil structure and fertility, as bio-control agent, and also provide a major food source for other organisms. Besides, some of them are regarded as serious pests of agriculture while some are notorious vectors of human diseases.

In this specialized field of insect science, the students will initially learn the classification and evolution of this large group along with some significant features of these tiny creatures in the 3rd semester. The course emphasizes on understanding the fundamentals of insects with regard to their biology, natural history and succinct features.

ZDSE(MJ)T 301: Entomology	**Points 50 Lectures**
Unit-I **Classification and Structural Organization**	
1. Classification upto order in general and up to families of selected orders: Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera and Orthoptera. Characters of important families of insects of economic importance.	6
2. Origin of insects: Different theories.	5
3. Insect fossils: a) Source of evidence; b) Extinct insect orders and their characters.	4
4. Origin and evolution of wing-couplings.	4
5. Integument: a) Chemical properties, functions; b) Changes during moulting.	4
6. Mechanoreceptors.	3
7. Chemoreceptors	3
UNIT-II: **Anatomy and Physiology**	
1. Digestion a) Microorganisms: Types, their role and transmission, b) Digestion of special substances; c) Nutritional requirements.	8
2. Structure and function of neuroendocrine system.	3
3. Composition of urine, mechanism of excretion through malpighian tubules.	4
4. Pheromones: Source, chemical nature, transmission, perception and application.	3 3

5. Osmoregulation.	

Suggested Literature:

1. Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th ed. Cambridge University Press.
2. David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.
3. Gillott, C. (2005). *Entomology*. 3rd ed. Springer Online Book - ISBN-13 978-1-4020-3183-0 (e-book).
4. Gullan, P. J. and Cranston, P. S. (2014). *The Insects – an outline of Entomology*. 4th ed. Blackwell Publishing.
5. Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.
6. Klowden, M. (2013). *Physiological Systems in Insects,* 3rd ed. Academic Press.
7. Richards, O. W. and Davies, R. G. (1977). *Imms: A General Text Book of Entomology.*10th ed. Vol. 1 and 2. Chapman and Hall.
8. Romoser, S. W. and Stoffolano, J. G. (1998). *The Science of Entomology*. 4th ed. McGraw Hill.
9. Speight, M. R., Hunter, M. D. and Watt, A. D. (2008). *Ecology of Insects: Concepts and Applications*. 2nd ed. Wiley-Blackwell.

Course Learning Outcomes:

Knowledge on the classification and diversity of insects along with their evolution pattern will be beneficial planning better pest control strategies and economic growth of the country. Additionally, the knowledge on insect physiology will be advantageous in designing and discovery of bio-control agents and management of vector borne diseases.

By learning the basic concepts of insect science, the students will be one step ahead regarding their scope in joining the agricultural industry and other research institutes concerned with discoveries of insecticides (NCL, CIL, IARI, IPFT, IGSMRI etc.) and taxonomy of insects (ZSI, BSI, FRI).

Course Objectives:

The prime objective is to introduce to the students contemporary and sophisticated molecular techniques used in cell and developmental biology that could assist them to understand the basic underlining principles and methodology involved therein.

ZDSE(MJ)T 301: Cell and Development Biology	**Points 50 Lectures**
Unit-I **Visualizing Cellular and Sub Cellular Components**	
1**.** Fixation, staining and application: i) Solutions: Definition, Composition, Expression, Ideal &non-ideal Solution. ii) Chemical & physical effects of some primary fixatives: Formalin, alcohol, picric acid, acetic acid.	

iii) Source and chemical composition of some dyes: Basic fuchsin, carmine, hematin, hematoxylene, eosin. iv) Chemical composition and properties of fluorescence dye, principle and application: DAPI, Propidium Iodide, Acridine orange, Rhodamine, DCFDA, Hoechst	16
2. Study of subcellular organelle under light microscopy and electron microscopy.	4
3. Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, PET scan, safety guidelines.	6
Unit-II **Tools and Techniques in Cell Biology**	
1. Chromatography: TLC, Column chromatography, Affinity chromatography.	6
2. DNA sequencing method.	3
3. Comet assay, FRAP assay, FRET assay.	6
4. Immunological assay: Monoclonal and polyclonal antibody generation and hybridoma technology.	6
5. *In vitro* mutagenesis and gene knockout.	6
Suggested Literature: 1. Developmental Biology: Michael J.F. Barresi Scott F. Gilbert (12th Ed). 2. Principles of Development: Lewis Wolpert and Cheryll Tickle (4th Ed.) 3. Genetics: A molecular approach. 3rd Ed. Peter J. Russell. Pearson International Edition. 4.The Cell: A molecular Approach. Geoffrey M. Cooper and Robert E. Hausman. 3rd Ed. ASM Press Washington, DC. 5. Kuby Immunology by Thomas J. Kindt. 6. Principles and Techniques of Biochemistry and Molecular Biology - by Wilson/ Walker 7. Methods in Molecular Biology. Gene Knockout Protocols. Martin J Thymms and Ismail Kola.	
Course Learning Outcomes: At the end of the course the students should have an overview of the recent advance techniques, their principles and their application methods which would draw a keen in them towards higher academic pursuit.	

THEORY (DISCIPLINE SPECIFIC ELECTIVE – MAJOR II)

Course Objectives: Culture techniques of fish form freshwater aquatic resources and fish pathology are included in this paper. Fish breeding and biotechnologyare also included in this paper.	
ZDSE(MJ)T 302: Fish and Fisheries	**Points 50** **Lectures**

Unit-I Aquaculture	
1. Different systems of aquaculture: Monoculture, polyculture; Definition, importance and types of Integrated fish farming.	6
2. Design, criteria and construction of fish farms (carps): principles of selection, soil characteristics and other parameters	6
3. Preparation and management of ponds for culture: use of chemical fertilizers and organic manures, control of weeds, pests and predators, fish toxicants, control of aquatic insects.	6
4. Fish pathology: Development of immune system, cells and tissues of the fish immune system, Humoral and cell mediated immune defense, Fish antibody molecules and their effector functions. Host-parasite interaction: immune-evasion mechanisms of fish pathogens. Environment and fish health; fin-fish diseases and their control.	8
Unit-II Fish Breeding and Biotechnology	
1. Role of pituitary and gonadotropins, natural breeding, environmental control of spawning, natural collection offish seeds, bundh breeding. Induced breeding care of brood fish, secondary sex characters, hypophysation, HCG, pheromones, GnRH, LH-RH and their analogues, new generation drugs, induced breeding and multiple breeding, environmental factors, limitations-inbreeding depressions.	6
2. Concept of biotechnology; bio-fertilization; bioprocessing and bio-filtration in aquaculture; cryopreservation of garnets; transgenesis.	6
3. Reproductive physiology: Reproductive strategies, Environmental factors regulating reproductive cycles, Hormonal and molecular mechanisms of oogenesis and spermatogenesis, Ovulation, spawning and spermiation, Fertilization and development of fish.	6
4. Animal cell culture: Primary culture, cell lines. Fish cell lines. Hybridoma technology. Diagnosis of genetic disorders. DNA probes. Gene therapy.	6

Suggested Literature:

1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons.
2. Beaumont, A. R. and Hoare, K. (2003). *Biotechnology and Genetics in Fisheries and Aquaculture*. Blackwell Publishing.
3. Dunham, R. A. (2004). Aquaculture and fisheries biotechnology: genetic approaches. CABI Publishing, Cambridge, USA.
4. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd.
5. Reddy, P. V. G. K., Ayyappan, S., Thampy, D. M. and Krishna, G. (2005). Textbook *of Fish Genetics and Biotechnology*. ICAR, New Delhi.
6. Chakraborti, N.M.; Chakraborty, P. P. and Mandal, S. C. (2010). *Biology, Breeding and Farming of Important Food Fishes.* Narendra Publishing House. New Delhi.

7. Evans, D. H. (1998). *The Physiology of Fishes*. CRC Press.
8. Hoar and Randall. *Fish Physiology,* Volumes I-XV (1969-onwards, Academic Press)
9. Bond, C. E. (1996). *Biology of Fishes*.2nd ed. Saunders Pub.
10. Evans, D. H. (1998). *The Physiology of Fishes*.CRC Press.
11. Kumar, R. (2011). *Biotechnology and Genetics in Fisheries and Aquaculture*. Arise Pub., Delhi.
12. Pillay, T. V. R. and Kutty, M. N. (2005). *Aquaculture: Principles and Practices*. 2nd ed. Blackwell Publishing Ltd.

Course Learning Outcomes:

All the basic information gathered in this paper will be utilized in the ZEl 301 paper of fish and fisheries. The study of culture techniques of various aquatic organisms helps in the production of healthy food for human consumption in a sustainable manner and also in employment generation. The students will be exposed to fish pathology and the modern immunological technique that is the need of the day to control disease related problems in the field.

Course Objectives:

The goal of this course is to provide students with education and training that enables them to learn the various types of mutation, molecular mechanism of DNA repair and their contribution towards onset of disease like human cancer. Further the objective of this course is to impart knowledge about the human chromosome especially sex chromosomes, their anomalies and impact on human. The application of basic principles of genetics in behavioural development and defects as well as the effects of various environmental factors on gene expression and phenotypic changes will also be covered in this course.

ZDSE(MJ)T 302: Cytogenetics and Molecular Biology	**Points 50 Lectures**
Unit I. **Cancer, Mutagenesis and DNA repair**	
1. Cancer: Clonal origin of Cancer; The nature of cancer; Warburg effect; Cancer stem cell concepts; Genetics and molecular basis of Cancer-Oncogenes, Tumor Suppressor genes, DNA repair genes and Apoptotic genes; Tumor microenvironment and promotion; Tumor progression angiogenesis, invasion and metastasis; Cancer and environment-physical, chemical, biological carcinogens, Cancer therapy-radio-, chemo- and immuno-therapy.	10
2. Mutations and mutagenesis: Types of mutation; biochemical basis of mutations; mutagenesis; spontaneous and induced mutation; reversion as a means of detecting mutagens and carcinogens.	8
3. DNA repair and retrieval: Repair of spontaneous and induced mutations; mechanism of DNA repair; repair by direct reversion; excision repair; SOS response.	8

Unit II **Human Cytogenetics and Behavioural genetics**	
1. Human genetics: karyotype and sex chromosomes; sex determination; role of Y-chromosome; sex mosaics; sex chromosome anomalies; sex influenced and sex limited genes.	8
2. Behavioural genetics influence of single defects on behaviour; Genetic analysis of behaviour in experimental animals, chromosome anomalies and insight into human behaviour.	8
3. Environmental effects and gene expression: effects of external and internal environment; phenocopies; twin studies; concordance and discordance; identical and fraternal twins.	8
Suggested Literature: 1. Strachan, T and Read, A (2018) Human Molecular Genetics 2. Geoffrey M. Cooper (2019) The Cell: A Molecular Approach 3. James D. Watson, Tania A. Baker, Stephen P. Bell (2018) Molecular Biology of Gene 4. Harvey F Lodish (2018) Molecular Cell Biology. 5. Robert A. Weinberg (2014) The biology of cancer.	
Course Learning Outcomes: The course will deliver the students to correlate phenotype with genotype, understand genetic interaction and their molecular basis of interactions. They will also know how mutations in genes can lead to diseases and provide an edge to pursue a career in the field of cancer biology.	

