DEPARTMENT OF ZOOLOGY

CENTRAL UNIVERSITY OF KERALA

M.Sc. Syllabus -2021

Godavari Block, Tejaswini Hills, Periya, Kasaragod – 671 320

About the Department

The Department of Zoology was established in 2010, one year after the University was founded through an Act of Parliament, 2009. The department functioned initially as the Department of Animal Science from the Riverside Transit Campus at Padannakad, Kasaragod District, for about nine years and subsequently translocated to the permanent University campus Tejaswini Hills, Periya, in July 2018. The department was rechristened in 2019 as the Department of Zoology and the Master's program as M.Sc Zoology. The department comes under the School of Biological Sciences and is housed in the Godavari building on the campus's northwestern side. Department has well-established P.G laboratories with a Cell culture facility, Insect collections, Drosophila Stock facility, Aquaculture facility, and auxiliary Central Instrumentation Facility. The department offers the most updated courses in the discipline of Zoology. The faculties have specialized in both basic and applied sciences research. The Master's dissertations work has been published in high-impact research journals. The alumni are pursuing Ph.D. in prestigious National and International institutes around the world.

M.Sc. Zoology Programme

M.Sc. in Zoology programme aims to equip students with recent advances in Zoology from organism to the molecular level. It also aims to empower students to understand society's challenges and the country that falls into the realms of Zoology, such as Systematics, Animal Physiology, Entomology, Economic Zoology, Molecular Biology, Genetics, Immunology, Endocrinology, Biostatistics, etc. It also offers students a series of diverse interdisciplinary elective courses to choose to specialize in the specific area of their interests in Zoology. Keeping the true spirit of a choice-based credit system scheme, 16% of the total credits are offered as elective courses and 84% of courses as core courses. This Programme is designed to ignite the inquisitive mind to enter into research in interdisciplinary areas. In the fourth semester, the major emphasis is on the dissertation, providing skill-based training to students in the relevant areas of Zoology.

The outcome of the Programme

After completing four semesters of M.Sc. in Zoology programme, it is expected that a student would sufficiently be skilled and empowered to solve the problems in the realms of Zoology

and its allied areas. They would have many job opportunities in the education (teaching), research, environment, agriculture-based, and health-related sectors. The bright and ignited mind may enter into research in Zoological/Biological/Bio-medical Sciences. The broad skills and more profound knowledge in the field would make them highly successful and excellent researchers in advanced research areas in the Biological sciences.

Eligibility for admission

The total number of seats: 40.

The reservation policy as per the Govt. of India applies to these total seats. M.Sc Zoology programme open for admission to students from B.Sc with Zoology Main and Botany and Chemistry/Biochemistry as subsidiaries or equivalent degrees to be admitted for Master's Degree.

Assessment of Students' Performance and Scheme of Examinations

Assessment of Students' performance shall consist of examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the Central University of Kerala.

Each course will carry 100 marks and will have two components:

(i) Continuous assessment for 40 marks (Internal test, Seminars, Assignments etc.,) &

(ii) End-semester examination for 60 marks.

Programme Structure

M.Sc. in Zoology programme is a two-year course divided into four semesters. A student must complete 72 credits for the completion of the course and the award of degree.

Course Credit Scheme

The course structure for the programme is given below.

Duration	Four semesters (16 weeks x 4)/two years
One semester	90 instructional days
One credit	1hour lecture or 2-4 hours of laboratory work/fieldwork per week
Maximum credits from Core courses	60 credits
Minimum credits from Elective courses	12 credits
Maximum credits per semester	30 credits
Minimum attendance required for each course	75%
Accumulated minimum credits for successful completion of the Programme	72 Credits (Core + Elective courses from all Semesters)

M.Sc. Zoology Course Structure						
Course Code	Course Title	Contact hrs/week				Credits
		L	P	T	Total	
L=Lecture; P=Practical; T=Tutorial						
Semester I						
ZGY5101	Taxonomy and Systematics	2	1	0	3	2
ZGY5102	Biochemistry	3	0	0	3	3
ZGY5103	Animal Physiology	3	0	0	3	3
ZGY5104	Cell & Molecular Biology	4	0	0	4	4
ZGY5105	Laboratory- Cell & Molecular Biology	0	4	0	4	2
ZGY5106	Laboratory- Biochemistry & Animal Physiology	0	4	0	4	2
	Total for Sem. I					**16**
Semester II						
ZGY5201	Neurobiology & Endocrinology	4	0	0	4	4
ZGY5202	Genetics	3	0	0	3	3
ZGY5203	Economic Zoology	2	0	0	2	2
ZGY5204	Evolutionary Biology	3	0	0	3	3
ZGY5205	Applied Entomology	3	0	0	3	3
ZGY5206	Laboratory- Genetics & Endocrinology	0	4	0	4	2
ZGY5207	Laboratory- Entomology & Economic Zoology	0	4	0	4	2
	Total for Sem. II					**19**
Semester III						
ZGY5301	Animal behaviour	3	0	0	3	3
ZGY5302	Developmental Biology	3	0	0	3	3
ZGY5303	Immunology	3	0	0	3	3
ZGY5304	Biostatistics and Bioinformatics	3	0	2	5	4
ZGY5305	Ecology & Field Biology	3	0	2	5	4
ZGY5306	Laboratory- Developmental Biology & Immunology	0	4	0	4	2
	Total for Sem. III					**19**
Semester IV						
ZGY5401	Dissertation	0	35	0	35	6
	Total for Sem. IV					**6**
	Credits for Core Courses – all Semesters					**60**
	Credits for Elective Courses – all Semesters					**12**
	Total Credits for Core and Elective Courses – all Semesters					**72**

L – Lecture; T- Tutorial; P- Practical; C- Credit

Elective Courses:

Course Code	ELECTIVES – Course Title	Contact hrs/wk				Credits
		L	P	T	Total	
L=Lecture; P=Practical; T=Tutorial						
ZGY5001	Techniques in Biological Research	2	2	0	4	3
ZGY5002	Biostatistics	2	0	2	4	3
ZGY5003	Academic Scientific Writing	2	0	2	4	3
ZGY5004	Philosophical Foundation of Taxonomy	2	2	0	4	3
ZGY5005	Ecology of Plant-Animal Interaction	2	0	2	4	3
ZGY5006	Marine Biodiversity and Conservation	3	0	0	3	3
ZGY5007	Conservation Biology	3	0	0	3	3
ZGY5008	Principles of Genetics	3	0	0	3	3
ZGY5009	Basics of Neurobiology	3	0	0	3	3
ZGY5010	Circadian Biology	3	0	0	3	3
ZGY5011	Natural History	3	0	0	3	3
ZGY5012	Toxicology	3	0	0	3	3
ZGY5013	Translational Immunology	3	0	0	3	3
ZGY5014	Science Communication	3	0	0	3	3
ZGY5015	R for Biologists	2	0	2	4	3

MOOC Courses

Sl.No	Course Name
1	Biomedical nanotechnology|
2	Biophysical chemistry
3	Biomass Characterization
4	Computer Aided Drug design
5	Drug Delivery: Principles and Engineering
6	Food Microbiology and Food Safety
7	Nanotechnology in Agriculture
8	Industrial Biotechnology
9	Functional Genomics
10	Analytical Techniques
11	Plant Developmental Biology
12	Transport Phenomena in Biological Systems
13	Tissue engineering
14	Introduction to Proteogenomics
15	Genetic Engineering: Theory And Application

SEMESTER I

ZGY5101: Taxonomy and Systematics

L-2: P-1: C-2: 48 h

Course Outcome:

By the end of this course, students will be able to:

- develop a theoretical and practical understanding of the principles of taxonomy and zoological systematics.
- comprehend taxonomic literature, and the technical language.
- put to use the ICZN nomenclatural practices in taxonomy.
- master the components of taxonomic and systematic descriptions of taxa.
- develop a comprehensive understanding of the practical methods of analyzing morphological and molecular characters.
- appreciate the role of systematics as one of the foundation courses in biology.
- master basic taxonomic and systematic procedures.

Course content:

Unit No.	Topics	Hrs
01	Linnaeus and taxonomy; hierarchical system of taxonomy; history of modern systematics; sampling taxa; systematization versus classification; International Commission for Zoological Nomenclature; nomenclature and ICZN code; inventorying biodiversity; systematics and fossil record; practical sessions for the unit.	8
02	Necessity of new species descriptions; recognizing species; species concepts in practice; taxonomic characters; examples of new species discoveries; mistakes and bad examples; establishing identity; finding and reading taxonomic literature; using museum collections: locating material, borrowing material, and visiting natural history collections; practical sessions for the unit.	8
03	Writing species descriptions; different kinds of taxonomic publications; the form of a descriptive paper; headings and synonyms; etymology; type and voucher material; diagnosis; taxonomic discussion; material examined; taxonomic keys; practical sessions for the unit.	8

04	Phylogenetic systematics: plesiomorphic and apomorphic conditions, apomorphy, synapomorphy and autapomorphy; taxa and characters: taxon selection, character selection and definition, character state discreteness, character correlation, homology assessment, transformation series and polarity, character weighting, character step matrix, and character x taxon matrix; practical sessions for the unit.	12
05	Cladograms: apomorphies as evolutionary novelties, recency of common ancestry, monophyly, polytomy, reticulation, taxon selection and polymorphic characters; constructing cladograms: maximum parsimony, comparison of outgroups, ancestral versus derived characters, consensus trees, attraction of long branches, maximum likelihood, Bayesian inference, coalescent methods, measures of homoplasy, cladogram robustness; cladogram analysis: phylogenetic classification, character evolution, dating methods, and speciation rates; practical sessions for the unit.	12

Course textbooks:

1. Winston, Judith E. *Describing species: practical taxonomic procedure for biologists*. Columbia University Press, 1999.
2. Simpson, Michael G. *Plant Systematics*. New York: Academic Press, 2019.
3. Williams, D.M. and Ebach, M.C. *Cladistics: A Guide to Biological Classification.* London. Cambridge University Press, 2020.

Additional Reading:

1. Wiley, E. O. and Lieberman, B.S. *Phylogenetics: Theory and Practice of Phylogenetic Systematics.* Wiley-Blackwell. 2011.
2. Mayr, E. E. Linsley, G. and Ursinger, R.L.. *Principles of Systematic Zoology*. New York: McGraw-Hill. 1953.
3. Schuh, Randall T. and AnBrower, A.V.Z. *Biological Systematics: Principles and Applications*, 2nd Edn. Comstock Publishing Associates. 2009.

ZGY5102: Biochemistry

L-3: C-3: 60 h

Course Outcome:

Upon completion of this course, each student will be able to:

- Understand the importance of biochemistry in living system and appreciate how chemistry and biochemical principles evolve in the diverse living condition of life.
- Understanding of biomolecules including its structure, properties, functions, derivatives and classifications and explains the metabolic pathways, regulation and importance of high energy compounds in cellular metabolism.
- Discuss the fundamental principles of enzyme action and biocatalysis. Learn how to analyse enzyme kinetics and estimate the activity of enzymes. Apply the knowledge in enzyme inhibition mechanism and introduce the area of treatment strategies for various diseases.
- Apply the concepts from bioenergetics and oxidative metabolism to interpret biochemical phenomena.
- Gain proficiency in laboratory techniques in biochemistry and be able to develop experimental/research skill in biochemistry.
- Exhibit quantitative research skills that help in executing quantitative analysis and mathematical reasoning to interpret biochemical data.
- Get the academic and laboratory experience needed to be eligible for apply for Academic, diagnostic and R & D institutions.