Learning Objectives: The goal of this course is to provide students with education and training to understand the different techniques associated with endocrine research at molecular levels. This course aims at in-depth understanding of the various hormone induced signalling cascades which are associated with tumorigeneses and developmental anomalies.	
ZDSE(MJ)T 302: Endocrinology and Reproductive Biology	**Points 50** **Lectures**
Unit-I **Techniques in Endocrine Research**	
1. Gel electrophoresis PCR, DNA-Protein interaction: electrophoretic mobility shift assay (EMSA),	4
2. Recombinant DNA technology–application in endocrine research, recombinant hormone production.	4
3. Principles and techniques of Southern, Northern, Western Blotting and Eastern Blotting and application.	4
4. Fluorescence technology: Fluorescence/ Confocal/ Super Resolution Microscopy, Flow cytometry (FACS) and Fluorescence Resonance Energy Transfer (FRET).	8

Unit-II **Endocrine Signalling and Metabolism**	
1. Signaling of peptide hormone a). G-protein types, G-Protein coupled receptors and their effectors- mechanism of receptor binding, Types of Receptor Tyrosine kinases (RTKs), Signaling with RTKs: Auto-phosphorylation of RTKs, Role of adapter protein and guanine nucleotide exchange factors inactivation of Ras, JAK-STAT Signaling pathway	12
2.mTOR signaling and metabolic disorders**.**	8
3. MAP kinase pathway, multiple MAP kinase pathways.	3
4. Thyroid hormones: biosynthesis, mechanism of action, regulation and metabolism of thyroid hormones; incidence of pathophysiology; thyroid hormone resistance; autoimmunity and thyroid disorder.	3
5. Steroid and steroid hormone signalling: structure of steroid and sterol, steroid hormone signaling, steroid hormone receptor: structure and types.	4
Suggested Literature: 1. Hadley Mac. E.- Endocrinology. 2. Chinoy, N.J. Rao, M.V., Desarai, K.J. and High land, H.N. – Essential techniques in reproductively physiology and Endocrinology. 3. Lodishetal- Molecular Cell Biology. 4. Zarrow, M.X., Yochin J.M. and Machrthy, J.L. – Experimental Endocrinology.	
Course Learning Outcomes: Students will be experts in techniques associated with endocrine research. They would also have fair knowledge on hormonal signalling associated with tumorigenesis. This course will provide students an edge to pursue a career in the field of Endocrinology in diagnostic centres associated with understanding endocrine anomalies.	

Course Objectives: The course aims to give an overview of basic ideas of parasitism and parasitic lifestyles includes drug resistance and parasite evasion. It will enable students to explore a number of important diseases, along with the diverse helminthes and worms responsible for them. The students learn about transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment and control of major parasites. The students are exposed to various non-pathogenic diseases also.	
ZDSE(MJ)T 302: Parasitology and Immunology	**Points 50** **Lectures**
Unit-I: Helminthes	
1. Classification of helminths.	6
2. Origin and evolution of parasitic helminth.	6
3. Life cycle pattern in trematoda, cestoda and nematode.	8
4. Biology, pathogenesis and control of: *Fascioloa hepatica*, *Echinoccocus*	

granulosus and *Loa loa*.	8
Unit-11: Epidemiology and Protozoa	
1. Leishmaniasis with reference to drug resistance.	4
2. Immunity in human trypanosomiasis.	4
3. Epidemiology: General and landscape Malaria, *Leishmania* and Filaria.	5
4. Nosology in relation to protozoa.	5
5. Nutrition of parasites.	4

Suggested Literature:

1. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
2. Kuby Immunology, Richard, Thomas, Barbara, Janis , W. H. Freeman and Company
3. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.
4. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts'Foundation of Parasitology*. 9th ed. McGraw-Hill International.
5. Schmidt, G. D. and Roberts, L. S. (2001). *Foundation of Parasitology*. 3rd ed. McGraw Hill Publishers.
6. William E. Paul, Lippincott Williams & Wilkins. Fundamentals of Immunology, Publishing [Latest edition].

Course Learning Outcomes:

Upon successful completion of this course the students would be able to learn about transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment and control of major parasites like protozoa and helminth. The course has been structured in a way that the students assimilate the classroom knowledge for applied aspects of protozoology, helminthology and public health.

Course Objectives:

As stated earlier in paper ZET 301, insects constitute one of the key components of our ecosystem in the form of pests, vectors, and masters of ecological functioning.

The course emphasizes on the key concepts of insect reproduction, hormonal regulation, and different behavioral activities. These concepts will help in better understanding of insect population growth along with reasons of increase in pest and vector insects of human concern.

ZDSE(MJ)T 302: ENTOMOLOGY	**Points 50 Lectures**
Unit I: Reproduction and Development	
1. Different types of reproduction, and accessory reproductive organs.	6
2. Castration, oviposition, factors controlling fertility and fecundity.	4
3. Metamorphosis a) Hormonal control of metamorphosis, factors affecting	

metamorphosis. c) Reversal of metamorphosis, d) Prothetely and metathetely. 4. Hormonal control of reproduction. 5. General idea (Upto the formation of three germinal layers) on embryonic development.	8 4 8
UNIT II: Insect Response and Behaviour	
1. Parental care: Types; examples. 2. Polymorphism and polyphenism; examples from different orders; significance. 3. Insect predation and parasitism: a) Prey and host location, b) Acceptance, c) Manipulation, d) Selection and specificity of host/prey. 4. Insect societies: a) Subsociality and eusociality: b) Evolution of eusociality 5. Insect defence: Defence by hiding, secondary lines of defence, mechanical defence; chemical defence (classification, nature and source of chemicals); defence by mimicry; collective defence.	4 4 4 4 4

Suggested Literature:

1. Atwal, A. S. and Dhaliwal, G.S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi.

2. Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th ed. Cambridge University Press.

3. David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.

4. Gillott, C. (2005). *Entomology*. 3rd ed. Springer Online Book - ISBN-13 978-1-4020-3183-0 (e-book).

5. Gullan, P. J. and Cranston, P. S. (2014). *The Insects – an outline of Entomology*. 4th ed. Blackwell Publishing.

6. Hoy, M. A. (2003). *Insect Molecular Genetics– An introduction to principles and Applications.*2nd ed. Academic Press.

7. Nation, J. L. Sr. (2016). *Insect Physiology and Biochemistry*. 3nd ed. CRC Press. Taylor and Francis.

8. Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological control of Insect pests.* Lewis Publishers.

9. Richards, O. W. and Davies, R. G. (1977). *Imms: A General Text Book of Entomology.*10th ed. Vol. 1 and 2. Chapman and Hall.

10. Speight, M. R., Hunter, M. D. and Watt, A. D. (2008). *Ecology of Insects: Concepts and*

Applications. 2nd ed. Wiley-Blackwell.

11. Srivastava, K. P. and Dhaliwal, G.S. (2013). *A textbook of Applied Entomology*. 1st ed. Kalyani Publishers, New Delhi.

Course Learning Outcomes:

Knowledge on the reproduction and hormonal regulation in insects will be extremely advantageous in planning pest and vector control strategies and also in discovery of bio-control agents.

By learning the concepts of insect science stated in this paper, the students will be among the first choice for recruiters from the agricultural industry and other research institutes concerned with discoveries of insecticides (NCL, CIL, IARI, IPFT, IGSMRI etc.) and taxonomy of insects (ZSI, BSI, FRI).

Course Objectives:

To provide a broad and comprehensive outlook to understand the mechanisms involved in growth and development of complex organisms focusing on both classical experiments and modern molecular and genetic techniques which would render an invaluable foundation for other aspects of biology as well as medicine.

ZDSE(MJ)T 302: Cell and Developmental Biology	**Points 50 Lectures**
Unit-I: Developmental Ramifications	
1. Morphogenesis: Morphogenetic processes, cell size and shape, Cell fusion, Cell death, Cell adhesion, morphogenetic movements, cell sorting, morphogenetic field, and regionalization.	9
2. Teratogenesis: Genetic teratology, Environmental teratology, Developmental mechanism, Contribution of teratology to Developmental Biology.	7
3. Ageing: Cellular basis of aging, Causes of aging, Free Radical Theory of Aging, role of anti-oxidant enzymes in the process of aging, aging related disorders.	9
Unit-II: Differentiation	
1. Differentiation: i. Cell aggregation and differentiation in *Dictyostelium* ii. FTIR based identification of early lineage commitment in differentiating cells. iii. Reversibility of differentiated state, criteria for dedifferentiation, metaplasia and transdifferentiation, modulation.	9
2. Neural crest cell migration based differentiation	7
3. Developmental regulatory networks (vertebrates): Signalling and development, Molecular mechanism of dorsoventral axis formation and three signal model of mesoderm induction in *Xenopus*.	9

Suggested Literature: 1. Developmental Biology: Michael J.F. Barresi Scott F. Gilbert,(12 th Ed) ISBN: 9781605358246 2. Principles of Development: Lewis Wolpert and Cheryll Tickle (4th Ed.)
Course Learning Outcomes: The students would build a foundation for a better understanding of the different processes involved in early development, their regulatory mechanism and different factors involved therein which would guide them to implant the knowledge of major milestones associated with cell and developmental biology.

THEORY (SKILL ENHANCEMENT COURSE)

Course Objectives: The course is designed to impart knowledge to students regarding the prospects of entrepreneurship development after completing their course of study, apart from regular job or higher study. The students will learn the techniques of various animal cultures and breeding and could directly incorporate that with the industry.	
ZSECT 301: Industrial/Economic Zoology	**Points 25**
1. Pisciculture: History, definition, scope and significance of aquaculture. Different aquaculture systems. Aquaculture – Problems and prospects in India 2. Apiculture: Social organisation of honey bee; selection of bees; methods of bee keeping; industrial application. 3. Sericulture: Mulberry silk worm; rearing of silkworms; sericulture industry; recent efforts sericulture in India 4. Lac culture: Host plant and cultivation of Lac; recent advancement in Lac cultivation; Lac industry in India. 5. Laboratory animal breeding: Controlled propagation of laboratory animals, animal breeding techniques.	5 5 5 5 5
Suggested Literature: 1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons. 2. Chakraborti, N.M.; Chakraborty, P. P. and Mandal, S. C. (2010). *Biology, Breeding and Farming of Important Food Fishes.* Narendra Publishing House. New Delhi. 3. The Honey Bee. James L. Gould and Carol Grant Gould, Times Books, 2002. 4. Economic Zoology by B. S. Jangi, CRC Press 5. Economic Zoology by K R Ravindranathan, Dominant Publishers	

6. Economic Zoology by G. S. Shukla, Wordery publishers	
Course Learning Outcomes: On completion of the course, the students will be able to undertake certain startups in the field of industrially and economically important fish, insects and animal culture, rearing and breeding. As they will gain expertise on various techniques of pisciculture, apiculture, sericulture, lac culture and animal breeding, they could be among the first choice for recruiters from firms and institutes concerned in this field.	

PRACTICAL (CORE)

Course Objectives: It is immensely important for students to be able to practically identify important insect pests and to take on further research on management of these insect pests after completing their course. Basic hands on training on People's Biodiversity Register and various techniques for estimation of density, frequency and abundance of animals in different ecosystems will also be useful for students in planning proper conservation strategies in their future ventures.	
ZCORL 309: Arthropod of Economic Importance, Concept of Biodiversity and Evolution	**Points 25**
Arthropods of Economic Importance 1. Identification of - i) Pests and their damage symptoms of agricultural crops and stored grains from theoretical course. ii) Insect predators/parasitoids of economically important insects (Honey bee/ Silkworm). 2. Sericulture (Mulberry): Silk worm, silk cocoon.	
Concept of Biodiversity and Evolution 3. Preparation of PBR. 4. Assessment of density, frequency and abundance of plants/ animals in a community using various techniques i.e. transect, quadrate analysis etc. 5.Laboratory note book &Viva voce.	
Suggested Literature: 1. Atwal, A. S. and Dhaliwal, G.S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi. 2. David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing. 3. Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological control of Insect pests.* Lewis Publishers. 4. Kormondy, E. J. (2002). *Concepts of Ecology*. 4th Indian Reprint, Pearson Education.	
Course Learning Outcomes:	

Knowledge on the morphology of various insect pests and damage symptoms caused by them will be beneficial in planning better pest control strategies and economic growth. Additionally, the knowledge on Sericulture technique will assist in the development of entrepreneurship in this field.
By hands on training in PBR and techniques of population study, the students will be able to undertake advance research and study in the field of animal conservation.

Course Objectives: The course is planned to give comprehensive practical knowledge on different types of toxicity testing.

ZCORL 310: Environmental Toxicology and Endocrinology	**Points 25**
Environmental Toxicology 1. Determination of LC50 / LD50 and 95% Confidence limit of anytoxicant to a selected aquatic/ terrestrial organism. 2. Effects of toxicants on blood parameter offish, serum LDH assay. 3. AAS/ HPLC for residue analyses of toxicant.	
Endocrinology 4. Performance of castration and ovariectomy in rat /mice. 5. *In vitro* study of motility of epididymal spermatozoa. 6. Estrous Cycle Stages from rat/ mice: Preparation and Identification 7.Laboratory note book &Viva voce.	

Suggested Literature:

1. Practical toxicology- David Woolley and Adam Wooley. CRC Press (Latest edition).
2. A practical guide to toxicology and human health risk assessment-Laura Robinson. Wiley.
3. Advanced practical zoology- P.S. Verma & PC Srivastava. S. Chand & Co. Ltd.
4. An advanced Laboratory Manual of Zoology. Podder T, Mukhopadhyay S, Das SK. Trinity Press.
5. Advanced Practical Zoology. Sinha JK, Chatterjee AK & Chattopadhyay P. NCBA.

Course Learning Outcomes:

At last, the students will be able to: Estimate various types of toxicity testing in test organisms and learn about harmful effects of toxicants on laboratory animals.

PRACTICAL (DISCIPLINE SPECIFIC ELECTIVE - MAJOR)

Course Objectives: Course objective is to provide hands on training on limnological parameters, identification of fishes, fish breeding and fish histology. Objective of seminar presentation course is to grow the presentation technique of the students on a recent development of aquaculture research.	
Fish and Fisheries	
ZDSE(MJ)L 301: LAB	**Points 50**
1. Assessment of Field studies (Fish Farm, Market, Co-operative societies etc.). 2. Limnological parameters of water, Organic carbon, Plankton, Algal Bloom, Bottom Biota. 3. Preparation of permanent stained slides of skin, gills, spleen, digestive tract (stomach and intestine), liver, endocrine glands and kidney gonads of fish. 4. Determination and comparison of hemoglobin content of water-breathing and air breathing fish. 5. Determination of gonadosomatic index and hepatosomatic index and their relations with regard to gonadal and body growth. 6. Preparation of pituitary extracts and induced breeding. 7. Identification of fish. 8. Determination of fecundity in major carp and catfish. 9. Visit to a fish farm and fish hatchery. 10. Submission of prepared slides. 11. Submission of Laboratory note book, field report and Viva-voce. 12.Seminar	
Course Learning Outcomes: All the practical information of aquaculture gathered in this paper. This study will to their practical life and also in research career. The students adapted with scientific research, review of research papers. They will be familiar with any type of professional interaction.	

Course Objectives: This course content comprises the items for hands on experience of the students on different techniques on Cytogenetics and Molecular Biology. In seminar presentation, is usually done in the form of review of the relevant literature in the respective field.	
Cytogenetics and Molecular Biology	
ZDSE(MJ)L 301: LAB	**Points 50**
1. Somatic mitotic chromosome preparation of mouse and/or fish by air-drying	

technique and study of chromosome aberration. 2. Study the differences in number, shape and size of chromosomes in normal vs. tumorcells, or normal vs. irradiated cells. 3. Setting up of genetic crosses and solving genetical problems. 4. RFLP/RAPD- genetic polymorphism (demonstration). 5. Southern blot (demonstration). 6. Plasmid DNA isolation: minipreps; Agarose gel electrophoresis of isolated plasmid. 7. Purification of DNA from an agarose gel. 8. Submission of Laboratory note book and Viva-voce. 9. Seminar	
Course Learning Outcomes: After successful completion of the course the candidate should be able get basic knowledge of the molecular and cytogenetics tools for studying the characteristic structural features of each chromosome the organizations in normal, mutant and cancer cells. It will help them to analyse human karyotype to detect gross genetic changes such as chromosomal deletion, duplication, translocation or inversion etc. which provides a source of diagnostic information for specific birth defects, genetic disorders and even cancers. They will also have an idea of isolating plasmid DNA, purification and studying genetic polymorphism in population practically and by solving numerical problems. The Seminar presentation will give them a foundation in preparing for their higher studies, data presentation and communication skills development.	

Course Objectives: The goal of this course is to provide students with the training to work on understanding and identifying endocrine glands, different techniques associated with endocrine research at molecular levels and have an exposure to techniques of hormone assay by ELISA. Seminar presentation course aims at developing presentation skills of the students on a research topic related to present day Endocrinology research. The objective of the course is to make students accustomed with reading original scientific research works, review works and develop a presentation out of the same. They are encouraged to present and have an interaction with the audience including the examiners.	
Endocrinology and Reproductive Biology	
ZDSE(MJ)L 301: LAB	**Points 50**
1. Preparation of cryo-sections and histochemical demonstration of lipid / cholesterol / 3β-HSD in adrenal of mammal. 2. Effects of epinephrine on blood glucose level in rats. 3. Oral glucose tolerance test (OGTT) or insulin tolerance test (ITT) in rats. 4. Demonstration of steroid RIA/ELISA. 5. Thyroid and adrenalectomy in mice/rat.	

6. Protein Extraction. 7. SDS-PAGE for separation of protein and Western Blotting. 8. PCR and Real-Time PCR demonstration. 9. Submission of Laboratory note book and Viva-voce 10. Seminar	
Suggested Literature: Original research papers and review papers from NCBI/ Pubmed	
Course Learning Outcomes: Students will be well-trained to work in research fields associated with basic and clinical endocrine research. Also, this training will allow them to pursue careers in diagnostic clinics associated with understanding endocrine disorders or other clinical manifestations at molecular level. Students will develop the concept of searching scientific articles, making presentations, deliver the same and interact with the audience by answering to the various queries of the audience. Students are expected to become confident about presenting a scientific work and handle forthcoming interviews in their careers.	

Course Objectives: Lab Course is intended to familiarize students with basic staining and impregnation techniques to plan and carry out experiments. The course will also provide students with knowledge of identification of various myxozoan, ciliophorans and blood parasites which can facilitate.	
Parasitology and Immunology	
ZDSE(MJ)L 301: LAB	**Points 50**
1. Standardization of Microscope: Drawings of protozoan to scale: of protozoan specimen, measurements. 2. Fixation, staining and identification of a cephaline gregariana of annelid & insect. 3. Blood parasites of birds and fishes. 4. Myxozoan parasites of fishes. 5. Ciliate parasites of fishes. 6. Coccidia of birds. 7. Parasites of toads and frogs. 8. Disease transmitting arthropod parasites. 9. Identification. 10. Submission of Laboratory note book and Viva-voce. 11. Seminar	
Course Learning Outcomes: Upon successful completion of this lab content students would be able to trained to diagnose, identify and detect some important parasites. Students will able to gain knowledge regarding	

various laboratory instruments, preparations of chemical and also adopt some preservations technique.

Course Objectives: This lab course is intended to introduce the students to dissection of insects and give them a hands-on training to explain the anatomy and physiology of the specimen.	
Entomology	
ZDSE(MJ)L 301: LAB	**Points 50**
1. Dissection: Cockroach (male reproductive, sympathetic), Blue bottle fly (digestive, nervous), Grasshopper (nervous, reproductive), *Chrysocoris* (digestive, nervous, reproductive), Honey bee (digestive, nervous, reproductive, sting apparatus), wasp (digestive, nervous, sting apparatus), Butterfly (digestive, nervous, reproductive), Housefly (digestive, nervous), Mosquito (digestive). Termite (digestive) (subject to availability of specimens). 2. Mounting: Types of antenna, genitalia, wings, legs, mouth parts, tympanum, internal organ system of available insects. 3. Morphometry: I) use of micrometers, ii) use of camera lucida. 4. Taxonomic key preparation. 5. Physiological experiments: i) Estimation of digestive and other enzymes ii) Studies on haemocytes iii) Determination of chitin. 6. Toxicology: i) Toxicological appliances (sprayers, dusters etc.) . 7.Submission of Laboratory note book and Viva-voce. 8.Seminar	
Course Learning Outcomes: Students will be trained to work in different areas of entomology. Students will develop ideas on current entomological research and projects. They will also be trained to deliver scientific lectures.	

Course Objectives: To impart hands on training to undertake several molecular techniques so that they built in them the capacity to translate the experience into good research practice.	
Cell and Developmental Biology	
ZDSE(MJ)L 301: LAB	**Points 50**
1.Isolation and Separation methods: Nucleic acid isolation, its quantitative measurement and fragmentation assay. 2. Agarose gel electrophoresis for Comet assay. 3. Demonstration of techniques: TLC and Column Chromatography. 4. Examination and submission of slides of chick liver, kidney, testis / ovary, brain of different stages of development.	

5. Methods of detection: i) Histochemical detection of lipid or glycogen, ii) Estimation of Sorbitol dehydrogenase enzyme as a marker for testes development. 6. Submission of Laboratory note book and Viva-voce.	

Course Learning Outcomes:

Students are expected to relate basics of molecular biology tools of their theoretical knowledge with that of practical training. Additionally, this training would also help them to explore new techniques which would elicit their urge towards deeper understanding and reaching out for troubleshooting on their own.

SEMESTER–IV

THEORY (CORE)

Course Objectives:

The major objective of this core paper is to understand languages of animals by means of their behavioral study.

The paper microbiology deals with various types of microorganisms and their ability to produce disease in animals and human. Besides, this course is also to make awareness among the young students about various disease-causing microorganisms.

ZCORT-411: Animal Behaviour and Microbiology	**Points 75**
Animal Behaviour	**Points 37** **Lectures**
1. Introduction to animal behavior: History, foundation, approaches and methods	**5**
2. Learning and memory: Forms of learning and memory, learning and habitat selection - migration, navigation and orientation	**5**
3. Kinship: Relatedness, inclusive fitness. selfishness, altruism	**4**
4. Conflict: Sexual selection, aggression, competition dominance, Infanticide.	**5**
5. Game theory - Models and strategies.	**5**
6. Communications: Channels, functions, origin and modification of signal, signal receiving mechanism.	**6** **7**
7. Evolution of feeding behavior: optimal foraging theory.	
Microbiology	**Points 38** **Lectures**
1. History of microbiology.	2
2.Bacteriology: Structure and function of capsule, pili, flagella, cell wall, cell membrane, outer-membrane, chromosome and plasmid.	6
3. Virology: Structural organization of viruses, Prions and viroids, Lytic cycle of bacteriophages, Lysogeny and lysogeny control, lysogenic conversion, induction and significance.	6
4. Animal and Veterinary Microbiology:	

Microbial interactions with animals (marine and freshwater invertebrates, ruminants), symbiotic light production, sulfide-based mutualism.	8
5. Disease causing microbes: *Escherichia coli* and *Streptococcus* spp.	6
6. Culture techniques: Microbial nutrition and growth; types of culture media, sterilization of culture media; culture techniques: pure cultures.	2
8. Industrial microbiology: Microbial fermentation; production and commercialization.	8
9. Mode of transmission, pathogenicity and prevention of microbial diseases: Air-borne (Tuberculosis), Food and waterborne (Typhoid) and Arthropod borne (JE and Yellow fever), SARS-COV 2 (infection and concept of herd immunity).	