Course content:

Unit No.	Topics	Hrs
01	Atoms and molecules: Atomic structure; Relation between atomic structure and chemical properties, Atomic orbitals; Wave functions; Electronic structure of atoms; Spin of particles; Formation of molecules from atoms -different types of bonds, its properties and strength	02
02	Biomolecules and cellular metabolism: 2.1. Carbohydrates: Structure, classification, properties, and biological importance; Important derivatives of monosaccharides; Blood group polysaccharides; Storage and structural polysaccharides; Bacterial cell wall polysaccharides; Proteoglycans and Glycoproteins; Structural features of oligosaccharide side chains 0- glycans and N- glycans; Glycolysis; Fate of pyruvic acid (Pyruvic acid dehydrogenase); TCA cycle; Glycogenolysis; gluconeogenesis, pentose phosphate pathway; Regulation of glucose metabolism.	10

	2.2. Proteins: Aminoacids: Structure, properties, and classification; peptide bonds; Zwitter ion; Amino acid-specific reactions; Peptides and its biological importance; Classification of proteins and biological functions; Levels of organization — primary, secondary, tertiary, quarternary and quintary; Sequencing of proteins; Ramachandran plot; Protein folding; Chaperons- structure and function; Protein-protein interaction, Protein-ligand interaction; Protein denaturation; Deamination; Transamination; Decarboxylation; Urea Cycle; Metabolism of glutamic acid; Inborn errors in amino acid metabolism	10
	2.3. Lipids: Classification and properties; Essential fatty acids; Omega-3 and omega-6 fatty acids; Triacylglycerides- properties and biological significance; Phospholipids- Structure, properties and functions; Isoprenoids; Sterols; Cholesterol; HDL and LDL; prostaglandins and glycolipids; Biosynthesis and oxidation of fatty acids (Beta oxidation); Biosynthesis of phospholipids, sphingolipid , glycolipid; Regulation of fatty acid metabolism.	10
	2.4. Nucleic acids: Nitrogenous bases-structure; nucleosides and nucleotides-structure, function and properties; structure of DNA and RNA; Different forms of DNA; Right handed and left handed helix; Supercoiling; Structural polymorphism in nucleic acids; DNA and RNA sequencing- dideoxy method; Biosynthesis and degradation of purines; Biosynthesis and degradation of pyramidines.	10
03	Enzymes: IUB classification, nomenclature and specificity; Mechanism of enzyme action; Michaeli's-Menten equation — derivation, double reciprocal plot, Line-Weaver-Bruke — method , significance of K_m and V_t'', values; Factors affecting enzyme action; Regulation of enzyme activity, enzyme inhibition, allosteric enzymes- positive and negative modulators; Vitamins as co-enzymes and RNA as enzymes	10
04	Bioenergetics: Enthalpy, entropy, free energy concept; Living body as a thermodynamic system; Energy of activation; Standard free energy; Energy-rich compounds- ATP, creatinephosphate and pyrophosphate; Role of ATP in the biological system.	04
05	Biological oxidation: Electron transport system in mitochondria, redox potential, mechanism of oxidative phosphorylation, chemiosmotic coupling hypothesis.	04

Suggested Literature:

1. Champe P.C., Harvey R.A. and Ferrier D.R. Biochemistry, 5th Edition, (2007) - Lippincott Williams & Wilkins, NY
2. Wilson K. and Walker J. Principles and Techniques of Biochemistry & Molecular Biology, 7th Edition (2010). - Cambridge University Press
3. Mary K. Campbell, Biochemistry 8th Edition – Harcourt Brace College Publishers
4. Thomas M. Devlin, Biochemistry, 7th Edition (2010) – A John Wiley and Sons, Inc. Publications.
5. Donald Voet and Judith G. Voet, Biochemistry, 5th Edition (2011) – John Wiley and Sons Publication.

6. David L. Nelson & Michael M. Cox, Lehninger, Principles of Biochemistry, 6th Edition– W. H. Freeman & Company, N.Y.
7. Robert K. Murray, Daryl K. Granner, Peter M. Mayer, Victor W. Rodwell (2012) Harper's Illustrated Biochemistry, 29th Edition – McGraw-Hill Lange
8. Elliott W. H. and Elliott C. P. Biochemistry and Molecular Biology, 5th Edition (2014) – Oxford University Press, N.Y.
9. Lubert Stryer with Gregory J. &Gatto Jr., Biochemistry, 7th Edition - W. H. Freeman & Company, N.Y. , Palgrave Macmillan.
10. Mahler, H. R. &Cordes, E. H. (1968): Basic Biological Chemistry, Harper & Row Publishers.
11. Awapara, J.(1968) : Introduction to Biological Chemistry, Prentice-Hall of India, New Delhi.
12. Ranganatha Rao, K. (1986): Textbook of Biochemistry (3rd Ed.), Prentice-Hall of India, New Delhi.
13. Cohn, E. E. & Stump, P. K.: Outlines of Biochemistry, 5thedition,WileyEstern, New Delhi.
14. Gerald, Litwalk, 2008. Human Biochemistry and Disease. Academic Press.
15. Guptha, R C and S. Bhargav, 2006. Practical Biochemistry (4th ed.). CBS Publ.
16. Jayaraman, J 2007. Lab. Manual in Biochemistry, New Age International Publ.
17. Sandhu, G.S. (1990) Research Techniques in Biological Sciences. Anmol Publications, New Delhi.

ZGY 5103: Animal Physiology

L-3: C- 3: 60 h

Course Outcome:

Upon completion of the course, each student will be able to:

- Value the different physiological systems in animals and apply physiological concepts and principles at the basic and applied levels.
- Develop a comprehensive knowledge of physiological activities in invertebrates and vertebrates and the role of evolutionary processes in driving the organisation of physiological systems.
- Describe how the physiological system and activities adapted for diverse environments.
- Develop an understanding of cellular physiology at different internal cell environment.
- Develop an understanding of nutrition and the role of enzymes in digestion and absorption.
- Understand the concept of thermophysiology and its regulation.
- Develop an understanding about neural transmission and functions associated with it.
- Understand physiology and regulation of muscle movement.

Course content:

Unit No.	Topics	Hrs
01	Nutrition: Intracellular and Extracellular Digestion; absorptive areas and mechanism of absorption of molecules; Hormonal and neuronal regulation of absorption	4
02	Respiration and Circulation: Respiration :Respiratory pigments in invertebrates and vertebrates; Transport of Oxygen and Carbon dioxide; Biological importance of pH; Resistance of cells to changes in pH; Cellular response to acidosis and ketosis; Hypercapnia, Regulation of Respiration Circulation: General plan of circulatory system; Functional morphology of heart; Haemotopoesis; Haemodynamics; Cardiac reflexes; Cardiac cycle and its regulation; Electrical characters of heart- normal and abnormal; Lymphatic system.	12
03	Homeostasis, Excretion and Thermoregulation: Homeostasis:Water and salts in cell environment; Osmotic properties of cells; Different mechanisms of ion transport across membranes; Regulation of body fluid composition in invertebrates and vertebrates- in different habitats- hyposmotic, hyperosmotic, terrestrial; Renal function- ultra- filtration, absorption, secretion, plasma clearance; Counter current mechanism; Hormonal regulations.	18

	Thermoregulation: Thermal relation with the environment- Ectothermy- Response to acute changes and chronic changes in the Environment,; Pattern of Enzyme modulation, adaptive response to freezing conditions; factors affecting body temperature, lethal temperature; Temperature regulating mechanisms; Acclimation and Acclimatization	
04	Photobiology: Photochemical reactions in biological light perception and regulation of Pigments; Biological clock -invertebrates & vertebrates; Bioluminescence; Phototransduction in compound and vertebrate eye.	8
05	Muscle physiology: Proteins of contractile system; Structure and physiology of vertebrate skeletal muscles; Smooth muscles and cardiac muscles; Twitch muscles and tonic muscles; Mechanism of muscle contraction; Molecular basis of muscle contraction; Energetics of muscle contraction.	8
06	Reproductive physiology: Reproductive organs and cells in Invertebrates and Vertebrates; Neural and endocrine co-ordination of reproductive organs; Spermatogenesis and Oogenesis; Functions of seminal vesicle and prostate gland; Reproductive cycles in Invertebrates and Vertebrates; Menstrual cycle – regulation and abnormalities; Placenta- structure and function; Physiology of pregnancy; Parturition; Lactation; Menopause and post menopause changes; Sex change- Protrandrous and protogynous hermaphroditism; Reproduction and environmental relation.	10

Suggested Literature:

1. General and Comparative Animal Physiology, Hoar. V. S. (1983) (ed), Prentice Hall, India
2. Comparative Physiology (Handbook of Physiology): Vol. 1, 2, Dantzler, W.H. (ed.) Oxford
3. Animal Physiology: Adaptation and Environmental, Nelson K. S. V(ed) Cambridge University Press, Cambridge, UK.
4. Animal Physiology: Anderson & Hill, IV ed.
5. Photobiologv- Lars Olof Bjorn, Third edition, Springer.
6. Animal Physiology- Sherwood, Klandorf,Yancey 2nd ed.
7. Principles of Animal Physiology- Christopher D Nioyes& Pam 3rd ed.
8. Bruce M Koeppen, and Bruce A Station, 2009. Brene and Levy Physiology.(7th edition). Elseiver publishers.
9. Clancy, and Mc vicar, A.J. Physiology and Anatomy, 3rd ed.
10. Cyril A. Keel , Eric Neil and Norman Joels. Samson wrightsAppled physiology. (13th Edition) Oxford University Press
11. David Randall, Warren burggrom, Katheleen, French, Eckert Animal physiology, Mechanisms and adaptation, W.H Freeman & company, 5th ed.
12. Gerard J Tortora 2006, A brief atlas of the skeleton surface anatomy and selected medical images. John wiley and sons, Inc. 4thed.

13. Gerard J Tortora, Bryan H Derrickson, 2009, Principles of Anatomy and Physiology, (14th edition) volume- I John Willey and sons, INC.
14. Guyton and hall, 2007, Text Book of Medical Physiology. (13th Edition).Elsevier publisher.
15. Iankay, 2000, Introduction to Animal physiology, 2nd ed, Viva book private limited.
16. Jensen, D (1976) The Principles of Physiology, 2nded, Appleton-Century- Crofts, New York.
17. Lauralee Sherwood, Hillarkaladrof, and Paul H Yancey , 2nded, Animal physiology from genes to organisms, Thomson books publishers.
18. PatWillmer, Grashan Stone and lan Johnston. Environmental physiology of animals. (2nd edition) Black Well Publishing.
19. Prosser, C.L, Comparative Animals Physiology, W. B Saunders & co, 3rd ed.
20. Sperelakis, N. and Banks, R.O. eds. Cell Physiology, Little, Brown & Co., London
21. Strand, F. L (1978) Physiology: A regulatory systems Approach, 4th Ed. Mamcmillan Publishing Co., New York.
22. Stuart Ira fox, 2006 Human physiology. (13th edition).McGraw hill higher education press.
23. William F. Ganong(1999): Review of Medical Physiology, Lange medical Publications(Appleton & Lange).

ZGY 5104: Cell & Molecular biology

L-4: C-4:72 h

Course Outcome:

After successful completion of the course the students can:

- Gain the knowledge about the organization in the prokaryotic and eukaryotic cell and the molecular mechanisms of the cellular processes.
- To draw parallels between the physiological processes at the cellular and organismic levels.
- Appreciate the importance of cell-cell adhesion and the extracellular matrix in the evolution of multicellular organisms.
- Able to design and comprehend experimental strategies for alteration of genes and gene products in variety of organisms.

Course content:

Unit No.	Topics	Hrs
01	***Cell structure, organelles and function:*** Cell theory, methods of studying cells, structures and functions of prokaryotic and eukaryotic cells, cell wall, plasma membrane, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, and structure & function of cytoskeleton.	12
02	***Cell division and cell cycle:*** Mitosis and meiosis, phases of cell cycle and regulation, tumor suppressors and role of helicases; regulation of cell proliferation and differentiation by hormones, and growth factors; cell differentiation; apoptosis. Turnover of cellular components: targeting of proteins to lysosomes for degradation; degradation of cytosolic proteins. Cells in culture: requirements for cell culture; aseptic technique; primary culture; cell lines; organotypic cultures; cytotoxicity assays.	10
03	***Cell signalling mechanisms:*** *K*ey concepts; proliferative, survival and death pathways; G-protein coupled receptors; receptor tyrosine kinases; MAP kinase cascade; second messenger systems; desensitization of receptors; signalling and toxins; signaling pathways in malignant transformation of cells; cell transformation: role of oncogenes.	10
04	***Nucleic acids:*** DNA as the genetic material; chemical structure and base composition of nucleic acids, double helical structures; different forms of DNA, forces stabilizing nucleic acid structure; super coiled DNA; properties of DNA, renaturation and denaturation of DNA; Tm and Cot curves. Structure of RNA; three-dimensional structure of tRNA.	10
05	***Central dogma of molecular biology: DNA Replication:*** General features, models of replication, prokaryotic and eukaryotic replication mechanisms; replication in phages. ***Transcription:*** Transcription in prokaryotes and eukaryotes, post-	16

	transcriptional processing of tRNA, rRNA and mRNA (5' capping, 3' polyadenylation and splicing); reverse transcription; Ribozyme; RNA splicing, spliceosome, alternative splicing, exon shuffling, catalytic RNAs, RNA editing. ***Translation:*** General features of genetic code, deciphering of genetic code, code in mitochondria; translational mechanism in prokaryotes and eukaryotes; inhibitors of protein synthesis; post translational modification and transport, protein targeting (signalling), non-ribosomal polypeptide synthesis.	
06	***Gene expression and Genome analysis:*** Prokaryotic gene expression: induction and repression; operon model: Lac operon, tryptophan operon, arabinose operon; Eukaryotic gene expression: transcription factors, histones acetylation and deacetylation; RNA gene silencing (RNAi), microRNAs. Regulation of gene expression in bacteriophage. ***Genome analysis:*** C-value paradox; genome analysis-microbial, yeast, *Drosophila*, human, organelle genomes; transposable elements in prokaryotes and eukaryotes; role of transposable elements.	14

Suggested Literature:

1. Molecular Cell Biology, Lodish*et. al.*, (2007), W.H. Freeman and Company, New York, USA
2. Molecular Biology of the Cell, Albert*set. al.*, (2008), Garland Science, Taylor & Francis Group, New York, USA.
3. Cell Physiology Source Book: A Molecular approach, Sperelakis, (2001), Academic Press, New York, USA.
4. Gerald Karp, Janet Iwasa, Wallace Marshall, (2019), Karp's Cell and Molecular Biology, 9th Edition, Wiley.
5. Lewin's GENES XII: (2018), Jones & Bartlett Learning.
6. Brown, TA (2016), Gene Cloning and DNA Analysis: An Introduction, 7th Edition, Wiley-Blackwell.
7. David L. Nelson & Michael M. Cox (2012), Lehninger Principles of Biochemistry, 6th Edition, W. H. Freeman.
8. Bruce Alberts, Karen Hopkin, Alexander D. Johnson, David Morgan (2020), Essential Cell Biology 5th Edition, W. W. Norton & Company.
9. Benjamin A. Pierce (2016), Genetics: A Conceptual Approach 6th Edition, W. H. Freeman.
10. Geoffrey Cooper (2019), The Cell: A Molecular Approach 8th Edition, Sinauer Associates, an imprint of Oxford University Press.
11. Wojciech Pawlina, Michael H. Ross (2019), Histology: A Text and Atlas: With Correlated Cell and Molecular Biology, Lippincott Williams & Wilkins.
12. Volkhard Helms (2019), Principles of Computational Cell Biology, From Protein Complexes to Cellular Networks, Wiley.
13. Greg Conradi Smith (2019), Cellular Biophysics and Modeling- A Primer on the Computational Biology of Excitable Cells, Cambridge Press.