Suggested Literature:

1. Animal Behavior. Alcock J. Sinauer Associate Inc. USA (latest edition).
2. Animal behavior. Drickamer LC. Vessey SH. Mc. Graw-Hill (latest edition).
3. Recent trends in animal behavior. Ruhela A and Sinha M. Oxford (latest edition).
4. Animal Behavior. Mathur. Rastogi Pub (latest edition).
5. Microbiology an introduction. Gerard JT, Berdell RF and Christine LC. Pearson Education. (Latest edition)
6. Essentials of microbiology. Amita J &Parul J. Elsevier (Latest edition).
7. Text book of microbiology and immunology. Parija SC. Elsevier (Latest edition).
8. Text book of microbiology. Ananthanarayan R and Paniker CKJ. Universities press.
9. Microbiology with diseases by taxonomy. Bauman Robert W. Pearson Education (latest edition).
10. Medical microbiology and parasitology. Nagoba BS & Asha P. Elsevier India. (Latest Edition).

Course Learning Outcomes:

After successful completion of this course the students will be able: to understand animals' complicated behaviour, degree of inter-specific and intra-specific relationship among the animals, to know the facts behind learning and memory.

Learn to maintain their hygienic environment and know about biology of microorganisms and their interaction with animals and human.

Course Objectives:

Major objective of this core paper is to introduce to the students contemporary molecular techniques for manipulation of genome that could assist them towards advanced understanding of biological processes in broad range of host organisms. Lectures will specifically address the historical standard techniques, principles of various different fundamental processes, and gradual evolution and context dependent medications of molecular techniques for their extended use. The student should be able to understand standard and system-specific gene manipulation approaches ranging from bacteria to

mammals. A prior exposure to recombinant DNA technology at undergraduate will help in the accelerated learning.

Tools and Techniques course is meant to impart knowledge to students on different techniques in Biological Sciences. The course is designed in such a way that the students get to understand the various different techniques that are used in biology; from the classical age-old methods to the present-day modern versions of various techniques. The course also deals with bioinformatics which would provide the students the confidence to use computer programs/ softwares for the daily design of experiments, data collection, and analysis of results.

ZCORT-412: Molecular Biology, Biotechnology, Tools and Technique	**Points 75**
Molecular Biology and Biotechnology	**Points 37** **Lectures**
1. Transcriptional gene expression: positive and negative regulations, RNA polymerases, promoters and regulatory sequences, activators and repressors of transcription, transcription initiation by RNA polymerases, regulation of transcription factor activity, elongation and termination of transcription.	**5**
2. Post-transcriptional gene control: Regulation of Pre-mRNA Processing; Splicing, Types of introns and their splicing, evolution of introns, catalytic RNA, alternative splicing and proteome diversity, micro RNA and other non-coding RNAs.	**5**
3. RNA Transport, Translation and stability of RNA: Structure of nuclear membrane and nuclear pore complexes, processes of nuclear import and export and their regulation; Degradation of RNA; Translational machinery and translational control - energetics of amino acid polymerization, tRNAs and their modifications, aminoacyl tRNA synthetases, accuracy during aminoacylation of tRNA, regulation of initiation of translation in eukaryotes, elongation and its control, inhibitors of translations.	**6** **6**
4.Basic recombinant DNA techniques: cutting and joining DNA molecules, restriction modification systems, various enzymes used in recombinant DNA technology, restriction maps and mapping techniques; nucleic acid probes, blotting techniques, DNA fingerprinting, foot-printing, methyl interference assay. Polymerase chain reaction– methods and applications.	**8**
5. Basic biology of cloning vectors: plasmids, phages, single stranded DNA vectors, high capacity vectors, retroviral vectors, expression vectors and other advanced vectors in use. Gene cloning strategies: methods of transforming E. coli and other cells with rDNA; methods of selection and screening of transformed cells; construction of genomic	**7**

and cDNA libraries; strategies of expressing cloned genes; phage display. 6. Manipulating genes in animals: gene transfer to animal cells, genetic manipulation of animals, transgenic technology, application of recombinant DNA technology; genetically modified organisms: gene knockouts, mouse disease models, gene silencing, gene therapy, somatic and germ- line therapy, Genome manipulation-CRISPR-Cas9 System.	
Tools and Technique	**Points 38** **Lectures**
1.Techniques for Cell Study: i. Basic Concepts of Microscopy: Magnification, Resolution, Limit of Resolution, Chromatic Aberrations. Types of microscopies: Bright Field Microscopy, Dark Field Microscopy, Phase Contrast Microscopy and Differential Interference Contrast Microscopy: Fluorescent Microscopes, Confocal microscopy. ii. Electronic Imaging Systems- Electron Microscopy, TEM Vs. SEM. Different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy. iii. Basic concept of flow cytometry. 2. Cell Fractionation Methods: i) Ultracentrifugation ii) Gradient Centrifugation. 3. Separation of Cell Constituents: i) Chromatography: ion exchange; gel filtration and HPLC. ii)Electrophoresis-PAGE, SDS-PAGE (One and Two dimentional). 4. Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques. 5. Spectroscopy: UV- spectroscopy, Circular Dichroism, surface plasma resonance methods. 6. Blotting Methods: Southern, Northern & Western blotting. RFLP, RAPD and AFLP techniques. 7. Pesticide formulation. 8. Database search tool; Sequence alignment and database searching; Computational tools and biological databases, NCBI, EMBL, PDB,Sequence similarity tools; Blast and FASTA Phylogenetic analysis with the program PHYLIP, DISTANCES, and GROWTREE. Basics of designing a microarray, image analysis and normalization, annotations.	8 4 4 4 4 4 5 5

Suggested Literature:

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA [Latest edition].
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK.
3. Cell and Molecular Biology. DeRobertis and De Robertis
4. Molecular Biology of the Gene, 2017, James D. Watson, A. Baker Tania, P. Bell Stephen (Author), Gann Alexander, Levine Michael, Losick Richard
5. Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition, ISBN-13: 9780136043027
6. Principles of Genetics, 7th Edition, D. Peter Snustad, Michael J. SimmonsISBN: 978-1-119-14228-7 2015
7. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 2018, ISBN: 9781316677056
8. Biochemistry Laboratory: Modern Theory and Techniques, Latest Edition, Rodney Boyer, Pearson Prentice Hall™ is a trademark of Pearson Education, Inc.ISBN-10: 0-13-604302-X, ISBN-13: 978-0-13-604302-7

Course Learning Outcomes:

After successful completion of the course the candidate should be able to design and comprehend experimental strategies for alteration of genes and gene products in variety of organisms.

The students will be able to have a comprehensive understanding about the techniques widely used in biological research and clinical understanding. At the end of the course, they would gain knowledge about the techniques and experiments that contributed to the understanding of molecular mechanisms of the cellular processes and be able to draw parallels between the physiological processes at the cellular and organismic levels. They will have in depth understanding of this rapidly changing field of modern biology and fast evolving tools and techniques for analysis of macromolecules, cells as well as understanding how bioinformatics can act as an efficient research tool.

THEORY (DISCIPLINE SPECIFIC ELECTIVE - MINOR)

Course Objectives:

The course Agricultural Entomology describes the interrelationship of nature, plants and insects in order to understand the magnitude of pest infestation on field crops before and after harvesting, insect pest morphology, bionomics, and enlightenment on different management strategies to ensure plant protection by controlling insect pests. The course describes concept of economic decision levels for pest population, potentiality of natural enemies in pest management.

ZDSE(MN)T 407: Agricultural Entomology	**Points 25 Lectures**
1. Important insect pests of cereals, pulses, vegetables, spices and condiments, beverages and fibre crops	5
2. Morphology, bionomics and management of:	
a) Rice Yellow stem borer (*Scirpophaga incertulas*).	
b) Rice brown plant hopper (*Nilaparvata lugens*)	
c) Sugar cane top borer (*Scirpophaga nivella*)	
d) Tea mosquito bug (*Helopeltis theivora*)	
e) Diamondback moth (*Plutella xylostella*)	5
f) Brinjal fruit and shoot borer (*Leucinodes orbonalis*)	
3. Plant protection techniques	5
4. Natural enemy diversity of agricultural pests in India and their potentiality	5
5. Economic decision levels for pest population;	
a) Concepts of economic levels	5
b) Dynamics of economic injury levels	
c) Calculation of economic decision levels using economic levels	

Suggested Literature:

1. Agricultural insects pests of the tropics and their control, Hill, D. S., Cambridge University Press, UK
2. Agricultural pests of South-East Asia and their management - A.S Atwal & G.S. Dhallwal
3. Concepts of IPM, Norris, Caswell-Chen and Kogan, Prentice-Hall, USA
4. Entomology & Pest Management, Pedigo, L. P.,Prentice Hall, New Jersey, USA
5. Insect Plant Biology, Schoonhoven, L. M., van Loon, J.A., &Dicke, M., Publisher Oxford University Press, USA
6. Interrelationship between insects and Plants, Jolivet, P., CRC Press, USA

Course Learning Outcomes:

Agricultural Entomology plays vital role in training students in understanding relationship of nature, plants and insects to ensure plant protection in agricultural field. The course study makes the students capable to identify different field crop pests and their damage symptoms, pest management techniques and beneficial role of natural enemies in pest management.

Course Objectives:

The objective of this course is to give a basic knowledge on molecular basis of cancer in

general to the students of this paper. In addition to that this course will give a vivid idea on pharmacogenomics , a field of medical science where genomic understanding will meet the need of pharmacology and strategic approach to deal different diseases including cancer. The last item is based on the most recent development of material science i.e. nanotechnology and its application in dealing with drug delivery and disease management by using nanoforms.

ZDSE(MN)T 408: Cancer Biology and Medical Genetics	**Points 25 Lectures**
1. Multistep tumorigenesis; Cell immortalization; Differences of normal cells and cancer cells; cell transformation and factors for cell proliferation; DNA and RNA tumor viruses.	5
2. Chromosomal abnormalities and molecular basis of cancer; Knudson's two-hit hypothesis in tumorigenesis; Genome instability in cancer;Epigenetics of Cancer; Cancer diagnosis, screening and treatment.	5
3. Genetic disease diagnosis and treatment: Application of medical genetics; Genetic Testing, Cytogenetic, Biochemical and Molecular; Gene therapy.	5
4. Pharmacogenomics - Concepts of Pharmacogenomics; Pharmacogenetics in disease prognosis and treatment, response and toxicity; Nutrigenomics; Personalized medicine.	5
5. Concept of nanotechnology and nanomedicine in cancer treatment.	5

Suggested Literature:

1. Human molecular genetics. T Strachan and A P Read CRC press fifth edition
2. Molecular cell biology. H Lodish, CA Kaiser et al WH Freeman and Company Seventh edition.
3. Nanotechnology: advances and real-life application. C Bhargava, A Sachdeva CRC press 2020 First edition
4. Handbook on nanotechnology application. K Faungnawakij et al Elsevier publication 2020 first edition

Course Learning Outcomes:

This course will decipher current knowledge on disease treatment including cancer.