ZGY 5105: Laboratory- Cell & Molecular Biology

P-4:C-2: 60h

Cell Biology

1. Sub cellular fractionation of functional mitochondria.
    a. Isolation of mitochondria from mouse liver by differential centrifugation.
    b. Determination of protein yield in the fractions by Lowry method.
    c. Identification of mitochondrial fraction by assay of marker enzyme.
2. Microtubules in vesicle transport in fish chromatophores.
3. Mammalian cell culture
4. Assessment of proliferation in cultured cells by MTT assay.
5. Over-expression and affinity purification of SH3-GST recombinant protein from bacterial cells.
6. Demonstration of protein-protein interaction between recombinant SH3-GST fusion protein and ovarian proteins by SDS-PAGE
7. Effect of protein synthesis/ DNA synthesis inhibitor on cell responses to a hormone.
8. Observation of DNA fragmentation in apoptotic cells.
9. Glut mediated transport of glucose across the plasma membrane in mammalian cells.
10. Electrophoretic mobility shift assay (EMSA) for Protein-DNA interactions.
11. Introduction to FACS analysis.

Molecular Biology

1. Isolation and purification of RNA, DNA and proteins.
2. Analysis of RNA, DNA and proteins by gel electrophoresis.
3. Restriction enzyme digestion of plasmid DNA.
4. Ligation of DNA fragments.
5. Studies on denaturation of DNA and determination of Tm and calculation of G: C content.

ZGY 5106: Laboratory- Biochemistry & Animal Physiology

P-4:C-2: 60h

Biochemistry

1. Reactions of monosaccharaides, disaccharides and polysaccharides, amino acids, proteins and lipids
2. Histochemical staining of carbohydrate, protein and nucleic acids
3. Chromatographic separation and elution of amino acids
4. Colorimetric estimation of total free amino acids
5.Quantitative estimation of Protein-Biuret method
6. Quantitative estimation of Protein-Lowry method
7. Spectral studies of DNA, RNA and protein using UV spectrophotometer
8. Polyacrylamide electrophoretic separation of protein
9. Estimation of total carbohydrates – Phenol sulphuric acid method
10.Colorimetric estimation of glucose – GOD- POD method
11. Colorimetric estimation of protein bound hexose
12.Lipid Soxhlet extraction
13.Colorimetric estimation of lipids
14. Determination of specific activity of any one enzyme: Spectrophotometric method.
15. Kinetic characterization of any one enzyme.
16. Zymogram for any one enzyme.

Animal Physiology

1. Preparation of a 'Good' buffer and determination of pH using pH meter
2. Comparison of the capacities of two buffers of the same pH
3. Demonstration of buffering capacity of body fluids
4. Determination of salivary amylase activity-effect of substrate concentration, pH and temperature
5. Enumeration blood cells using hemocytometer
6. Demonstration of Diffusion using dialysis tube
7. Demonstration of osmotic haemolysis
8 . Determination of vertebrate haemoglobin
9 . Determination of blood pressure and pulse rate
10. Enumeration of RBC of human blood
11. Total and Differential count of WBC
12. Determination of chloride regulation of estuarine crab.
13. Estimation of the rate of oxygen consumption of a Fish
14. Demonstration of cell forms from invertebrate blood smear preparation

SEMESTER II

ZGY 5201: Neurobiology & Endocrinology
L-4: C-4: 72 h

Course Outcome:

This is an introduction and survey course of general and contemporary endocrinology topics. The aim is to develop a working understanding of the molecular basis for the synthesis, actions and regulation of hormones and their receptors in healthy and disease states. The students are expected to be able to generally interpret endocrinology papers from scientific literature. Masters students enrolled in this course will attend lectures, laboratories on research techniques, prepare essays and present to the class. Students will critically review papers on a chosen topic (discussed and agreed with the course instructor, could be related to their own research), and present their topic in a 30-minute seminar.

Learning Objectives:

I. Knowledge:

- Refresh and reorient students to their basic understanding of the neuro endocrine system.
- Provide recent advances in each aspect discussed.
- Selection of relevant articles reporting major findings.
- Critical analysis of methods used, results obtained and conclusions reached.
- Identification of ethical issues related to the use of animals and/humans.
- Understanding of novel methods used in neuroendocrine research.
- Identification of general implications of the endocrine research findings on human and/or animal population.

II. Skills:

- Grasp and summarize the current (up-to-date) information on endocrine system.
- Deeper understanding of the theory and practice of neuroendocrine research techniques.
- Hone critical literature review skills required to assess a research project reported.
- Develop a solid understanding of techniques used in the endocrine research projects discussed in articles.
- Present the critical analysis of the paper within the given period of time to peers and the instructor.
- Engage the audience by prompting questions and initiating discussions.
- Ability to summarize the individual work clearly, and place it within a larger topic/context.

III. Values:

- Demonstrate a very solid understanding of the current knowledge base in endocrinology at the graduate level.
- Develop important writing and presentation skills: to critically assess a major research paper and effectively present it to peers in a clear and organized manner. This will help them as young researchers in the long run.

Course content:

Unit No.	Topics	Hrs
01	General organization of peripeheral central and peripheral nervous system. Type and structural characteristics of neurons, connections and synapses, action potential-general factors, ionic mechanism, conduction, giant nerve fibers; Myelination of neurons; synapses- electrical and chemical transmissions, synaptic potential; synaptic polarity; Neurotransmitters in invertebrates and vertebrates- chemical nature, classification, synthesis, transport and function; vertebrate brain-cerebral cortex, epilepsy, sleep emotion, limbic system and hypothalamus; Neuro-muscular disorders.	10
02	Concept of Endocrinology, Historical perceptive, Classes of chemical messengers, peptide hormones, steroid hormones, bioamines, eicosanoids, chalones, neurotransmitters, neuropeptides, neurosteroids, neurohormones, pheromones, synthetic hormones, prohormones, paracrine, merocrine, cytogenic secretion.	8
03	Vertebrate endocrine glands: Morphology and anatomy of endocrine glands, hormones of the adipose and GIT, Biosynthesis of pancreatic, steroid, thyroid hormones, hypothalamus and hypophyseal secretion, hypothalamohypophyseal interaction, endocrine axes, function of hormones, disorders of hormonal imbalance, Regulation of hormone secretion, Concepts of feed-back regulation, synthesis and metabolism of hormones, half-life of hormones metabolic clearance rate, miscellaneous hormones, eicosanoids, prostaglandins, prostacyclins, thromoboxanes, leukotrienes,Pheromones.	10
04	Mechanisms of hormone action: General and molecular mechanism of action of amines, polypeptide and steroid hormones, Overview of cell surface receptor structures, Mechanism of signal transduction in vertebrates hormone receptors–as mediation of endocrine signals, classes of endocrine receptors, receptorligand interaction, cell surface receptors-structure and regulation of receptor units. Cell surface receptor dimerization, Mechanism of insulin action. Second messengers of hormonal action, cyclic nucleotides, inositol triphosphate, cAMP as second messengers, genomic action of cAMP, G protein and its dual control on adenylate cyclase, receptor crosstalk, ligand-gated ion channels, non-genomic actions of steroid hormones.	12
04	Cell Growth Factors :Types of growth factors, mechanism and its functional role in cellular activities, somatomedins, IGF, epidermal growth factor, transforming growth factor, platelet derived growth factor, fibroblast growth factor, Nerve growth	10

	factor, hepatocyte growth factor. Hormonal control of cell growth and cell cycle control.	
06	Hormones and Cancer: Hormonal control of development of cancer, hormone therapy in cancer Treatment, Oncogenes and hormonal function, Breast cancer and Hormone receptor status, Etopic production of hormones by tumour cells. ras oncogene mediated signaling, activation pathway of MAP kinase.	10
07	Principles and application of techniques in molecular endocrinology: Radioimmunoassay and enzyme linked immunoassays- basic principles and measurement of steroid hormone receptors- electrophysiology, immunocytochemistry, *in situ* hybridization, autoradiography, *in vitro* perfusion. Careers in endocrinology.	12

Suggested Literature:

Please note that if and when newer (e.g. new edition of a book) and/or more relevant materials (e.g. new textbooks) become available, the resources listed will be likely be replaced with newer information.)

1. Endocrinology, Eds. Hadley ME and Levine JE. Benjamin Cummings. ISBN-13: 978-0131876064.
2. Fish Physiology: Fish Neuroendocrinology; Eds. Bernier NJ et al., Academic Press, ISBN: 978-0-12-374631-3.
3. Handbook of Neuroendocrinology, Flink et al. Academic Press. ISBN: 978- 0-12-375097-6.
4. McDonald's Veterinary Endocrinology and Reproduction, Ed. Pineda M, and Dooley MP. Wiley-Blackwell, ISBN-13: 978-0813811062.
5. Knobil and Neill's Physiology of Reproduction. Eds. Neill, JD et al., Elsevier Inc. ISBN: 978-0-12-515400-0.
6. Comparative endocrinology, Eds: Gorbman et al., Wiley. ISBN-13: 978-047106266.

Reference Journals (available online)

1. Endocrinology
2. Molecular Endocrinology
3. Journal of Endocrinology
4. Journal of Neuroendocrinology
5. Hormones and Behaviour
6. General and Comparative Endocrinology
7. Cell Metabolism
8. Cell
9. Nature
10. Science
11. Biology of Reproduction
12. Endocrine Reviews
13. American Journal of Physiology – Endocrinology and Metabolism & other AJP series
14. Trends in Endocrinology and Metabolism
15. Peptides

16. Regulatory Peptides
17. Domestic Animal Endocrinology
18. Endocrine
19. International Journal of Endocrinology

Neurobiology

Suggested Literature:

1. Principles of Neuroscience 5th Edition E. Kandel, J Schwartz, T Jessell, S Siegelbaum, A Hudspeth (2013)Mc Graw Hill Medical
2. Development of Nervous system 3rd Edition Dan H Sanes., Thomas A Reh., illiam A Harris. (2012) Elsiever
3. Fundamental neuroscience Squire, 4th Edition L., Berg, D., Bloom, F.E., Du Lac, S., Ghosh, A. and Spitzer, N.C. eds., (2012).. Academic press.
4. Principles of Neurobiology, Luo Liqun, (2015), Garland Science. Taylor & Francis Inc.
5. Neuroanatomy : An Illustrated coloured text.5th Edition Ed A. R. Crossman and D. Neary (2015) London Churchill Livingstone Elsevier
6. Fundamental neuroscience for basic and clinical applications E-book Haines, D. E., & Mihailoff, G. A. (2017).. Elsevier Health Sciences.
7. Current diagnosis & treatment neurology 3rd Edition Brust, J. C. (2018).. McGraw Hill Professional.
8. Bradley and Daroff's Neurology in Clinical Practice, 7 th Edition (Bradley's Neurology in Clinical Practice) Joseph Jankovic, John C Mazziotta, Scott L Pomeroy, Nancy J. Newman Elsiever (2016)
9. Handbook of Neurochemistry and Molecular Neurobiology, Abel Lajtha, Maarten E. A. Reith, (2020), Springer.
10. Basic neurochemistry: principles of molecular, cellular, and medical neurobiology Brady, S., Siegel, G., Albers, R. W., & Price, D. (Eds.). (2011).. Academic press.
11. Guyton and hall, 2007, Text Book of Medical Physiology. (13th Edition).Elsevier publisher.
12. Animal Physiology: Hill, Wyse & Anderson, 4th Edition.Sinauer associates Inc (2016)
13. Cyril A. Keel , Eric Neil and Norman Joels. Samson wrightsAppled physiology. (13th Edition) Oxford University Press.
14. William F. Ganong (1999): Review of Medical Physiology, Lange medical Publications(Appleton & Lange).

ZGY 5202: Genetics

L-3: C-3: 60 h

Course Outcome:

- Genetics course will open up several opportunities for students in research and employability.
- Genetics has made extensive use of model organisms, many of which will be used to teach this course in school, undergraduate and graduate level. By observing genetic mutations in *Drosophila*, students can correlate phenotype with genotype, understand genetic interaction and their molecular basis.
- Cytogenetics will impart knowledge on the human chromosome constitution that would help apply basic principles of chromosome behavior to disease context.
- Students will be able to set hands on genetic crosses to understand inheritance pattern, and evaluate statistical significance by counting the progeny as statistical analysis provides crucial insight into many biological processes.
- This course will highlight the extension of Mendelian Genetics, dosage compensation, the evolution of the gene's concept, and its amalgamation with molecular biology and the study of genetic diseases.
- Students will learn how genetic information is passed on in eukaryotes and prokaryotes, how genes work together in a complex manner in the biological system and any alteration that can lead to significant phenotypic change.

Course content:

Unit No.	Topics	Hrs
01	**Science of Genetics:** Introduction: milestones in genetics; Mendelian Genetics-Genes and rules of inheritance; Watson and crick- the structure of DNA; The human genome project-sequencing DNA and cataloging genes. Extensions of Mendelian principles: codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage, sex-limited, and sex influenced characters.	14
02	**Cytogenetics:** Chromosomal theory of heredity; concept of gene; linkage and crossing over; chromosome mapping; cytogenetic mapping; linkage analysis in humans; tetrad analysis, mapping with molecular markers.	10
03	**Mutation, DNA Repair, and Recombination:** The molecular basis of mutation and process - loss of function, the gain of function, germinal verses somatic mutants, insertional mutagenesis; phenotypic effects. DNA repair mechanisms and DNA recombination mechanisms.	10
04	**Advanced Genetics:** Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance. Sex determination in organisms; dosage compensation in *C.elegans*, Drosophila and Human; Lyon hypothesis. Genetic	16

	disorders (numerical and structural alterations of chromosomes); genetics of ABO system, Rh disease and inheritance, sickle cell haemoglobin and thalassemia. Cytological techniques: Analysis of mitotic chromosomes; the human karyotype, polyploidy, aneuploidy, amniocentesis and chorionic biopsy, chromosomal abnormalities, the pattern of gene inheritance- pedigree analysis. Applications of molecular genetics – diagnosis of human diseases -gene therapy; DNA profiling: DNA fingerprinting and footprinting. Applications of Genetics: Animal breeding, inbreeding, and outbreeding, heterosis.	
05	**Population genetics:** Genetic variation, polymorphism, polyploidy, gene pool, gene frequency, theory of allele frequencies: Hardy-Weinberg equilibrium, disequilibrium, factors disrupting gene equilibrium.	10

Suggested Literature:

1. Alberts *et. al.*, (2008), Molecular Biology of the Cell, Garland Science, Taylor & Francis Group, New York, USA.
2. Benjamin Lewin's Genes XII: (2018), Jones & Bartlett Learning.
3. David L. Nelson & Michael M. Cox (2012), Lehninger Principles of Biochemistry, 6th Edition, W. H. Freeman.
4. Benjamin A. Pierce (2016), Genetics: A Conceptual Approach 6th Edition, W. H. Freeman.
5. Geoffrey Cooper (2019), The Cell: A Molecular Approach 8th Edition, Sinauer Associates.
6. Gangane SD, (2019), Human Genetics, Elsevier.
7. Hamilton, Matthew (2011), Population Genetics, John Wiley and Sons, Inc.
8. William S. Klug, (2020), Essentials of Genetics, Pearson Education.
9. Snustud and Simmons, (2015), Principles of Genetics, 7th Edition, Wiley.
10. Daniel Hartel, (2019), Genetics: Analysis of genes and genomes, 9th Edition, Jones & Bartlett.
11. Robert Booker, (2018), Genetics: Analysis and Principles, 6th Edition, Mc Graw Hill.
12. Robert DeSalle, Michael Yudell, (2020), Welcome to the Genome, 2nd Edition, Wiley-Blackwell.
13. Benjamin A. Pierce, (2017), Genetics: A Conceptual Approach 6th Edition, W. H. Freeman.
14. Tom Strachan, Andrew Read, (2011), Human Molecular Genetics 4th Edition, CRC Press.
15. Ricki Lewis, (2018), Human Genetics, 12th Edition, McGraw-Hill.
16. Julia Richards R. Scott Hawley (2010), The Human Genome, 3rd Edition, Academic Press.
17. Bruce R. Korf, Mira B. Irons, (2013), Human Genetics and Genomics, 4th Edition Wiley-Blackwell.

ZGY 5203: Economic Zoology

L-2: C-2: 48 h

Course Outcome:

Upon completion of the course, each student will be able to:

- Gain knowledge to define the concepts of the applied subjects like Fisheries, Aquaculture and Pest Control.
- identify, freshwater, marine fishes.
- Gain knowledge to explain the tools and techniques used in aquaculture and agricultural practices.
- describe the fish species commonly used in aquaculture.
- Describe the common agricultural pests from nearby area and Illustrate the diseases in aquaculture and agriculture.
- Classify freshwater and Marine fishes and Categorize economically important fish species.
- Gain knowledge to define the concepts of the applied subjects like Apiculture and Sericulture.
- Identify different species and casts of honeybees and species of silkworm.
- Explain the tools and techniques used in apiculture and sericulture.
- explain the important pests of apiculture and sericulture.
- Describe the economic importance of honeybee and silkworm.
- Illustrate management of the apiary and sericulture units.
- Classification of Apis, Bombyx and Anthereria.
- Select economically important species of Apis for uni-floral and multi-floral honey production.

Course content:

Unit No.	Topics	Hrs
01	**Apiculture, Sericulture and Lac Culture, Vermiculture** Apiculture- Honey bees, Bee culture methods, Modern equipment in Apiculture, Honey bee products: bee wax and its uses, chemical composition of honey and uses and management of Apiary. Disease in Apiculture, parasites and predators in Apiculture. Sericulture: Silk worm moths, Sericulture and extraction of silk, Types of silks Lac insect culture: Methods of Lac culture, Uses of lac, Enemies of lac insects, Lac production in India Vermiculture: Importance of vermiculture, vermicomposting, common worms used in vermiculture-*Eisenia Andrei*, *Eisenia foetida* and *Lumbricus rubellus* , vermiculture medium, methods for vermiculture, Vermiculture techniques for farmers	12

02	**Poultry husbandry** Breeds of fowl: Exotic breeds: *Rhode Island Red, Plymouth Rock, New Hampshire.* ; Indigenous breeds: *Chittagong, Gangus*. Nutritive value of eggs and importance of egg production. Poultry breeding: Economic tracts - relation with breeding, meat products; Poultry farming in India; Common diseases in poulty and its control measures	8
03	**Animal Husbandry** Animal Husbandry- Livestock husbandry - origin, domestication of cattle. Breeds of cattle, Artificial insemination, Storage of semen, Embryo transfer technology, Common diseases and Control measures in Animal husbandry: Anthrax, Foot and mouth disease, Rinderpest	8
O4	**Aquaculture** General principles of Aquaculture, criteria for selection of species of Aquaculture, Commercially important Aquaculture species in India, Fresh water, brackish, marine fin fishes and shell fishes. Classification of fish farms and farming techniques (filters, aerators, RAS, Aquaponics, Biofloc), ornamental fishes and crustaceans Mariculture: Recent development in coastal and open sea mariculture. Cage culture, Pen Culture, culture of Pearl oysters, Edible oysters, Groupers, Cobia and sea weeds. Brackish Water Aquaculture: Traditional brackish water farming practices in India. Culture of Milk fish, Pearl spot, Asian sea bass, Crab, Shrimp (*Penaeus indicus, P. vannamei*), Mussels, edible oysters. Importance of mangrove ecosystems in fisheries. Freshwater Aquaculture: Traditional and modern aquaculture system, GIFT Tilapias, Carp, Anabas, Cray fish. Seed production in Aquaculture: Seed resources and seed collection techniques of fin fishes and shell fishes. Induced breeding of shell fishes and fin fishes (Carp). Cryopreservation, Hatchery techniques of shrimp seed production(*Penaeus indicus* and *Macrobrachium rosenbergii*), live feeds. Diseases: Viral, bacterial and parasitic diseases in Aquaculture and its control	10
05	**Human parasites and Insect Vectors of human diseases:** Human parasites: Habits, habitat, life cycle, mode of infection, control measures of human parasites: *Entamoeba hystolytica, Plasmodium vivax, Taenia solium, Ascaris lumbricoides, Wuchereria bancrofti, Enterobius vermicularis* *Insect vectors of human diseases: Anopheles, Culex, Aedes, Xenopsylla, Cimex, Pediculus, Phthirus* (habits, structure, disease caused and control).	10

Suggested literature

1. David, B. V. and Ananthakrishnan, T. N. (2004). General and Applied Entomology Second Edition. Tata McGraw Hill Publishing Company Limited, New Delhi.

2. Peter Bogdanov (1998) Commercial Vermiculture: How to Build a Thriving Business in Redworms, Kindle edition
3. Chakraborty, C. & Sadhu, A. K. 2000. Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Daya Publishing House. x+102pages, figs., plates.
4. Dholakia, A. D. 2004. Fisheries and Aquatic Resources of India. Daya Publishing House. xxx + 413pages, figs., tables, index.
5. Horvath, L., Tamas, G., Seagrave, C. Carp and Pond Fish Culture. Wiley-Blackwell. 188 pages.
6. Jangi, B. S. 1991. Economic Zoology. CRC, first edition (June 1, 1991), 200 pages.
7. Khan, A.A. (Editor), 2007. Encyclopedia of Economic Zoology. 2 vols. Anmol Publications Pvt. Ltd. (April 1, 2007), 624 pages.
8. Logan,L. B. 2007. Practical Carp Culture (Paperback – 09-2007). Kissinger Publishing. 136 pages.
9. Meehan, William E. 2002. Fish Culture: In Ponds and other Inland Waters. Vedams eBooks (P) Ltd. 287 pages.
10. Thomas, P.C., Rath, S.C. & Mohapatra, K.D. 2003. Breeding and Seed Production of Fin Fish and Shell Fish. Daya Publishing House. xviii+402pages, 40 colour plates., figs., tables.
11. Tomar, B.S. 2004. Introduction to economic zoology. Emkay Publ.,Delhi. 381 pages.
12. Tucker Jr., John W. 1998. Marine Fish Culture. Springer, 760 pages.
13. Melhorn, H(ed) 2008- Encyclopedia of Parasitology vol 112 Springer Tranger,
14. Brown, H.W. & Neve, F. A. (1994): basic Clinical parasitology (6th ED) Appleton and lange, Norwalk, Connecticut
15. Solusby, E.J.L. (1982): Helminth, Arthropods and Protozoa of Domestic Animals, ELBS
16. Kettle, D.S (1990): Medical and Veterinary Entomology, CAB International, U.K.
17. Smith, J.D (1985): Introduction to Animal Parasites, Blackle, Glasgow
18. Kanneey, C.R (Ed) (1976): Ecological Aspects of parasitology, North Holland Publishing Co. Amsterdam
19. Service, M.W. (2000): Medical Entomology for Students, Cambridge University Press
20. Marr, J (1995): Biochemistry and Molecular Biology of Parasites
21. Marr,J.J, Nilsen, T.W and Komuniecki, R.W (2003): Molecular Medical Parasitology. Academic Press
22. Yamaguti, S. (1963): Parasitic Copepoda and Brachiura of fishes, Interscience New York
23. Fleck, S.L & Moody, A.H. (1988): Diagnostic Techniques in Medical parasitology, ELBS Zoological, ZSI, Culcutta

ZGY 5204: Evolutionary Biology

L-3: C-3: 60 h

Course Outcome:

By the end of this course, students will be able to:

- describe the mechanisms and patterns of evolution using morphological, molecular, biochemical, ecological data.
- understand evolution from both extinct and living examples.
- identify and describe the evolutionary processes observable in the natural world.
- understand how biogeography, behavior and ecology are better understood in the light of evolution.
- explain the evolution of the *homo* genus, and the artificial selection of domesticated animals.
- explain the rise of evolutionary biology in the nineteenth and twentieth centuries.
- build a holistic understanding of life, which will help them lay the theoretical foundation for their teaching and research career in biology.

Course content:

Unit No.	Topics	Hrs
01	Natural philosophy before Darwin, rise of evolutionary biology, evolutionary synthesis, evolutionary biology since the synthesis, fundamental principles of biological evolution.	08
02	Inheritance of variation, gene mixing with segregation, recombination and asexual inheritance, rates and effects of mutations, nongenetic inheritance, the genetical theory of natural selection, phenotypic evolution, directional selection, artificial selection, phenotypic plasticity, genetic drift, genetic divergence between populations, gene flow and selection, species and speciation.	16
03	Sexual selection, fitness and its components, diverse life histories and fitness, cooperation and conflict, evolutionarily stable strategies, evolution of altruism, species interactions and co-evolution; gene and genome evolution: birth and death of genes, evolution of genome size and content.	14
04	Fossil record, emergence of life, precambrian life, cambrian explosion, paleozoic, mesozoic and coenozoic life, geography of evolution, evolution of biodiversity, macroevolution, origin of major groups of animals, gradualism and saltation.	14
05	Evolution and society; the evidence for evolution: the fossil record, DNA, biogeography, scientific observations; evolution of *Homo sapiens*, domesticated plants and animals.	08

Course textbooks:

1. Futuyma, J. Douglas. *Evolution*. 3rd edn. Sinauer Associates, 2017.
2. Losos J.B. et al. ed. *The Princeton Guide to Evolution*. Princeton University Press, 2014.
3. Zimmer, C. and Emlen, D.J. *Evolution: Making Sense of Life*. 2nd edn. W. H. Freeman and Company, 2016.