Course Objectives:

The course has been design to cover several diagnostics and treatment strategies used in medical sciences in the light of embryological perspectives

ZDSE(MN)T 409: Medical Embryology	**Points 25 Lectures**
1. Medical implications : Infertility- Diagnostic infertility, causes of infertility	5
2. Assisted Reproductive Technologies: Sperm and ova bank; Artificial Insemination donor (AID); in vitro fertilization (IVF), procedures, variations of IVF, Success rates and complications; Gamete Intrafallopian transfer (GIFT), Intracytoplasmic sperm Injection (ICSI), Surrogate mothers.	5

3. Genetic errors of human development- Down syndrome, Fragile X syndrome, Turner's Syndrome.	5
4. Future of medicine: Differentiation therapy, gene therapy (Ex Vivo and In vivo), germ line gene therapy.	5
5. Techniques used in Medical Embryology :i) Amniocentesis ii) Chorionic villus sampling iii) Ultrasonography iv) DNA Finger printing v) Karyotyping	5

Suggested Literature:

1. Developmental Biology: Michael J.F. Barresi Scott F. Gilbert,(12 th Ed).
2. Principles of Development: Lewis Wolpert and Cheryll Tickle (4th Ed.).
3. Principles of Genetics. 3rd Ed. D. Peter Snustad and Michael J. Simmons. Wiley Publication.
4. iGenetics: A molecular approach. 3rd Ed. Peter J. Russell. Pearson International Edition.
5. Biology of human reproduction. Ramon Pinon Jr. University Science Book publishers.

Course Learning Outcomes:

The students shall have an overall idea in the area of medical sciences which have been explored in diagnostic and therapeutic application in embryologic stage.

Course Objectives:

To enable the students to know about the Stock Improvement of fish, Non conventional aquaculture technology, Pheromones and reproductive behaviour, Physiology of fish migration and behaviour and Coastal aquaculture.

ZDSE(MN)T 410: Aquaculture Technology	**Points 25 Lectures**
1. Stock Improvement: Induced breeding and bundh breeding, sex reversal and sterility, Selective breeding, Androgenesis and Gynogenesis, Polyploidy, Hybridization, Shell fish reproduction: Endocrine control of reproduction, role of neurotransmitters.	4
2. Non conventional aquaculture technology: Raceways and recirculatory system, Cages and pen culture, Wastewater aquaculture Organic aquaculture, Aquaponics and hydroponics, Biofloc culture.	4
3. Pheromones and reproductive behaviour, parental care. Regulation of seasonal reproduction: Role of environment (photoperiod, temperature, rainfall), Role of hypothalamo-hypophyseal system and pineal gland, role of peripheral endocrine system.	4
4. Physiology of fish migration and behavior: Behavioral response to the environment. Circadian rhythm. Hormones in communications, pheromones, concept on fish behavior and regulatory mechanism.	4
5. Coastal aquaculture: Status of coastal aquaculture in India, *Culture of prawn*: major cultivable species, techniques of larval rearing, growout technology.	4

Culture of shrimp: major cultivable species, Reproduction and rearing Grow out of shrimp.	5

Suggested Literature:

1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons.
2. Beaumont, A. R. and Hoare, K. (2003). *Biotechnology and Genetics in Fisheries and Aquaculture*. Blackwell Publishing.
3. Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed. Hindusthan Pub. Corp. John Wiley and Sons.
4. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd.
5. Chakraborti, N.M.; Chakraborty, P. P. and Mandal, S. C. (2010). *Biology, Breeding and Farming of Important Food Fishes.* Narendra Publishing House. New Delhi.
6. Lagler, K. F., Bardach, J. E., Miller, R. R. and Passino, D. R. (1977). *Ichthyology*.2nd ed. John

Course Learning Outcomes:

At the completion of Aquaculture Technology, students will be able to:

K now about different technology of Aquaculture that will help to their research activity and also in practical life if they are engage in fish farming related activity.

Course Objectives:

The course will provide detailed knowledge about various types of hormones and their mechanism of action.

ZDSE(MN)T 411: Hormone and Signal Transduction	**Points 25 Lectures**
1.Wnt, Hedgehog, TGFβ, Notch signalling pathways.	4
2.Subclasses of nuclear receptor ligand, Nuclear Receptor Signalling Mechanism.	4
3.Hormones in tumorigenesis.	4
4.Immune response and cancer therapy with special emphasis on hormonal therapies.	4
5. Neuroendocrine regulation of immune system; Stress hormones and immune responses; Melatonin.	4
6. Neuroendocrine disorders; genetic versus environmental cause.	5

Suggested Literature:

1. Vertebrate endocrinology-Norris DO. Elsevier academic press (latest edition).
2. Basic endocrinology, an interactive approach-Neal JM. Blackwell Science (latest edition).
3. Endocrine physiology-Molina PE. McGraw Hill Lange (latest edition).
4. Medical immunology-VirellaG. Informa Health care(latest edition).
5. Immunology-Kindt TJ, Goldsby RA, Osborne BA &Kuby J. WH Freeman & Co.

Course Learning Outcomes:

At the end of the course the students will –gather concept of various types of hormones & their receptors, be able to understand deep knowledge about hormone signalling and know

about neuroendocrine disorders as well as its regulation by immune system.

Course Objectives: The course examines the general biology, life cycles, modes of transmission, and pathogenesis of major parasites on global human health. The students would be able to learn about transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment and control of major protozoan, helminths and arthropod parasites.

ZDSE(MN)T 412: Parasites and Diseases	**Points 25 Lectures**
1. Primary amoebic meningoencephalitis.	4
2. Important Myxozoan genera of fishes - Structure and life history of any *Myxobolus* sp.	4
3. Important genera of fish parasitic ciliates -*Icthyopthirius* sp.	4
4. Some common helminthes of freshwater fishes and their life cycle patterns: a)*Proteocephalus* sp., *b)Camallanus* sp.	4
5. Structure, Pathobiology prophylaxis and diagnosis of causative agents of filariasis.	4
6. Parasitic insects: *Cimex lectularius and Xenopsylla cheopis*.	5

Suggested Literature:

1. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
2. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.
3. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts'Foundation of Parasitology*. 9th ed. McGraw-Hill International.
4. Schmidt, G. D. and Roberts, L. S. (2001). *Foundation of Parasitology*. 3rd ed. McGraw Hill Publishers.

Course Learning Outcomes:

Upon successful completion of this course the students would be able to learn pathological changes associated with parasite infections and achieved a analytical view on the role of vectors and intermediate hosts in parasite transmission.

THEORY (DISCIPLINE SPECIFIC ELECTIVE – MAJOR I)

Course Objectives: To enable the students to know about the Fishing crafts, gears, modern technology, Environmental Impact and Post-harvest technology. To make the students understand the fishing technique, environmental impact and Post-harvest technology.	
ZDSE(MJ)T 403: Fish and Fisheries	**Points 50** **Lectures**
Unit-I **Fishing Crafts, Gears, Modern Technology and Environmental Impact of Aquaculture**	
1. Crafts: Terminology of fishing boats; Inland and Marine crafts, types, mechanization of crafts, trawlers, techniques of trawling.	**7**
2. Gears: Basic knowledge of mesh aid knots, fishing gear materials, different types of nets and their operation, Rods and lines.	**7**
3. Remote sensing: Concept, sonar, radar; Fishways and screens. Role in marine fisheries resource management and exploitation.	**7**
4. Environmental Impact of Aquaculture: Aquaculture wastes and future developments in waste minimization, environmental consequences of hyper-nutrification.	
Extension services: Basic principles and emerging issues of extension, Role of information and communication technology.	**8**
Unit-II **Post-harvest technology**	
1. Spoilage of fish- microbial changes, changes in amino acids, protein, oil, Breakdown products, rigor mortis	**7**
2. Principles and methods of fish preservation,, Problems associated with fish preservations, processing and curing offish, Qulaity control in fish processing industry.	**7**
3. Fish by products and marketing of fish by-products.	**7**
Suggested Literature: 1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons. 2. Beaumont, A. R. and Hoare, K. (2003). *Biotechnology and Genetics in Fisheries and Aquaculture*. Blackwell Publishing. 3. Dunham, R. A. (2004). Aquaculture and fisheries biotechnology: genetic approaches. CABI Publishing, Cambridge, USA. 4. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd. 5. Lagler, K. F., Bardach, J. E., Miller, R. R. and Passino, D. R. (1977). *Ichthyology*.2nd ed. John Wiley & Sons, New York. 6. Kumar, R. (2011). *Biotechnology and Genetics in Fisheries and Aquaculture*. Arise Pub.,	

Delhi.
7. Pillay, T. V. R. and Kutty, M. N. (2005). *Aquaculture: Principles and Practices*. 2nd ed. Blackwell Publishing Ltd.
8. Parker, R. (2012). *Aquaculture Science*. 3rd ed. Delmar, Cengage Learning, USA.
9. Wealth of India, ICAR.

Course Learning Outcomes:

After completion of this paper students will be able to:

K now about different fishing crafts, gears, Environmental Impact of Aquaculture, fish preservation, processing methods and about different fish by-products that will help to gaing knowledge in fishing activity and in their research activity.

Course Objectives:

Epigenetic alterations are heritable changes in gene expression that occur without causing any change in DNA sequences. This course is oriented about the progression of scientific knowledge using different model organisms as well as the mechanism underlying epigenetics. This course will give a vivid idea about the transposition mechanism and transposition related to cancer. This course contains the subject on intriguing features of human evolution with transposition. The content of syllabus having the point on extra chromosomal inheritance will focus on mitochondrial inheritance and related disorders.

ZDSE(MJ)T 403: Cytogenetics and Molecular Biology	**Points 50 Lectures**
Unit I **Epigenetics**	
1. A brief history of epigenetics - overview and concepts; Chromatin Structure, Chromatin modifications and their mechanism of action, types and mechanism of chromatin remodelling; concept of 'histone-code' hypothesis.	7
2. Epigenetics in saccharomyces cerevisiae, position effect variegation, heterochromatin formation, and gene silencing in Drosophila, fungal models for epigenetic research: *Schizosaccharomyces pombe* and *Neurospora crassa*; RNAi and heterochromatin assembly, role of noncoding RNAs;	7
3. Chromatin structure and epigenetics marks - transcriptional silencing by polycomb group proteins, transcriptional regulation by trithorax group proteins, histone variants and epigenetics, epigenetic regulation of chromosome inheritance, epigenetic regulation of the X chromosomes in *C.elegans*, dosage compensation in Drosophila, dosage compensation in mammals.	7
4. Epigenetics and genome imprinting - DNA methylation in mammals, genomic imprinting in mammals, nuclear transplantation and the reprogramming of the genome. epigenetics and human disease, epigenetic	7

determinants of cancer.	
Unit II **Transposons and Extra-nuclear inheritance**	
1. Mobile genetic elements: Characteristics of transposable elements in prokaryotes and eukaryotes; AC/DS system in maize; P element in Drosophila; Salmonella phase variation; retrosposons 2. Extra-nuclear inheritance: Streptomycin resistance in chlamydomonus; Kappa particles; criteria for extra-chromosomal inheritance, infectious heredity. 3. Recombination: Homologous recombination, Mechanism of recombination in bacteria and mammals, Gene conversion, Classes of recombinases and types of site-specific recombination, Transpositional recombination, Mitotic and meiotic recombination, Recombination and genomic instability, Application in genetic engineering.	7 7 7
Suggested Literature: 1. Genetics. R J Brooker McGraw Hill publication. Fourth edition 2. Review of Epigenetics: A reference manual by J M Craig and N C Wong 2021 NCBI 3. Epigenetics and cancer. Z Herceg and T Ushijima Academic press 2020 4. Extrachromosomal inheritance. JL Jinks. Prentice Hall foundation of Modern genetics series. 5. Lewin's Genes XII .Jones and Barlett publisher Inc. 2017.	
Course Learning Outcomes: This part of syllabus will enhance the knowledge on epigenetics and related mechanisms basically of the students who are studying Cytogenetics and molecular biology as specialization.	