ZGY 5205: Applied Entomology

L-2: P-2:C-3: 60 h

Course Outcome:

- To introduce the world of insects and their interaction with the ecosystem and human being
- To help students identifying the insects
- To introduce the methods to manage agriculturally important insects
- The students identify insects
- The students use insects as a bionidicator for their biodiversity studies
- The students learn methods to manage insects

Modus operandi:

- The students will collect insects throughout the course.
- The course will be handled with a collection of insects and several short or longer field works and field tours.

Course content:

Unit No.	Topics	Hrs
01	Evolution, Diversification, and Distribution of insects Evolution of insects, primitive insects; adaptive radiation and diversification of insects; global distribution of insects across biogeographical zones, terrestrial and aquatic insects	2
02	Adaptive radiation in insect morphology and functions Insect morphology; types and functions of antenna, mouthparts, head, thorax, abdomen, genitalia, wings; diversification through the process of adaptive radiation. Enquiring reliable morphological key characters of insects Insect vision and bioluminescence, insect acoustics; chemo-reception and production Insect behavior; pheromones, allomones, kairomones, host-induced plant volatiles; synomones and their application Practicals: Insect morphology	10
03	Collection, preservation, and labeling of insects Insect collection methods; pan traps, pitfall traps, Malaise traps, Winkler bag, Berlese funnel; flight interception trap; sweep net; sticky trap; manual search of insects; insect collection using bait traps. Wet and dry preservation techniques; mounting and pinning specimens; Labelling of insects; barcoding insects Practicals: Collection and storage methods	10
04	Insects through Orders Identification of insects to Orders using morphological key characters; Dichotomous keys for identifying insects to orders; Order characters; Order functional diversity; Students will display insects in insect boxes for examination and evaluation	10

	Practicals: Identification of insect orders	
05	Insects through families – Parasitic Hymenoptera Identification of insects in the superfamilies of Ichneumonoidea and Chalcidoidea Biology and host range of families of Chalcidoidea Practicals: Identification of Ichneumonoidea and Chalcidoidea	10
06	Insects as beneficial organisms Insects as pollinators; diversity of insect pollinators; morphological and behavioral traits of insect pollinators; bees as pollinators; bees for beekeeping; identification of common bees; pollen and nectar analyses; insects as food; nutritional value of insects Practicals: Identification of major pollinators	8
09	Insects as a pest Major pests, minor pests, sporadic pests; managing insect pests; looper pests of tea as an example; pesticides including biopesticides; integrated pest management; habitat management for pest control; biological control of insect pests Practicals: Identification of major and minor pests	10

Suggested Literature:

1. Chapman R.F. The Insects: Structure and Function (1998)
2. Mathewes R.W. and Mathews J.R.. Insect Behavior. Springer (2014)
3. Córdoba-Aguilar A., González-Tokman D, et al. Insect behavior: From mechanisms to ecological and evolutionary consequences. Cambridge University Press (2018)
4. Insects of Australia, CSIRO-Canberra; Volume 1 & 2
5. Study of Insects, Borror and DeLong
6. Narandran T.C. Parasitic Hymenoptera and Biological Control. Paramount Publications (2000)
7. Sinu P.A. and Shivanna K.R. Mutualistic interactions between flowering plants and animals. Manipal University Press (2016)
8. Nair, M.R.G.K.1986. *Insect and Mites of Crops in India*. ICAR, New Delhi. Pradhan, S. 1969. *Insect Pests of Crops.* National Book Trust, India, 208p.
9. Regupathy, A.N., Chandramohan, S., Palanisamy and Gunathilagaraj, K. 2003. *A Guide on Crop Pests*. TNAU, Coimbatore, 276.
10. Gurr M. et al. Ecological engineering for pest management: advances in habitat manipulation for arthropods. Cornell University Press (2004)

ZGY 5206: Laboratory- Genetics &Endocrinology

P-4:C-2: 60h

Genetics

1. Study of *Drosophila* and mutants (a) general morphology of *Drosophila* (b) mounting of sex comb (c) important mutant study
2. Demonstration of Mendel's and Non-Mendelian principles using *Drosophila* crossing experiments
3. Preparation and study of metaphase chromosomes from mouse bone marrow: (a) Chromosome banding (C, G, H banding) and (b) Study the differences in number, shape and size of chromosomes in normal vs. toxin treated cells.
4. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion etc. from the pictures provided.
5. Study of sex chromatin in buccal smear
6. Chromosome study –squash preparation of grasshopper testis (meiosis), onion root (mitosis) and polytene chromosome (*Drosophila*).
7. Study of transcriptional activity in polytene chromosome upon heat shock induction
8. Study of Hardy– Weinberg equilibrium in human population by taking the any relevant population data

Endocrinology

1. Dissection of endocrine glands in fish and chick (any two vertebrates)
2. Preparation of single cell suspension of any one tissue for in-vitro study.
3. Histological study of endocrine glands using haematoxylin -eosin stain in any two vertebrates.
4. Disorders of endocrine glands

ZGY 5207: Laboratory-Entomology & Economic Zoology

P-4:C-2: 60h

Entomology

1. Study of mouth parts of insects: Cockroach, female mosquito, house fly, and honey bee.
2. Morphology of different species of locally available honey bee species and enlisting their foraging plants
3. Field visit and collection of different mosquito larvae (Polluted water, paddy field, tree holes, manmade containers, tyres etc)
4. Identification of adult mosquitoes (*Anopheles*, *Culex*, *Aedes*) with special reference to vectorial capacity.
5. Honeybee -pollen basket (Mounting).
6. Honeybee -sting apparatus (Mounting).
7. Study of the sclerites of head and thorax of different Orders of insects: Grasshopper, Cockroach, Housefly, Honeybee
8. Study of the different types of insect antennae
9. Report on study of insects associated with carcasses
10. Collection, identification, preservation of insects of agricultural/medical/veterinary importance.

Economic Zoology

1. Identification of Exotic/ Indigenous breeds of cattle (Gir, Red Sindhi, Sahiwal, Vechur, Kankrej, Krishna Valley, Jersey, Holstein Friesian, Brown Swiss, Red Dane, Ayrshire)

2. Identification of Exotic/ Indigenous breeds of fowls (Rhode Island Red, Plymouth Rock, New Hampshire, Chittagong, Gangus).

3.Identification of human parasites (*Entamoeba hystolytica*, *Plasmodium vivax, Taenia solium, Ascaris lumbricoides*, *Wuchereria bancrofti*, *Enterobius vermicularis*).

4. Preparation of whole mounts of animal ectoparasites.

5. Identification of culture species of shell fishes (shrimps, crabs, lobsters, Pearl oysters, edible oysters) and brine shrimp.

6. Identification of culture species of fin fishes (groupers, cobia, milk fish, pearl spot, Asian sea bass, GIFT, carps, Tilapia, Anabas)

7. Identification of marine/freshwater ornamental fishes

8. Induced growth/reproduction in shrimps/crabs (Eyestalk ablation method)

9. Identification of earthworm of vermiculture (*Eisenia fetida* and *Lumbricus rubellus*)

10. Report on the field visit to cattle/ poultry/ fish/ shrimp farms and hatcheries/ industries/ research institutes of agricultural/veterinary/fisheries importance.

SEMESTER III

ZGY 5301 Animal Behavior
L-3: C-3: 60 h

Course Outcome:

By the end of this course, students will be able to:

- critically analyze the Niko Tinbergen's four foundational questions in animal behaviour studies.
- identify and describe the pattern of behaviour in animals.
- explain physiological and neurological mechanisms of animal behaviour.
- evaluate the difference in the behavioral patterns of animals in different developmental stages.
- explain the evolutionary origins of behaviours.
- compare and contrast the higher forms of learning among vertebrates.

Course content:

Unit No.	Topics	Hrs
01	Niko Tinbergen's Four Whys: function, evolution, causation and development; unit of behaviour; units of the nervous system; reflex; latency; summation; facilitation; inhibition; feedback control.	10
02	Development of behaviour; instinct and learning; changes to nervous system as the animal develops; influence of hormones on early behavioural development, diversity of parental behaviour in response to early experience, animal play, imprinting, sexual imprinting, development of songs in birds.	12
03	Definition and action of stimuli, sensory capacities: vision, hearing, chemo-sensing such as taste and smell, and other extraordinary senses; recognition of pattern, super-normal stimuli, sign stimuli; generalized feature detection for pattern recognition; communication, animal signalling: effectiveness, honesty and deception; honeybee dance; calls in vervet monkeys.	12
04	Decision-making: routines, time budgets and mechanisms; motivation; idea of goal; homeostasis and negative feedback; inhibition and disinhibition, conflict and displacement activities, physiology of decision making, conflict and physiological stress.	12
05	Learning as an adaptation, sensitization and habituation, associative learning, higher forms of learning in primates and other animals, social learning and culture, nature of animal mind and memory, phylogeny of behaviour; social organization, benefits of group living, eusociality, vertebrate territoriality, dominance in social living systems, mammalian social behaviour.	14

Course textbook:

1. Manning, A. and Dawkins, M.S. *An introduction to animal behaviou*r, 6th ed. Cambridge University Press, 2012.

Additional reading:

1. Barnard, Chris. *Animal Behaviour*. Pearson Education, 2004.
2. Alcock, J. *Animal Behavi*our. Sinauer Associates, 2013.
3. Wyatt, T.D. *Animal Behaviour: A very Short Introduction*. Oxford University Press, 2017.

ZGY 5302: Developmental Biology
L-3: C-3: 60 h

Course Outcome:

Course Learning Outcomes:

- This course 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.
- .Students will also understand that cells only express a proportion of their genome, and that differential gene expression underlies cell differentiation and any alteration in the entire process of development leads to devastating diseases.

This advanced level 3 credit course in developmental biology will focus to provide a well-rounded and up-to-date curriculum to address both basics and advancements in comparative (multi-species) developmental biology. Masters students enrolled in this course will attend lectures, laboratories on research techniques, prepare essays and present to the class. Students will critically review papers on a chosen topic (discussed and agreed with the course instructor, could be related to their own research), and present their topic in a 30-minute seminar.

Knowledge:

- Appreciation for the diversity of life on earth.
- Understanding the process and outcomes of evolution.
- Observing of the interdependence of living things.
- Understanding the role of biology in addressing societal issues.
- Observing emergent properties of complex biological networks.

Skills:

- Design, conduct and interpret scientific research.
- Apply a scientific approach to problems.
- Communicate findings using models, charts and graphs.
- Communicate new research findings to lay audiences.
- Communicate biological research findings using scientific writing.

Course content:

Unit No.	Topics	Hrs
01	History and basic concepts: the origin of developmental biology- cell theory, mosaic and regulative development, discovery of induction, genetics and development; basic concepts of developmental biology- cell division, cell differentiation, signaling, patterning.	8
02	Model systems: vertebrates model organisms- *Xenopus laevis,* chicken, mammals, Zebrafish; invertebrate model organisms- *Drosophila melanogaster, Caenorhabditis elegans;* Sea urchin.	8
03	Early embryonic development of vertebrates and invertebrates: structure of the gametes–:the sperm, the egg; fertilisation events in invertebrate (sea urchin) and vertebrate (mouse), cleavage and gastrulation; axes and germ layers.	8

	morphogenesis– cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation, cell migration.	
04	Morphogenesis: cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation, cell migration; Embryogenesis in insects.Axis specification in Drosophila; origin of anterior- posterior and dorsal- ventral patterning- role of maternal genes, patterning of early embryo by zygotic genes; segmentation genes- the gap genes, the pair– rule genes, the segment polarity genes, the homeotic selector genes- bithorax and antennapedia complex.	10
05	General concepts of organogenesis: development of chick limb- development and patterning of vertebrate limb, proximal- distal and dorso- ventral axis formation, homeobox genes in patterning, signaling in patterning of the limb; insect imaginal disc– determination of wing and leg imaginal discs, organizing center in patterning of the wing, butterfly wing development, the homeotic selector genes for segmental identity; insect compound eye– morphogenetic furrow, ommatidia, signaling, eyeless gene; kidney development– development of ureteric bud and mesenchymal tubules.	8
06	Postembryonic development: growth- cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence.	6
07	Regeneration: epimorphic regeneration of reptile (salamander) limb, requirement of nerves for the proliferation of blastema cells; Morphollaxis regeneration in hydra; embryonic stem cells and their applications.	6
08	Medical implications of developmental biology: genetic errors of human development- the nature of human syndromes– pleiotropy, genetic heterogeneity, phenotypic variability, mechanism of dominance; gene expression and human disease– inborn errors of nuclear RNA processing, inborn errors of translation; teratogenesis- environmental assaults on human development,teratogenic agents like alcohol, retinoic acid etc.	6

Suggested Literature:

Please note that if and when newer (e.g. new edition of a book) and/or more relevant materials (e.g. new textbooks) become available, the resources listed will be likely be replaced with newer information.)

1. Developmental Biology, Gilbert, (8th Ed., 2006) Sinauer Associates Inc., Massachusetts, USA
2. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz, (3rd Ed., 2006), Oxford University Press, New Delhi, INDIA.
3. Analysis of Biological Development, Kalthoff, (2nd Ed., 2000), McGraw-Hill Science, New Delhi, IND.