Course Objectives: The course is designed to develop comprehensive understanding about hormones , hormone receptors and their complex mechanisms of action to regulate various physiological as well as reproductive functions.	
ZDSE(MJ)T 403: Endocrinology and Reproductive Biology	**Points 50** **Lectures**
Unit-I **Hormone action and testicular and ovarian function**	
1. Hormonal regulation of spermatogenesis. 2. Suppression of testicular activity by steroidal and non-steroidal agents. 3. Biosynthesis and metabolism of androgen and influence of androgen on accessory sex organ. 4. Biosynthesis and metabolism of ovarian hormone.	6 6 6 6

Unit-II **Hormones of Reproductive Cycle, Pregnancy, Parturition and Lactation**	
1. Biosynthesis and metabolism of ovarian hormone.	6
2. Regulation of ovarian follicular development in primates: follicular growth; factors regulating follicular growth; pattern of follicular atresia; follicular selection and dominance. Diseases: polycystic ovarian disease, hirsutism, and hyperandrogenism	6
3. Endocrine role in normal development of breast and lactation.	6
4. Endocrinology of pregnancy.	4
5. Endocrine roles in breast cancer, cervical cancer and uterine cancer.	4

Suggested Literature:

1. William's text book of endocrinology-Melmed S, Polonsky K, Larsen PR and Kronenberg H. Elsevier.
2. Endocrinology- Fox T, Brooks A, Baidya B. JP Medical London.
3. Gardner DG, Shoback D- Greenspan's Basic and clinical endocrinology, McGraw Hill Lange.
4. Jameson JL. Harrison's Endocrinology. McGraw Hill Education.
5. Goodendocr man HM. Basic Medical endocrinology. Academic press.
6. Endocrinology-Mac E Hadley and Jon E Levine. Pearson.
7. Introduction to endocrinology- Chandra S Negi. PHI.
8. General endocrinogy-Turmer CD and Bagnara JT. East-West press Pvt. Ltd.
9. Vertebrate endocrinology-Norris DO. Elsevier academic press.
10. Basic endocrinology, an interactive approach-Neal JM. Blackwell Science.
11. Endocrine physiology-Molina PE. McGraw Hill Lange.
12. Human reproductive biology- Richard EJ & Kristin HL. Academic press.
13. Reproductive biology- Gayatri P. Alpha science.
14. Handbook of Reproductive biology. Francisco A. Hayle Medical.
15. Biology of human reproduction. Ramon Pinon. University Science Book.

Course Learning Outcomes:

At the end of the course the students will be able to-learn about hormones and their receptors, gather knowledge about biosynthesis, structure, function and their complex signalling pathways, understand hormonal regulation of reproductive functions.

Course Objectives:

The course aims to give an overview of basic ideas of vector borne parasitic lifestyles including host responses and parasite evasion. A special emphasize has been given on zoonotic potential of various diseases. It will enable students to explore a number of important diseases, along with the diverse protozoans and arthropods responsible for them.

ZDSE(MJ)T 403: Parasitology and Immunology	**Points 50** **Lectures**
Unit-I **Biology of Parasitic Protozoa**	
1. Structure and biology of *Trichomonas vaginalis.* 2. Structure and biology of *Trypanosoma evansi* and Surra disease. 3. Structure, life-cycle, pathology and control of *Trichodina* in fishes and Microspora in insects. 4. General consideration of amoebae in man. 5. Coccidia and coccidiosis in birds (with special reference to *Eimeria tenella*).	2 6 7 4 6
Unit-II **Zoonosis and Vector Biology**	
1. Avian and simian malarial parasites. 2. Comparative characterization of human malaria parasites 3. Zoonoses with special reference to Japanese Encephalitis and Toxoplasmosis. 4. Ultra structure of Trypanosomes 5. Structure, biology and control of: Reduvidbug, Non biting dipterans and lice.	5 5 5 5 5

Suggested Literature:

1. Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.
2. Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley and Sons Inc.
3. Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
4. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
5. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.
6. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts'Foundation of Parasitology*. 9th ed. McGraw-Hill International.
7. William E. Paul, Lippincott Williams & Wilkins. Fundamentals of Immunology, Publishing[Latest edition].

Course Learning Outcomes:

Upon successful completion of this course the students would be able to learn about transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment and control of major zoonotic diseases. The course has been structured in a way that the students assimilate the classroom knowledge for applied aspects of public health and some future aspects of lab to land implication of their knowledge.

Course Objectives:
The mission of this course ranges from basic aspects of arthropod ecology, morphology, parasitology, and physiology to applied subjects in apiculture, agricultural, medical and veterinary pest management. The agricultural entomology and insect-plant interaction course describes the interaction of nature, plants and insects in order to understand the gravity of pest problem on standing crops and harvested yields and highlights various control methods to ensure crop protection by controlling insect pests of important crops. The course describes adverse effects of pesticides and management of crop pests by biological and Integrated Pest Management (IPM) approach.

ZDSE(MJ)T 403 Entomology	**Points 50 Lectures**
Unit-I: Applied Entomology: Insects of Agricultural and Medical Importance	
1. Morphology, life history and control of major pests of (two of each): Cotton, medicinal plants and mango.	4
2. Morphology, biology of gall insects (only two sp.) and their control; mechanism of gall formation; significance of gall formation; gall-insects association.	4
3. Locust: different sp., their distribution, biology and control.	4
4. Role of insects and acarine in transmission of human diseases.	4
5. Life history, structures involved and mode of transmission of diseases by the *Xenopsylla cheopis*.	4
6. Medicinal insects.	2
7. Biological note on Dengue and malaria (Vector and pathogen); Mode of transmission and symptoms.	4
Unit-II **Insect Management**	
1. Chemical insecticides: classification, properties, pharmacology and mode of action of some commonly used insecticides.	4
2. Chemosterilants and hormonal analogues	4
3. Fumigants: Chemical nature, properties, toxicity, mode of action, application and operational precautions.	4
4. Biological control: classification (bio-control by bacteria, virus, protozoa, fungi), ecological consideration, method of bioagents introduction; examples; advantages and disadvantages.	4
5. Integrated pest management: importance; components; phases; method of implementation; Example; merits and demerits	4
6. Antifeedants, attractants, repellents and biopesticides: uses.	4

Suggested Literature:

1. Atwal: Agricultural pests of India and south east Asia, Kalyani Publishers, 1986

2. Insect Plant Biology, Schoonhoven, L. M., van Loon, J.A., & Dicke, M., Publisher Oxford University Press, USA
3. Interrelationship between insects and Plants, Jolivet, P., CRC Press, USA
4. Entomology & Pest Management, Pedigo, L. P.,Prentice Hall, New Jersey, USA
5. Concepts of IPM, Norris, Caswell-Chen and Kogan, Prentice-Hall, USA
6. Agricultural insects pests of the tropics and their control, Hill, D. S., Cambridge University Press, UK
7. Lac-culture in India- N. Ghorai, International Books and periodical supply service, New Delhi
8. Medical Entomology- Bruce F. Eldridge, John D. Edman, Kluwer Academic Publishers
9. Medical and Veterinary Entomology Mullen, G. ,Durden, L., Academic Press, USA
10. Medical and Veterinary Entomology, Kettle, D. S., Cabi Press, USA

Course Learning Outcomes:
The course study makes the students capable to learn ill effects of pesticides and management of crop pests by bio-rational methods in an integrated approach (IPM) and impart concerned knowledge to the farmers and get involved in various pest management organizations.

Course Objectives:
To cultivate the essence of advancement in the developmental genetics, structure and function of genes and genomics, and aquatint the students with
recent advances in the epigenetics and trans generational inheritance which covers inheritance beyond genomics.

ZDSE(MJ)T 403: Cell and Developmental Biology	**Points 50 Lectures**
Unit-I **Gene expression during organogenesis**	
1. Genetic regulation during development: Gradients in early embryogenesis in Drosophila. Cell fate and differentiation, signaling pathways. Role of microtubules in development, Axis specification, Gap genes; pair rule genes, segment polarity genes; axis formation; homeotic genes; homeo-domains; Hox genes & HOM-c genes, Dosage compensation in *Drosophila* and in mammals; sex determination, developmental mutations in *Drosophila*.	**16**
2. Development of *C. elegans*: Asymmetric cell divisions and cell – cell interaction. Signaling pathways in vulval induction. Epigenetic regulation of the genetic material in *C.elegans*.	**10**
Unit-II **Growth, development and Regeneration**	
1. Growth: Definition, pattern, factors influencing growth and development.	6

2. Post embryonic development- larval forms in *Xenopus*, environmental regulation of normal development.	10
3. Promising field of tissue repair and restoration, factors; Field action in regeneration. Sonic hedgehog and limb enhance-specification of antero-posterior pattern; Interaction between positional information and self-organization mechanism; mechanism of Shh signalling.	10

Suggested Literature:

1. Developmental Biology: Michael J.F. Barresi Scott F. Gilbert, (12 th Ed)
2. Principles of Development: Lewis Wolpert and Cheryll Tickle (4th Ed.)3. Principles of Genetics. 3rd Ed. D. Peter Snustad and Michael J. Simmons. Wiley Publication.
4. iGenetics: A molecular approach. 3rd Ed. Peter J. Russell. Pearson International Edition.

Course Learning Outcomes:

The students should be able to connect the metabolic reprogramming and development of diseases through the lens of epigenetic modification and gene expression strategies.

THEORY (DISCIPLINE SPECIFIC ELECTIVE – MAJOR II)

Course Objectives:

The course is designed as a modern course for understanding marine fisheries, oceanography, marketing, conservation and marine biodiversity. It is planned for students who have already learnt about the basic fisheries and aquaculture technology.

ZDSE(MJ)T 404: Fish and Fisheries	**Points 50 Lectures**
Unit-I: Marine Fisheries and Oceanography	
1. Survey of marine fisheries: offshore, deep sea, divisions.	4
2. Coastal fisheries: Coastal zones, features, EEZ, CRZ.	4
3. Coral reefs: Origin, Global Reef distribution, Status of coral reefs, Environmental factors, Structure of corals, Reef zonation and composition, Reef conservation.	7
4. Deep Sea Biology: Environmental characteristics, Adaptations, Midwater community, Ecology. Zonation. Hydrothermal vents.	7
5. Earth and ocean floor: Origin. Structure of earth. Continental Drift. Classification of marine environment: Continental shelves, slopes, rise. Submarine canyons. Ocean trenches. Island arcs. Ocean Ridges, Upwelling and Downwelling. Eddies. Inertial currents. Longmuir circulation. Thermohaline circulation. Deep ocean circulation.	8

UNIT II: **Marketing, Conservation and Marine Biodiversity**	
1. Marketing: fish markets in India, strategy, structure, price formation.	4
2. Cooperative societies: principle, organization and function.	4
3. Stock Assessment and Management: Marking, Tagging and Population enumeration, Length-weight relationship, Age and growth, Fecundity estimation, Application of statistical methods in fisheries.	4
4. Fish conservation and fisheries act and environment act.	4
5. Marine Biodiversity: Status of Global Marine Biodiversity. Gradients of Marine Biodiversity. Census of Marine Life. Status of Marine Biodiversity in India. Threats. Protected areas. Marine Biosphere Reserves.	4

Suggested Literature:

1. Dunham, R. A. (2004). Aquaculture and fisheries biotechnology: genetic approaches. CABI Publishing, Cambridge, USA.
2. Parker, R. (2012). Aquaculture Science, 3rd ed. Delmar, Cengage Learning, USA.
3. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Willey and Sons.
4. Bond, C. E. (1996). *Biology of Fishes*. 2nd ed. Saunders Pub.
5. Chakrabarti, N. M. (1998). *Biology, Culture and Production of Indian Major Carps – A Review*. Narendra Publishing House. New Delhi.
6. Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed., HindusthanPub.Corp. John Wiley and Sons.
7. Srivastava, C. B. L. (1999). *Fish Biology*.Narendra Pub. House.
8. ICAR (2011). *Handbook of Fisheries and Aquaculture*. 2nd Ed. ICAR, New Delhi

Course Learning Outcomes:

Marine Fisheries and Oceanography, Marketing and conservation of aquatic resources is most essential in the present scenario of climate change and anthropogenic activities. India has long coastline with many fish landing centres that help in the livelihood and income generation.