Reference Journals

1.Developmental Biology - Journal - Elsevier

2. Frontiers in Cell and Developmental Biology
3.Russian Journal of Developmental Biology | Home - Springer
4.The Company of Biologists' journals – Development
5.BMC Developmental Biology

ZGY 5303: Immunology

L-3: C-3: 60 h

Course Outcome:

- The students develop skills necessary for critical analysis of contemporary literature on topics related to health and disease and the role of the immune system.
- To understand the molecular and cellular components and pathways that protect an organism from infectious agents or cancer.
- To explore the structure, function, and genetics of the immune system's components.
- The course also emphasizes the research and development opportunities for therapeutic intervention arising from recent advances in immunology.
- Upon completing the course, students have a sound understanding of the immune system's essential elements, preparing them to engage further in this rapidly evolving field.
- Understand the immunomodulatory strategies essential for generating or suppressing immune responses as required in hypersensitivity reactions, transplantation, autoimmune diseases, and cancer.
- Learn to review the literature to determine the data's strengths and weaknesses published in immunology and its novelty.
- Design new methods to improve existing vaccines and other immunotherapeutic strategies.

Course content:

Unit No.	Topics	Hrs
01	**Overview of the immune system:** The need, immune defence, antigens, cells, and molecules of the innate immune system, recognize microbes by the innate immune system, innate immunity, and inflammation. Adaptive immune system: Lymphocytes, lymphoid organs, tissues, mucosa-associated lymphoid tissues, lymphocyte traffic and circulation, adaptive immunity at birth.	10
02	***Antibodies:*** Antibody structure and classes, generation of diversity of antibodies, allotypes and idiotypes, monoclonal antibodies, antigen-antibody complexes, immunoassay, antibody functions. *The Antibody Response:* The B cell-receptor complex, co-receptor, and signalling, B-cell activation, the cellular basis of the antibody response, antibody responses in different tissues. Cell-mediated immunity: The role of T - cells in immune responses, T-cell recognition of antigen, shaping the T-cell repertoire, T-cell activation, Clonal expansion, and development of memory and effector function. Regulation of the immune response: Central tolerance, peripheral tolerance, the role of antigen, regulation by T cells and antibody, neuroendocrine regulation of immune responses.	12
03	***Vaccination and Transplantation:*** Principles of vaccination, immunization, antigen preparations, vaccines to pathogens and tumors. Transplantation antigens; rejection mechanisms; prevention of graft rejection.	08
04	***Disorders of the immune system:*** *Immunodeficiency:* Deficiencies in the immune system, primary/congenital immunodeficiency, secondary immunodeficiency,	14

	diagnosis and treatment of immunodeficiency. *Hypersensitivity:* Definition and classification, IgE-mediated (type I) hypersensitivity: allergy; IgG and IgM mediated (type II) hypersensitivity; Immune complex-mediated (type III) hypersensitivity; delayed (type IV) hypersensitivity. *Autoimmunity and autoimmune diseases:* The spectrum and prevalence of autoimmunity; factors contributing to the development of autoimmune disease; mechanisms of development, diseases pathogenesis-effector mechanisms; diagnosis and treatment of autoimmune disease	
05	***Tumor immunology and Immunotherapy:*** Origin and host defence against tumors; tumor antigens; immune responses to tumors; immunodiagnosis; cytokine and cellular immunotherapy of tumors; immunotherapy of tumors with antibodies, tumor vaccines. Immunotherapy: cytokine, antibody, and cell-mediated immunotherapy; cytokine-mediated immunotherapy, antibody-mediated immunotherapy, and cellular immunotherapy.	16

Suggested Literature:

1. Judith, AO, Jenni, P., Sharon AS, Patricia PJ, and Kuby J. (2013), Immunolog, 7th Edition, W.H. Freeman.
2. Klaus DElgert, (2009), Understanding The Immune System, 2nd Edition, John Wiley & Sons New Jersey.
3. William E. Paul (20130, Fundamental Immunology, 7th Edition, Lippincott Williams & Wilkins.
4. Seng-Lai Tan (20150, Translational Immunology, 1st Edition, Elsevier.
5. Abul K. Abbas, Andrew H (2014), Cellular and Molecular Immunology 8th Edition, Saunders, Elsevier.
6. Boegel, Sebastian (Ed.), (2020), Bioinformatics for Cancer Immunotherapy, Springer
7. Bruce A. Chabner, Dan L. Longo, (2018). Cancer Chemotherapy, Immunotherapy and Biotherapy, Wolters Kluwer Health.
8. Jeffrey Actor, (2019), Introductory Immunology, 2nd Edition, Academic Press.
9. Frank C. Hay, Olwyn M.R. Westwood (2002), Practical Immunology, 4th Edition Blackwell Science Ltd.

ZGY 5304: Biostatistics and Bioinformatics

L-3: P-2: C-4: 72 h

Course objectives

- To introduce the statistical methods used in biological research
- To give a hands-on training on statistical tools
- To introduce the fundamental approaches available for analyzing genome data

Outcome

- The students gain knowledge and experience on handling biological, environmental, ecological data.
- The students gain knowledge on formulating and testing hypotheses.
- The students apply their knowledge in their M.Sc. dissertation works and research works.
- Students design sampling methods.
- Students extract genomic data and analyze it.
- Students use statistical softwares for analyzing their own data.

Modus operandi

1. The students will be collecting field data at the very beginning of the course and use that throughout the course for various statistical analyses.
2. The course will introduce the statistical principles, theories, and application for all topics.
3. The data will be analyzed using excel, EstimateS, and R.
4. The students will be given specimens/ samples for genomic DNA extraction, sequencing, and analyzing the data.

Unit No.	Topics	Hrs
01	Sampling and Processing Data Introduction: Use and application of Statistics in Biology; Statistics in Field Biology; Limitations of Statistics; Sampling and Processing data; Scales of measurement: Nominal scale, Ordinal Scale, Interval Scale, Ratio Scale; Derived variables; The frequency Table; Continuous and discrete data; Processing count data; Data matrix formats; Types of variables *Tutorial: Data entry and clean-up; Introduction to Excel program, R program*	8
02	Measuring Central Tendency and Variability Mean, Median, Mode: applications and limitations Range, Standard Deviation, Variance, and Coefficient of variations: applications and limitations Overdispersion: checking overdispersion and dealing with the overdispersed data Data transformations: types and analyzing transformed data Log-transformation, Square-root transformation, Arcsinh transformation, Arcsine transformation Tutorial: Calculating central tendency and variability using excel and R	10

03	Graphics Descriptive plots to visualize data: bar plot, frequency plots, box and whisker plot, scatterplot, pie-charts Tutorial: Plotting graphs using Excel and R	5
04	Probability and distribution of probability Principles of probability, compound probability, probability distribution, Gaussian distribution, binomial distribution, poisson distribution, negative-binomial distribution Is data normally-distributed? Methods; Standardizing normal curve; two-tailed, one-tailed, z-score, t-score Tutorial: Calculating z-score/ t-score	10
05	Sample to populations and statistical testing Standard error: calculation of SEM, confidence-intervals (95% and 99%) Basis of statistical testing; formulating hypothesis, experimenting and testing hypothesis, one-tailed or two-tailed tests; type 1 and type 2 errors Analyzing frequency: Chi-square test; contingency tables Parametric and non-parametric tests Testing means of two large and small samples; testing two or more large count data Student t-test/ z-test for unmatched data, matched data F-test/ variance test Testing Mean of more than two samples: one-way ANOVA Testing Median: Mann-Whitney U-tests, Wilcoxon's matched pair test, Kruskal-Wallis rank ANOVA test; post-hoc test Tutorial: Hands-on training on all statistical methods using Excel/ R	15
06	Correlation and Regression Descriptive to predictive statistics; measuring correlations; dependent and independent variables; covariance, strength and significance of correlation; Pearson's correlation coefficient; Spearmann rank correlation Regression: Simple linear regression; fitting a regression line, significance of regression Tutorial: Hands-on training on Correlation, Regression using excel/ R	6
07	Measuring Diversity and Population Alpha diversity, Shannon diversity; Simpson's diversity; Beta diversity; Similarity studies; Dendrograms; Jaccard's similarity index; Sorensen similarity index, Morrisita-Horn similarity index; Lincoln method for estimating population Tutorial: Hand-on training on measuring diversity using EstimateS and R-packages	8
08	DNA analysis	10

	Primer Designing, Checking sequence quality, Databases; NCBI, GenBank, DDBJ, EMBL, PDB, miRbase, Pubmed Sequence File Format-FASTA, FASTQ, NEXUS; Sequence Alignment-sequence similarity, identity, and homology, Multiple sequence alignment-BLAST, Phylogenetic tree construction methods and programs- Distance based/Character based; Maximum likelihood/NeighbourJoining/Maximum ParsimonyTutorial: DNA extraction; Checking quality; analyzing genomic data	

Suggested Literature:

1. Fowler, J., Cohen, L., Jarvis, P. Practical Statisitcs for Field Biology, John Wiley & Sons
2. Crawley M.J. An Introduction to R. Wiley Publishers
3. Kamath, A., Meleth, S., Sathiakumar, N. R Manual for Health Science Researchers. Manipal University Press
4. Zar, J.H. Biostatistical analyses. Pearson Education, India
5. Crawley, M.J. R Book; Wiley International (2017)
6. Kothari, C.R., Garg, G., Research Methodology: Methods and Techniques. New Age
7. International Publishers (2000)
8. Dsouza H.S., Sajankila S.P., Satyamoorthy K. Manipal Laboratory Manual for Biotechnologists. MUP (2012)
9. Quicke D. Buther B.A. et al. Practical R for Biologists: An introduction (2021)
10. Magurran A. Measuring biological diversity. Blackwell Publishers (2003)
11. Xiong J. Essential Bioinformatics. Cambridge University Press (2006)
12. Ibrahim, K.S. et al. Bioinformatics: A student's companion. Springer (2017)

ZGY 5305: Ecology & Field Biology

L-3: P-2: C-4: 72 h

Course objectives

- To introduce the theory and application of ecology
- To generate interests in the areas of conservation of biodiversity

Outcome

- The students identify insects
- The students use insects as a bioindicator for their biodiversity studies
- The students learn methods to manage insects

Unit No.	Topics	Hrs
01	Population Ecology Attributes of population: Population growth, exponential and logistic models and their variants; density; Density dependent and density independent factors; Doubling time of population; Natality, mortality, biotic potential, carrying capacity; Survivorship and age structure; Seasonal population fluctuation. Patterns of population distribution, aggregation and Allee's principle; Isolation; Succession and climax: Types of succession, trends of succession; Models of succession; Concept of climax community; theories on climax, ecotone and edge effect; Ecotypic differentiation; r and k strategies. Types of Meta populations - Levins Meta population, Mainland-island Meta population, Population fragmentation, Population viability analysis: Methods for estimating populations and abundance; Methods for studying life tables	12
02	Community Ecology Community ecology: Community concept; Individualistic and organismic nature of communities; Qualitative and quantitative characters of community; Ecological niche; Gause's theory of niche, coexistence patterns of competing species. Galapagos finches as a demonstration of inter-specific competition. Species diversity and its measurement. Species interactions in communities: mutualisms, commensalism, ammensalism; herbivory; prey-predator interaction; tri-trophic interaction; competition; invasive species and invasion; migration. Lotka-Volterra model, co-evolution of prey-predator interactions – Red Queen hypothesis. Methods of studying vegetation, communities	10
03	Biodiversity patterns Limits of Distribution; The Niche; Overcoming the Barriers; The Community; The Ecosystem; Ecosystems and Species Diversity; Biotic Assemblages on a Global Scale; Mountain Biomes; How Many Species are There? Latitudinal and altitudinal Gradients of Diversity; Rapport's Rule; Is Evolution Faster in the Tropics? The Legacy of Glaciation; Latitude and Species Ranges; Diversity and Altitude; Biodiversity Hotspots; Diversity in Space and Time; Intermediate Disturbance Hypothesis; Dynamic Biodiversity and Neutral Theory; Global Patterns of Climate; Climate Diagrams	10

	The Evidence for Plate Tectonics; Changing Patterns of Continents; How Plate Tectonics affects the Living World, Part I: Events on Land; How Plate Tectonics affects the Living World, Part II: Events in the Oceans; Islands and Plate Tectonics; Terranes; Plate tectonics and Wallacea Methods for studying biodiversity patterns	
04	Island theory of Biogeography; The Challenges of Arriving; Immigration; emigration; Problems of Survival; Adapting and Evolving; Nestedness; Living Together: Incidence and Assembly Rules; Taxon cycling; The Biogeographical Regions Today; The Basis of Mammal Biogeography; Patterns of Distribution Today: The Mammals; History of Today's Biogeographical Regions; The Old World Tropics: Africa, India and South-East Asia; Australia; New Caledonia; New Zealand; The West Indies; South America	10
05	Conservation Ecology Principles of Remote Sensing: Concepts of Remote Sensing; Geographical Information System (GIS): Basic principles, components and terminologies; Applications of Remote Sensing and GIS: Forest resources - forest type mapping, forest density mapping, change analysis, matrix analysis;	10
06	Field Biology experiments	20

Suggested Literature:

1. Emery W. and Camps A., (2017) Introduction to Satellite Remote Sensing 1st Edition Atmosphere, Ocean, Land and Cryosphere Applications, Elsevier Publications
2. Rees W.G (2013) Physical Principles of Remote sensing (3 rd edition), Scott polar, Research Institute, University of Cambridge, New York.
3. George Joseph (2008) Fundamentals of Remote Sensing (2 nd edition), Universities press, Hyderabad.
4. Lillies T. M. and Kiefer R.W (2003) Remote Sensing and Image Interpretation, John Wiley and Sons.
5. Biodiversity and Biogeography (Read: Biogeography: An Ecological and Evolutionary Approach Cox, CB, Moore PD, Ladle RJ. Johns Wiley & Sons 2016; ninth edition).
6. Practical Field Ecology: A Project Guide. 2011. C. Philip Wheater, James R. Bell and Penny A. Cook. Wiley-Blackwell.
7. Ecology; Concepts and applications, 2018 Manuels C. Molles, 7th edition
8. Field and laboratory methods for general ecolgy1997 James E.Brown and 2 more, McGraw-Hill
9. Fundamentals of Ecology 2004. 5th edition, Eugene Odum.
10. Sutherland, W.J. The Conservation handbook: Research, Management and Policy. Blackwell Science.
11. Magurran, A.E., McGill, B.J. Biological Diversity: frontiers in measurement and assessment. Oxford.
12. Graca M.A.S., Barlocher, F., Gessner, M.O. Methods to study litter decomposition: A practical guide. Springer.
13. Zhou, J. Thompson, D.K., Xu, Y., Tiedje, J.M. Microbial Functional Genomics. Wiley

ZGY 5306: Laboratory-Developmental Biology & Immunology
P-4: C-2: 60 h

Developmental Biology

1. Lifecycle of *Drosophila*
2. Life cycle stages of amphibian
3. Hormonal control of amphibian development –effect of thyroxin/iodine
4. Regeneration in frog tadpole
5. Regeneration in Hydra
5. Vital staining of chick embryo – window method
6. Preparation of permanent stained whole mounts of chick embryo
7. Labeling of chick notochord using immunocytochemistry

Immunology

1. Determination of immunoglobulin concentration using Single radial immune diffusion technique.
2. Study on the Antigen and Antibody pattern using Ouchtorlony double radial diffusion technique.
3. To perform hemagglutination assay for ABO blood group typing determination of and Rh factor.
4. To perform Immuno-electrophoresis of given sample.
5. To determine the concentration of antigen through ELISA.
6. Immunoblot analysis.
7. To determine Total Leukocytes Count (TLC) of the given sample.
8. To determine Differential Leukocytes Count (DLC) of the given sample.
9. Isolation of human PBMCs (peripheral blood mononuclear cells) through Density gradient centrifugation and check the viability of isolated lymphocytes.

ELECTIVE COURSES

FOR

DEPARTMENT AND INTER-DEPARTMENT STUDENTS

ZGY5001:Techniques in Biological Research

L-2: P-2: C-3: 48 h

Course outcome:

By the end of this course, students will be able to:

- fulfill the required techniques of traditional biology labs while students engage in the discovery process of tackling *real* research.

Unit No.	Topics	Hrs
01	Microscopy- Light microscopy, phase contrast microscopy, Confocal laser scanning microscopy, scanning and transmission electron microscopy, Darkfield microscopy, Micrometry, Imaging. Electrophoresis and Centrifugation: Gel electrophoresis, Immuno electrophoresis, Differential, and Ultra centrifugation, Cell fractionation.	08
02	Histology and Histological Techniques: Histology methods, Cryostat, Staining techniques, Histochemistry, Immunocytochemistry. Chromatography and Photometry: TLC, Column Chromatography, HPLC, GC, Colorimetry, Spectrophotometry, NMR, Infrared spectrometry.	14
03	Techniques in Molecular Biology: Micromanipular sequencing with PCR, Probes, Vectors, Plasmids, Southern Blot, Northern, Western Blots, Dot Blot, Slot Blot. In-situ Hybridisation. DNA Flow Cytometry. Interphase Cytogenetics.	10
04	The Polymerase Chain Reaction. Laser Capture Microdissection: Techniques and Applications in the Molecular Analysis of the Cancer Cell. The In-situ Polymerase Chain Reaction. TaqMan® Technology and Real-Time Polymerase Chain Reaction. Gene Expression Analysis Using Microarrays. Comparative Genomic Hybridisation in Pathology. DNA Sequencing and the Human Genome Project.	16

Suggested Literature:

1. Bioinstrumentation L Veerakumari, MJP Publishers, Chennai, 2006
2. Research Methodology for biological science, Gurumani, MJP Publishers, Chennai, 2006
3. Biophysical Chemistry: Principles and Techniques, Avinash Upadhyay et al., Himalaya Pubishing House, 1997
4. Biophysical Chemistry: Techniques for the study of biological structure and functions, Charles C. R. & Paul. S. R. W.H. Freeman & Co. New York, 2004
5. Research Methods in Biological Sciences, Palanichamy and Shunmughavelu., Palani Paramount Publishers, Tamil Nadu, 1997.

ZGY5002: Biostatistics

L-2:T-2:C-3: 48 h

Course outcome:

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

- Apply the statistical theory and methods while working on a research project work.
- Describe the appropriate statistical methods required for a particular research design.

Unit No.	Topics	Hrs
01	Introduction .General principles. Sampling. Sampling errors. Skewness and kurtosis. Measures of Central Tendency- Mean, Median, Mode. Standard Deviation and Standard Error.	08
02	Distribution- Probability, Probability rules in genetics – Produce and addition rules, Normal and binomial distribution, Poisson distribution – Frequency distribution.	14
03	Testing and Significance- Paired –T-test, Unpaired T-test, Chi-squire test.	10
04	F-ratio, One way analysis, Two way analysis, Multiple range test, Dunkens test.	08
05	Correlation and Regression- Dose response – LC 50 . Construction of Graphs and Diagrams- Bar diagram, Pie diagram, Histogram, Frequency curve.	08

Suggested Literature:

1. Fisher.R.A., Statistical Methods for Research
2. Biometrical Genetics – Dover Publication, New York
3. Ostle B, Statistics in Research.
4. Agarwal, B.L(1996) Basic Statistics.New Age International (P) Ltd. Publ.
5. Bailey, N.T.J (1981). Statistical Methods in Biology. Hodder and Stongtton, London.
6. Finney, D.J. (1980). Statistics for Biologists. Chapman and Hall, London.
7. Caswell, F. (1982). Success in Statistics. John Murray Publishers Ltd., London.
8. Gupta, S.P. (1996). Statistical Methods. Sultan Chand & Sons Publishers, New Delhi.

ZGY5003 Basics of Academic Scientific Writing

L-2: T-2: C-3: 48 h

Course outcome:

By the end of this course, students will be able to:

- reflect on their current approach to writing.
- evaluate the quality of their writing critically.
- explain the basic structure of English grammar and writing conventions essential for academic scientific writing.
- describe the structure and components of a paragraph.
- develop skills to write error-free and clear academic scientific text.
- utilize their acquired writing skills for preparing academic essays, scientific articles, and dissertation.

Unit No.	Topics	Hrs
01	Development and communication of thinking; reflections on the current writing approach; importance of redrafting and proofreading.	08
02	Structure of English language; building simple, compound and complex sentences; the information flow across paragraphs; structuring given and new information; importance of punctuation; clarity; precision and brevity; language and conventions in academic scientific writing; universal features of scientific writing.	14
03	Structuring and maintaining textual coherence across introduction, methodology and discussion; building an argument; defining terminology.	10
04	Referencing; incorporating quotations; equations; abbreviations; tables and figures; UK vs US spelling; formatting and presentation.	08
05	Reading and building common structures; referencing; paraphrasing; developing good academic practices.	08

Course textbooks

1. Bottomley, Jane. *Academic Writing for International Students of Science*. New York: Routledge, 2015.
2. Bailey, Stephen. *Academic Writing: A Handbook for International Students*. New York: Routledge, 2006.

Additional Reading:

1. Turabian, Kate L. *A manual for writers of research papers, theses, and dissertations: Chicago Style for students and researchers.* The University of Chicago Press, 2013.
2. Aliotta, Marialuisa. *Mastering academic writing in the sciences : a step-by-step guide.* Taylor & Francis Group, LLC, 2018.

ZGY 5004 Philosophical Foundations of Taxonomy

L-2:P-2:C-3: 48 h

Course outcome:

By the end of this course, students will be able to:

- Gain the basic knowledge on taxonomy.

Unit No.	Topics	Hrs
01	**Defining Species:** Definition and Delimitation of Species from one another, Species and the Birth of Modern Science, Quest of Taxonomy for Fixed Classes and the Constant Evolutionary Change. The Reality of Species, The Importance of Knowing What a Species Is, Dualism of the Species Concept- the Epistemic vs. the Operative Goal, Species Concept as a Cognitive Preset in the Human Mind.	16
02	**Traits in Taxonomy:** Taxonomical Relevance of Traits, Differences in Traits between Two Species, Homologous Traits, Use of Differences in Genes Between Two Species, Taxonomy and the Phylogenetic Distance.	14
03	**Diversity within the Species: Polymorphisms and the Polytypic Species:** The Meaning of Taxonomic Terms, Morphs, Races and Subspecies, Allelic diversity and Allelic Polymorphism.	10
04	**Identifying and Describing Species:** Theory and Practice of Identifying and Describing Species, Nomenclature and the New Taxonomy, Taxonomic Judgment.	08

Suggested Literature:

1. Werner Kunz. 2012. *Do Species Exist? Principles of Taxonomic Classification*. Wiley-VCH Verlag& Co.
2. Simpson, G.G. *Principle of Animal Taxonomy*. Oxford IBH Publication company.
3. Mayr, E. and Ashlock, P. D. *Principles of Systematic Zoology*. 1991. McGraw Hill, New York.
4. Mayr, E. *Systematics and the Origin of Species.* 1942. Columbia University Press,New York.

ZGY 5005: Ecology of Plant and Animal Interaction

L-2:T-2:C-3: 48 h

Course outcome:

By the end of this course, students will be able to:

- Gain the knowledge on the state-of-the-art in concepts, methodologies, and research opportunities in the subject matter of the course.
- Demonstrate knowledge of the historical development of concepts and theories related to ecological interactions among plants and animals.
- Explain current concepts of co-evolutionary interactions among plants and animals.
- Apply ecological knowledge and concepts to current issues in conservation of biodiversity.
- Develop scientific reading, writing, and information gathering skills, especially as they pertain to plant-animal interactions.

Unit No.	Topics	Hrs
01	Introduction: Diversity of interaction, multi-trophic level interaction; food webs; trophic cascades; Interactions and Coevolution; ecology of fig-fig wasp interaction	08
02	Pollination Biology: Mutualism; plants' perspective, animal's perspective, pollination modes; floral rewards: pollen and nectar, foraging behaviour of animals and pollination; major pollinator types of tropics; nest ecology of pollinator insects; case study on social and solitary bees; Evolutionary responses; diurnal and nocturnal pollination, methods to study pollination ecology	14
03	Fruit, Seed and dispersal Ecology: Mutualisms and Antagosims: Frugivory: Frugivores; Major frugivorous animals of India; Seed dispersal: Primary and secondary seed dispersal, dispersal by birds, bats and mammals, secondary seed dispersal by insects; Myrmecochory, Evolution of dispersal; directed seed dispersal; Seed Predation: types of seed predation; pre-dispersal seed predation; post-dispersal seed predation; seed loss to animals; seed loss to pathogens; Evolution of seed predation; Methods to study frugivory, seed dispersal and seed predation.	10
04	Plant-Insect herbivore-natural enemy interaction: Antagonisms: plant defences; natural enemy and herbivores: physiological and behavioural responses of herbivores; Generalist and specialist herbivores; generalist and specialist insect natural enemies; insectivorous birds as generalist predators; tri-tropic interactions; semiochemicals; herbivory in tropics and temperate climates; climate change and herbivore-natural enemy interaction in tropics and temperate areas; ecological impacts of herbivory.	08
05	Ant-Plant interactions: Mutualisms and Antagonisms: Plants as ant food: pollen and nectar feeding ants; aphid-tendering ants; harvester ants and leaf-cutter ants; Plants as ant-shelters; Ants as plant protectors and pollinators; Ants as primary	08

	and secondary seed dispersers; The rewards: Elaiosomes and Diaspores; Life history of ant-fed plants and ant-garden systems; ant-devil's garden; Ant-plant interaction in agriculture	

Optional Practicals:

1. Field techniques to study pollination, frugivory, seed dispersal and seed predation
2. Identification of different pollinators
3. Identification of different pre-, and post-dispersal seed predators
4. Identification of aphid-tendering ants
5. Study of fig-fig wasp mutualism
6. Statistical analysis and interpretation of field collected data
7. Field visits and field reports

Suggested Literature:

1. Burslem, D. Pinard, M., Hartley, S., 2007. Biotic interaction in the tropics. Their role in the maintenance of species diversity. Cambridge University Press. 414 pp.
2. Herrera, C.M. and Pellmyr, O. 2002. Plant-Animal Interactions: An Evolutionary Approach. Wiley-Blackwell. 328pp.
3. Rico-Grey, V. and Oliveira P.S. 2007. The Ecology and Evolution of Ant-Plant Interaction. University of Chicago press. 331 pp.
4. Youngstead, E.K. 2008; Neotropical Ant-gardens: Behavioral and Chemical Ecology of an Obligate Ant. North Carolina State University. 163 pp.
5. Ghazoul, J. and Sheil, D. 2010. Tropical Rain forest Ecology, Diversity and Conservation. Oxford. 516 pp.
6. Lansky, E.P. and Paavilainen, H.M. 2009. Figs The Genus Ficus. CRC Press. 415 pp.
7. Sinu, P.A. & Shivanna, K.R. (2016) Mutualistic interaction between flowering plants and Animals (Manipal University Press)

ZGY 5006: Marine Biodiversity and Conservation

L-3:C-3: 48 h

Course outcome:

Students who complete this course will be able to:

- Outline concepts and issues related to managing coastal and marine biodiversity.
- Differentiate clearly, between the ecological and socio-political context, conservation approaches and legal-policy framework.
- Conduct assessment and monitoring of coastal and marine habitats and species and prepare field reports
- To acquire more knowledge on coastal and marine biodiversity relevant issues.
- Choose their study pathways to suit their research interests and career aspirations in marine biology.