Course Objectives:

This course content gives emphasis on developmental genetics and human population genetics. As research in this area spans a broad range of topics , approaches and experimental system, this course is oriented about the molecular aspect of genetic control of growth and development of organisms. The second unit gives emphasis on the fate of genes in space and time at the level of a reproducing population and its associated gene pool specifically human.

ZDSE(MJ)T 404: Cytogenetics and Molecular Biology	**Points 50** **Lectures**
Unit I **Developmental genetics and Genomics**	
1. Genetic regulation during development: Gradients in early embryogenesis	

in Drosophila. Cell fate & signaling pathways. Gap genes; segment polarity genes; axis formation; homeotic genes; homeo-domains; Hox genes & HOM-c genes.	6
2. Medical implications of developmental genetics: Infertility, Teratogenesis, Stem cells and tissue engineering.	5
3. Structural genomics: Genome sequencing, High resolution genome mapping- radiation hybrid mapping; physical mapping of genomes, FISH	5
4. Functional genomics: Study of gene interaction by the yeast two-hybrid system; Protein-DNA interaction, ChIP Assay, Study of developmental regulation using DNA-chips, Loss of functional gene-Mutagenesis, RNAi, knockdown/knockout model.	6
5. Comparative genomics: Homologous genes-Orthologous, paralogous; Sequence homology; Evolutionary relationships, Phylogenetic analysis. Comparative genomics of bacteria, organelles, and eukaryotes.	6
Unit II **Population genetics**	
1. Allele frequencies and genotype frequencies: Hardy-Weinberg relationship	6
2. Haplotype frequencies and linkage disequilibrium, changing allele frequencies.	6
3. Population structure and inbreeding.	
4. Evolutionary genetics: Origin of species, phylogenetic trees, molecular evolution, evolutionary developmental biology.	5 5
Suggested Literature: 1. Principles of developmental genetics. Sally A Moody Academic Press publication second edition 2. Developmental genetics. B Wilson. Scientific e resource. 2014 3. Principles of population genetics. D L Heart and AG Clark OUP USA Fourth edition 4. Population genetics: A concise guide. J H Gillespie John Hopkins University Press second edition.	
Course Learning Outcome: Students will get knowledge on genetic basis and advances in the research on early development and growth of organism. From the second unit they can be enlightened with the idea of genetic makeup in the environment and population.	

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Course Objectives: The course is designed to provide deep knowledge about hormonal regulation of reproductive cycle as well as biorhythm of animals especially in primates. Besides, it will also help to acquire complex knowledge about neuroendocrine regulations of immune system.

ZDSE(MJ)T 404: Endocrinology and Reproductive Biology	**Points 50** **Lectures**
Unit - I **Endocrinology of fertility and infertility**	
1. Infertility in males and females and their remedial measures. Azoospermia Oligozoospermia, Varicocoele, Cryptorchidism, Premature ovarian failure, Polycystic ovarian syndrome, Luteal insufficiency, Endometriosis	**7**
2. Induction of ovulation and spermeation: Oocyte and sperm maturation substances; their probable mode of action.	**7**
3. Fertility control i) ovulation suppression by oral and injectable steroidal contraceptive ii) use of implants and IUDs.	**7**
Unit - II **Neuroendocrine-immune system & reproductive physiology**	
1.Reproductive cycles: Menstrual cycle, Control of seasonal reproductive cycle, Photoperiod and temperature, endocrinology of photo-sexual activity by pineal gland hormones	**7**
2. Neuro endocrine-immune interactions: chemical nature and signalling of cytokines; neuron endocrine regulations of immune processes and immune regulatory effects of HCG and neuropeptides.	**7**
3. Hormonal control of stem cells: Role of stem cell biology in different organ; roles in malignancy.	**7**
4. Primer pheromones, Estrous cycle disruption, Male induction of estrus (Whitten effect), Male induced pregnancy block (Bruce effect), Pheromones and puberty, Human reproductive pheromones	8

Suggested Literature:

1. William's text book of endocrinology-Melmed S, Polonsky K, Larsen PR and Kronenberg H. Elsevier.
2. Endocrinology- Fox T, Brooks A, Baidya B. JP Medical London.
3. Gardner DG, Shoback D- Greenspan's Basic and clinical endocrinology, McGraw Hill Lange.
4. Jameson JL. Harrison's Endocrinology. McGraw Hill Education .
5. Goodendocr man HM. Basic Medical endocrinology. Academic press.
6. Endocrinology-Mac E Hadley and Jon E Levine. Pearson.
7. Introduction to endocrinology- Chandra S Negi. PHI.
8. General endocrinogy-Turmer CD and Bagnara JT. East-West press Pvt. Ltd.
9. Vertebrate endocrinology-Norris DO. Elsevier academic press .
10. Basic endocrinology, an interactive approach-Neal JM. Blackwell Science.
11. Endocrine physiology-Molina PE. McGraw Hill Lange (latest edition).
12. Human reproductive biology- Richard EJ & Kristin HL. Academic press.
13. Reproductive biology- Gayatri P. Alpha science.
14. Handbook of Reproductive biology. Francisco A. Hayle Medical.
15. Biology of human reproduction. Ramon Pinon. University Science Book.

Course Learning Outcomes:

At the end of the course the students will be able to-learn about hormonal regulations of reproduction, gather knowledge about hormonal regulation of biorhythm, understand hormonal regulation of neuroendocrine regulation of immune system and know hormonal regulation of stem cells.

Course Objectives:

The course has been prepared to help understand the ability of our immune system to defend against invading pathogens or parasites in a logical fashion. The course also emphasizes the research and development opportunities for therapeutic intervention arising from recent advances in immunology. The immunological aspects of disease will also be discussed using case-based studies. The students will be able to comprehend the roles of lymphoid organ, cells of immune system, antigens, antibodies, MHC, antigen presentation and immunity to infectious diseases.

ZDSE(MJ)T 404: Parasitology and Immunology	**Points 50 Lectures**
Unit-I Parasite physiology, biochemistry	
1. Membrane transport mechanism in parasites.	6
2. Reproductive physiology in parasites.	6
3. Energy metabolism in parasitic protozoa and helminths.	8
Unit-II Immuno-parasitology	
1. Principles of immunity in relation to virus, bacteria, protozoa, helminths.	7
2. T-cell receptor organ and functions of immune response.	6
3. Antigen-antibody reaction and its role in clinical parasitology.	6

4. Basic immunological changes due to parasitic infection, antigen vaccination, immunopathology.	7
5. Structure and function of antibody.	4

Suggested Literature:

1. Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.
2. Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley and Sons Inc.
3. Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
4. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
5. Kuby Immunology, Richard, Thomas, Barbara, Janis , W. H. Freeman and Company.
6. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.
7. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts' Foundation of Parasitology*. 9th ed. McGraw-Hill International.
8. William E. Paul, Lippincott Williams & Wilkins. Fundamentals of Immunology, Publishing.

Course Learning Outcomes:

At the end of the course, the students should be able to to identify the cellular and molecular basis of immune responsiveness and understand how the innate and adaptive immune responses coordinate to fight invading pathogens.

Course Objectives:

The agricultural entomology and insect-plant interaction course describes the interaction of nature, plants and insects in order to understand the gravity of pest problem on standing crops and harvested yields and highlights various control methods to ensure crop protection by controlling insect pests of important crops. Medical Entomology will highlight the direct injuries and diseases caused by arthropods transmission of vertebrate parasites and pathogens. The course offers information on transmission of diseases, methods of surveillance for diseases, effective Integrated Management of Vector control and other methods of prevention of arthropod borne diseases.

ZDSE(MJ)T 404 Entomology	**Points 50 Lectures**
Unit-I Plant Protection and Insect Host Relationship	
1. Plant protection appliances: sprayers and dusters; their merits and demerits	6
2. Insect and plant diseases: insect as vector, insect borne viruses causing plant diseases; insect vector-plant virus relationship.	6
3. Insect plant interaction: a) mechanism of host selection (host habitat finding, host finding, host recognition; host acceptance); b) role of nutritional component in host selection; c) allelochemicals and host	6

selection. 4. Co-evolution in insect and plant: types; co-evolution with pollinating insect; mimicry.	6
Unit- II Population, Forensic and Soil Entomology	
1. Principles of population studies:' sampling, objectives and practical application. 2. Factors controlling population: abiotic (temperature, moisture, rain fall and photoperiodism), biotic (food and natural enemies). 3. Forensic entomology: types; importance of medico legal forensic entomology, stages of death; importance of insects in medico criminal investigation; estimation of time of death using insects; common arthropods associated with dead body; application and case study. 4. Population study method: intrinsic rate of increase; life table construction and its application. **5.** Soil insects: types, important role of edaphic factors (moisture, temperature and pesticide) on soil insects.	6 6 6 6 6

Suggested Literature:

1. Atwal: Agricultural pests of India and south east Asia, Kalyani Publishers, 1986
1. Insect Plant Biology, Schoonhoven, L. M., van Loon, J.A., &Dicke, M., Publisher Oxford University Press, USA
2. Interrelationship between insects and Plants, Jolivet, P., CRC Press, USA
3. Concepts of IPM, Norris, Caswell-Chen and Kogan, Prentice-Hall, USA
4. Agricultural insects pests of the tropics and their control, Hill, D. S., Cambridge University Press, UK
5. Lac-culture in India- N. Ghorai, International Books and periodical supply service, New Delhi
6. Medical Entomology – A.K. Hati
7. Medical Entomology- Bruce F. Eldridge, John D. Edman, Kluwer Academic Publishers
8. Medical and Veterinary Entomology Mullen, G. ,Durden, L., Academic Press, USA
9. Medical and Veterinary Entomology, Kettle, D. S., Cabi Press, USA

Course Learning Outcomes:

Agricultural and applied Entomology plays a major role in training students in understanding the interaction of nature, plants and insects in order to ensure crop protection by controlling economically important insect pests of various crops.

Course Objectives:

The goal of this course is to provide students with education and training that enables them to make significant contributions to understand and tackle the different signaling mechanism involved in initiation and progression of multitude of metabolic processes. Students also learn about the current state of the epidemiology, clinical diagnosis, treatment, and prevention of human cancers.

ZDSE(MJ)T 404: Cell and Developmental Biology	**Points 50 Lectures**
UNIT I **Cell Synchronization**	
1. Physiology of cell division: Cell Cycle, synchrony in cell division, inhibition of cell division, source of energy. 2. Intracellular Signaling and Cell surface receptor Signaling a). G-proteins, G-protein-coupled receptors and their effectors, Receptor Tyrosine kinases (RTKs),Auto-phosphorylation of RTKs, initiation of MAP kinase signaling, JAK-STAT Signaling pathway, TGFβ Signaling pathway b) Intracellular receptors, steroid hormone signaling pathways 3.Characteristics of tumor cells; detection of tumor using CAT scan, MRI scan and fMRI scan, Oncogenes and their proteins, classification and characteristics of chemical carcinogen; role of radiation and DNA repair in carcinogenesis. Importance of nano-medicine in cancer therapy.	**10** **10** **10**
Unit-II **Cell Contact and Developmental Neurobiology**	
1.Cell -cell adhesion: types of cell binding, adhesive proteins, their role in cell-cell interaction, gap junctions, extracellular matrix, integrins differentiation movement of leucocytes into tissues. 2. Developmental neurobiology: General organization of nerve fibers, axon ultra structure, neurotubules and neurofilaments, neural induction, neurogenesis, emergence of central nervous system, neural tube polarity, program cell death during neuronal development, common neuronal disorders.	**10** **10**
Suggested Literature: 1. Developmental Biology: Scott F Gilbert [Latest edition]. 2. Principles of Development: Louis Wolpert [Latest edition]. 3. Principles of Genetics. 3rd Ed. D. Peter Snustad and Michael J. Simmons. Wiley Publication. 4. iGenetics: A molecular approach. 3rd Ed. Peter J. Russell. Pearson International Edition. 5. The Cell: A molecular Approach. Geoffrey M. Cooper and Robert E. Hausman. 3rd Ed. ASM Press Washington, DC. 6. Molecular Cell Biology- 4th Ed. James E. Darnell, Harvey Lodish, Arnold Berk, Lawrence Zipursky, Paul Matsudaira, David Baltimore 7. Molecular Biology of the Cell. 4th Ed. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter.	
Course Learning Outcomes: The students should be well versed with the multi parametric cellular signaling pathways involved in metabolic pathways, their malfunctioning, their detection with the aid of recent	

sophisticated diagnostic tools with special emphasis to cancer biology which would encourage the students to pursue a research career in future.

PRACTICAL (CORE)

Course Objectives: This lab course is intended to introduce students to Animal Behaviour and Microbiology. The course also will provide students with a hands-on training on microbiology.	
ZCORL 411: Animal Behaviour and Microbiology	**Points 25**
Animal Behaviour 1. Demonstration of behavioral change of fish /chick in relation to toxicant / chemicals. 2. Study of habituation to light stimulus in the earthworm. 3. Demonstration of photo tactic response of house fly.	
Microbiology 4. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria, Preparation of slant and stab. 5. Pure culture techniques: Spread plate, pour plate and streak plate. 6. Simple staining of bacteria and study of cell types; differential staining: Gram staining. 7. Biochemical tests for characterization: Catalase, Nitrate reduction, Indole production, Methyl red and Voges–Proskauer test. 8.Laboratory note book &Viva voce.	
Course Learning Outcomes: The course provides the students training on Animal Behaviour and Microbiology. Microbiological training will help to advantages on getting industrial job.	
Course Objectives: This lab course is intended to introduce students to standard biochemical techniques common in a molecular biology lab, such as Gel electrophoresis, DNA digestion, setting up genetic crosses, DNA and protein estimation etc. The course also will provide students with a hands-on understanding of how modern cell and molecular biology techniques can be used to discover and understand cellular function.	
ZCORL 412: Molecular Biology, Biotechnology, Tools and Technique	**Points 25**
Molecular Biology and Biotechnology 1. Setting up and solving of genetic crosses. 2. Demonstration of short term tissue culture. 3. Restriction enzyme digestion of plasmid DNA. 4. Demonstration of PCR Analysis and DNA Electrophoresis. **Tools and Techniques** 5. Centrifugation technique: Differential centrifugation for separation of	

nuclei, cell debris, mitochondria. 6. Colorimetric estimation of Protein, DNA/RNA. 7. Demonstration of PAGE. 8.Demonstration of PBMC isolation and counting under microscope. 9.Direct estimation of biochemical parameters of blood/urine using biochemistry analyser. 10. Formulation of commercially available pesticide. 11.Laboratory note book &Viva voce.	
Course Learning Outcomes: The course provides the students with the necessary training to enable them to understand theprinciples that underpin basic and applied research, and to translate that understanding into good researchpractice.	

PRACTICAL (DISCPLINE SPECIFIC ELECTIVE MAJOR)

Course Objectives: The laboratory course is to provide hands on training on soil parameters, feed formulation and analysis, digestive enzyme analysis and molecular analysis of fish tissue. Objective of seminar presentation course is to grow the presentation technique of the students on a recent development of aquaculture research.	
Fish and Fisheries	
ZDSE(MJ)L 402: Lab	**Points 50**
1. Physico-chemical analyses of soil: pH and available phosphate. 2. Gut content analyses of fish. 3. Feed formulation and proximate analysis of feed and fish. 4. Analysis of proximate composition (moisture, dry matter, crude protein, ether extract, crude fibre, ash, NFE etc.) of fish tissue and feed samples. 5.Quantitative detection of digestive enzymes (protease, α-amylase and lipase), SGPT and SGOT analysis of fish. 6.Agarose gel electrophoresis for DNA, DNA isolation from fish liver. 7.Lab Notebook + Viva voce.	
Course Learning Outcomes: All the practical information about biochemical and molecular mechanisms of aquaculture gathered in this paper. This study will help to their research career. The students adapted with scientific research, review of research papers. They will be familiar with any type of professional interaction.	

Course Objectives: This course content comprises the items for hands on experience of the students on different protein purification techniques.

In seminar presentation, is usually done in the form of review of the relevant literature in the respective field.	
Cytogenetics and Molecular Biology	
ZDSE(MJ)L 402: Lab	**Points 50**
1. Localization of Ag- NORs, C-heterochrornatin in mouse chromosomes. 2. Isolation of Total RNA, determination of its purity and concentration. cDNA synthesis. 3. Demonstration of dosage compensation by study of sex chromatin in human buccal epithelial cell Smear. 4. Isolation of membrane proteins from mammalian cells through different chromatographic techniques. Separation of proteins using native and SDS gel electrophoresis. 5. Demonstration of ELISA. 6. Model scientific paper writing general rules. 7. Laboratory Notebook + Viva voce.	
Suggested Literature: 1. Protein purification techniques-a practical approach. Simon Roe OUP Oxford second edition, 2001 2. Culture of animal cells. A manual of basic techniques and specialized applications. R L Freshney Wiley-Blackwell seventh edition 2016. 3. Seminar papers . J B WeltonSr Broken Weather press 2016.	
Course Learning Outcome: The students also get exposed to the tissue culture methods and techniques of identification of proteins on paper and solution by antigen-antibody reaction. After that the specific topic is presented through power point mode and the merit of the review paper is evaluated.	

Course Objectives: The course is designed to provide deep practical knowledge related to endocrinology and reproductive physiology.	
Endocrinology and Reproductive Biology	
ZDSE(MJ)L 402: Lab	**Points 50**
1. Bio-assay of LH by OAAD test 2.Lipids steroid separation by TLC 3. Demonstration of ELISA reader and estimation of hormone. 4.Determination of the stages of spermatogenesis in rat testis by PAS-Hematoxyllin technique or cyclic changes in the exfoliate cytology of vaginal epithelium in rat. 5. Preparation and submission of slides: testis, ovary, adrenal gland, epididymis, prostate, uterus and seminal vesicle .	

6. Laboratory Notebook + Viva voce.	

Suggested Literature:

1. Advanced practical zoology- P.S. Verma & PC Srivastava. S. Chand & Co. Ltd.
2. An advanced Laboratory Manual of Zoology. Podder T, Mukhopadhyay S, Das SK. Trinity Press.
3. Enzyme histochemistry: A laboratory manual of current methods. Cornelis JF Van Noorden and Wilma M Frederiks. Oxford University Press.
4. Advanced Practical Zoology. Sinha JK, Chatterjee AK & Chattopadhyay P. NCBA.
5. Junqueira's Basic Histology text and atlas. Anthony M. McGraw Hill Lange.
6. Histochemistry in focus. Shyamsundari K &Hanumantha Rao K. MJP.
7. Principles and techniques of biochemistry and molecular biology. Wilson K & Walker J. Cambridge University Press.
8. Manual of practical medical biochemistry. Jones E. Jaypee brothers medical publishers.
9. Advanced methods in molecular biology and biotechnology-A practical Lab Manual. Khalid ZM, Sameena ML and Rovidha SR. Academic Press Inc.

Course Learning Outcomes:

At the end of this course the students will learn various histochemical techniques and their demonstration, acquire comprehensive practical knowledge in molecular endocrinology. understand various types of practical knowledge related to endocrinology and reproductive physiology.

Course Objectives:

This course especially focuses on the modifications/adaptations found in different physiological systems of various organisms across the animal kingdom.

Parasitology and Immunology	
ZDSE(MJ)L 402: Lab	**Points 50**
l. Isolation and identification of peritoneal macrophages of rat. 2. Parasites of fishes. 3. Identification of lymphoid tissue (spleen, thymus and lymph node, Bursa of Fabricius). 4. Blood parasites of birds and fishes. 5. Deposition of collected materials. 6. Laboratory Note book + viva voce.	

Course Learning Outcomes:

Upon completion of the course students have a sound understanding of the essential elements of the immune system, preparing them to engage further in this rapidly evolving field. The course also has a strong lab component, where certain classical and interesting exercises will be conducted to answer various practical queries in animal physiology.

Course Objectives:

Course objective is to provide hands on training on various aspects of entomology: ecology,

collection and taxonomy. By learning these basic techniques, the students can easily pursue research career in advance field of entomological science.	
Entomology	
ZDSE(MJ)L 402: Lab	**Points 50**
1. Study of field and stored grain insects (at least 10 examples). 2. Ecology: i) Ecological instruments ii) Soil insects: a) Methods of extraction b) Sorting of material and their identification c) Plotting of results in tables and diagrams. iii) Terrestrial insects: a) light trap b) net sweeping c) Aspirator method v) Estimation of population, frequency, relative density, abundance using Quadrate and Mark and release methods vi) Determination of Diversity index of a field population, vii) Estimation of nature of damage and loss of plants and produce. 3. Collection of social insects and their nests. 4.Taxonomy: Collection and identification of insects up to family. 5. Submission of field reports, Life cycles, specimens. 6. Laboratory Notebook + Viva voce.	
Course Learning Outcomes: The students will gain knowledge on diversity of insects, their ecology, collection techniques and taxonomic procedures. The students will submit a review work on specific topic of entomology and will present that through power point in their final exam. The merit of the review work will be evaluated by examiners.	

Course Objectives: The course would help to inculcate in the students the urge to comprehend and relate the theoretical techniques with that of practical training. The curriculum has been designed to nurture their ideas, skill, and competency which would trigger their research outlook so that they may utilize their experience for their future research.	
Cell and Developmental Biology	
ZDSE(MJ)L 402: Lab	**Points 50**
1. a) SDS-PAGE for separation of proteins, b) Western blot. 2. Demonstration of ELISA, cell culture techniques. 3. Estimation of % cellular cytotoxicity by Trypan blue method. 4. Immunohistochemistry for detection of protein. 5. Review on recent developments in cell biology and developmental genetics. 6. Laboratory notebook + viva voce.	
Course Learning Outcomes: At the end of the course the students should be able to design research problems independently and find out the solution of the same. The overall training would help them to explore different molecular techniques which would definitely help them in their future research endeavor.	

PROJECT/DISSERTATION

Fish and Fisheries	
ZDSEP 402: Project/ Review work/ Dissertation	Points 100
Cytogenetics and Molecular Biology	
ZDSEP 402: Project/ Review work/ Dissertation	Points 100
Endocrinology and Reproductive Biology	
ZDSEP 402: Project/ Review work/ Dissertation	Points 100
Parasitology and Immunology	
ZDSEP 402: Project/ Review work/ Dissertation	Points 100
Entomology	
ZDSEP 402: Project/ Review work/ Dissertation	Points 100
Cell and Developmental Biology	
ZDSEP 402: Project/ Review work/ Dissertation	Points 100

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