Unit No.	Topics	Hrs
01	**Marine Biodiversity** Marine living and non-living resources. Classification of marine organisms by habit and habitat. Marine flora – marine bacteria, microalgae, macro algae, fungi, sea grass, salt marshes and mangroves and kelp forest, their distribution pattern in Indian EEZ. Marine planktons, zooplankton and phytoplankton. Vertical and dinural migration of plankton. plankton blooms. Planktonic deposits and ooze in marine environment. Marine fauna – corals, sea anemones, copepods, barnacles, octopus, sea urchins, sea cucumber, ascidians, protochordates, Marine vertebrates - cartilaginous fishes, bony fishes, fossil fishes, Seahorses, marine reptiles, marine mammals, adaptations of marine mammals,	14
02	**Special Marine communities** Types coral reefs, formation and bleaching of reefs. Deep sea organisms and their adaptations. Hydrothermal vent communities and their adaptations . wood bores and biofoulers	08
03	**Threats of marine biodiversity** Major threats of marine ecosystem diversity and function – over fishing, marine pollution, climate change, diseases, global warming, sea level rising, ocean acidification, eutrophication, harmful algal blooms, dead zones and oil spills. Habitat fragmentation and degradation. Community shift. Invasive species. Control measures for invasive species. Goast net.	12
04	**Marine diversity conservation** Regulations for conservation. endangered marine mammals and sea turtles, polar bear and penguin, CITES, Red data list and its categories marine sanctuaries, marine protected areas (MPA), large marine ecosystems (LME), maritime boundaries, EEZ, territorial water	14

Suggested Literature:

1. Biological Oceanography an Introduction, 2nd Edition, Carol M. Lalli and Timothy R. Parsons, University of British Columbia, Vancouver, Canada
2. Encyclopedia of Marine Science, C. Reid Nichols, President and Oceanographer, Marine Information Resources Corporation, Ellicott city, Maryland and, Robert G. Williams, Ph.D. Senior Scientist, Marine Information Resources Corporation, Adjunct Instructor, Craven Community College , New Bern, North Carolina.
3. Marine Biodiversity in India, Venkataraman K, Raghunathan C, Raghuraman R, sreeraj C R; 2012. Marine Biodiversity: 1-164 (Published by the Director, Zoological Survey of India, Kolkata) Published: May,2012.
4. Introduction to Marine Conservation Biology, Tundi Agardy, Network of Conservation Educators and Practitioners, Center for Biodiversity and Conservation, American Museum of Natural History.
5. Marine Biology 7 to 11 editions, Peter Castro, and Pomona Michael E. Huber.
6. Invitation to Ocenography 5th edition, Paul R. Pinet Colgate University, Jones and Bartlett Publishers.

ZGY 5007:Conservation Biology
L-3: C-3: 48 h

Course Learning Outcomes: Conservation Biology is the scientific study of the phenomena that affect the maintenance, loss, and restoration of biological diversity.
Students who complete this course will be able to:

- Explore the vast field of biodiversity and environmental conservation.
- Gain knowledge on conservation decisions of local, national and international concern.
- Understand how human population growth and resource consumption drive environmental problems.
- Identify major environmental threats facing species, communities, and ecosystems.
- Define terms and principles relevant to conservation biology.
- Learn basic tools for assessing and addressing environmental health and degradation, with an emphasis placed on field exercises.
- Understand the complexity of many conservation issues, and how conservation biology operates in a multidisciplinary manner; recognize the importance of economics, sociology, politics, and biology and their interactions in both causing and resolving environmental problems.

Unit No.	Topics	Hrs
01	Biodiversity and Conservation Biology**:** Overview and causes of recent extinctions, Identification and prioritization of Ecologically sensitive area (ESA), Coarse filter and fine filter approaches. National and International efforts for conservation: Information on CITES, IUCN, CBD International agreements for conserving marine life, Convention on wetlands of International Importance (Ramsar convention). Evaluation of priorities for species and habitats: Choosing species to protect: species quality, Conservation indices, Hotspots for conservation, Major tropical wilderness areas and ecoregions, World heritage sites.	08
02	Theory and analysis of conservation of populations: Stochastic perturbations - Environmental, Demographic, spatial and genetic stochasticity. Population viability analysis-conceptual foundation, uses of PVA models. Management Decisions for small populations using PVA models. Minimum viable populations & recovery strategies for threatened species.	08
03	Conservation of Natural Resources: Management of natural habitats. Continental biomes, Management of oceanic islands, Management of aquatic habitats, Management of fragmented habitats, zonation and biosphere reserves. Management of species**:** Metapopulations, Conservation Genetics, Population viabilities, *In situ* methods, *Ex situ* methods. Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).	10

04	Restoration, Translocation and Mitigation: Re-introduction, Control of introduced species, Restoration management, Translocation of Habitats, Mitigation, Urban Wildlife. Measuring success and cost effectiveness.	12
05	Non-defined Conservation areas: Indigenous Community Conserved Areas; sacred groves, soppinabetta forests, minor forests. Livelihoods and conservation; examples of tropical conservation.	08

Suggested Literature:

1. Yahner, R.H. 2012. Wildlife Behavior and Conservation
2. Hunter, M.L., Gibbs, J. 2007. Fundamental of Conservation Biology
3. Ghazoul J and Sheil D. 2010. Tropical rain forest ecology, diversity and conservation
4. Sutherland, W.J. 2000. Conservation Handbook
5. Sodhi, N.S., Brook, B.W., Bradshaw, C.A. 2007. Tropical Conservation Biology
6. W. Sutherland., Ecological census technique
7. Mani., Biogeography of India
8. K. Malhotra., Cultural and ecological dimension of sacred grove in India
9. The wildlife protection act

ZGY 5008: Principles of Genetics
L-3:C-3: 48 h

Course Learning Outcomes:

Students who complete this course will be able to:

- Get several opportunities in research and other sector employability.
- Understand Mendel's laws and basic genetics, some of the most incisive analytical approaches that are now being used across the spectrum of biological disciplines.
- Gain knowledge on the human chromosome constitution that would help apply basic principles of chromosome behavior to disease context.
- Highlight the extension of Mendelian Genetics, dosage compensation, the evolution of the gene's concept, and its amalgamation with molecular biology and the study of genetic diseases.

Unit No.	Topics	Hrs
01	Science of genetics – milestones in genetics; Mendelian Genetics-Genes and rules of inheritance; Watson and Crick- the structure of DNA; The human genome project-sequencing DNA and cataloging genes. Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, sex linkage, sex-limited, and sex influenced characters.	08
02	Cytogenetics – Chromosomal theory of heredity; the gene's concept; Cell division-mitosis and meiosis; the cell cycle: linkage and crossing over; chromosome mapping; cytogenetic mapping; linkage analysis in humans.	08
03	Mutation, DNA repair, and Recombination: The molecular basis of mutation and process - loss of function, the gain of function, germinal verses somatic mutants, insertional mutagenesis; phenotypic effects. DNA repair mechanisms and DNA recombination mechanisms.	10
04	Advanced genetics: sex determination- in organisms; dosage compensation in *C.elegans*, Drosophila, and Human; Lyon hypothesis. Genetic disorders (numerical and structural alterations of chromosomes); genetics of ABO system, Rh disease and inheritance, sickle cell hemoglobin, and thalassemia. Cytological techniques: Analysis of mitotic chromosomes; the human karyotype, polyploidy, aneuploidy, amniocentesis and chorionic biopsy, chromosomal abnormalities, the pattern of gene inheritance- pedigree analysis. Applications of molecular genetics – molecular diagnosis of human diseases -gene therapy; DNA profiling -DNA finger printing and foot printing,	12
05	Population Genetics: Genetic variation, polymorphism, polyploidy, gene pool, gene frequency, theory of allele frequencies: Hardy-Weinberg equilibrium, disequilibrium, patterns disrupting gene equilibrium; population genetic equilibrium.	08

Suggested Literature:

1. Principles of Genetics, Snustad, and Simmons, (2005), 4th Ed. John Wiley & Sons, USA.
2. Modern Genetic Analysis: Integrating Genes and Genomes, Griffiths, J.F., Gelbart, M., Lewontin, C. and Miller, W. H. Freeman and Company, New York, USA.
3. Genetics, J. Russell, Benjamin-Cummings Publishing Company, San Francisco, California, USA.
4. Molecular Biology of the Gene, Watson *et al*.,(2004), 5th Ed. Pearson Education, Delhi, INDIA.
5. The World of the Cell, Becker, Klein smith, and Hardin, (2004) Pearson Education Pvt. Ltd.
6. Genes IX, Lewin, 9^{TH} TH Edn (2019), Jones and Bartlett Publishers, Boston, USA.

ZGY 5009: Basics of Neurobiology

L-3:C-3: 48 h

Course Learning Outcomes: Students who complete this course will be able to:

- Understand the structure and function of cells comprising the nervous system.
- Explain the molecular, chemical, and electrical signaling in the nervous system.
- Describe how neurons are connected in neuronal circuits that control bodily functions and behavioral output.
- Describe how the interactions between these neuronal systems via various neurotransmitters influence the functions of the body.
- Describe the functions of the nervous system, such as the regulation of movement, motivation, pain, emotions, and memory, and how these can be dysfunctional in neurological and neuropsychiatric disorders.
- Generate a hypothesis from a set of observations and then design experiments to test the hypothesis.

Unit No.	Topics	Hrs
01	Organization of the nervous system: structure and function of the nervous system- anatomy of the central and peripheral nervous system, cells of the nervous systems, neurons and glia, organization of synapses, and neurons in the brain.	06
02	Cellular aspects of neurobiology: The structure of plasma membrane, membrane potential: Ionic equilibrium- diffusion potential; The Nernst equation, Donnan equilibrium, The sodium pump, membrane conductance, Behavior of ion channels, mechanism of the nerve action potential.	06
03	Synaptic transmission: Neurons as a secretory cell- neurotransmitter and neuromodulators: chemical and electrical signals of nerve cells, transmission at a chemical synapse, neurotransmitter release, excitatory and inhibitory synapses, family of neurotransmitter gated ion channels, indirect actions of neurotransmitters, presynaptic inhibition and facilitation, neuronal integration.	10
04	Neurogenesis: neuronal determination, neuronal proliferation, neuronal migration, process outgrowth. The growth cone, families of cell adhesion molecules, neurite guidance, neurotrophic factors, neurotrophin receptors, and synapse formation are stages of synapse formation at the neuromuscular junction.	08
05	Complex brain functions: Learning and memory: mechanism of consolidation and retrieval, kinds of learning, neural growth in learning, learning deficiencies and disorders: effect of aging on memory, Alzheimer's disease, Korsakoff's syndrome. Cognitive functioning and disorders: Intellectual disability, Autism. Psychological disorders: Schizophrenia, Fragile X Syndrome, Huntington's disease, Parkinson's disease.	06

Suggested Literature:

1. Cellular and Molecular Neurobiology, Hammond C, (1996), Academic Press, USA
2. Neurobiology, (2011), Parasher, Y.K Campus Books International, India.
3. Neurobiology Gordon M. Shepherd, (1994), Oxford University Press.
4. Principles of Neurobiology, Luo Liqun, (2015), Taylor & Francis Inc.
5. Basic Neurochemistry: Principles of molecular, cellular and medical neurobiology, Brady ST et al., (2012) 8th Edition, Academic Press, USA.
6. Elements of molecular neurobiology, Smith CUM, (2002) John Wiley & Sons Ltd, England.
7. Fundamental Neuroscience for Basic and Clinical Applications, 5th Edition, by Duane E. Haines and Gregory A. Mihailoff (2018), Elsevier.
8. Handbook of Neurochemistry and Molecular Neurobiology, Abel Lajtha, Maarten E. A. Reith, (2020), Springer.
9. Neuropsychiatry and Behavioral Neurology: Principles and Practice 1st Edition by David S, Laura T. S., Kirk R. D. (2021), McGraw Hill.
10. Current Diagnosis & Treatment Neurology, 3rd Edition by John Brust, Mc Graw Hill.

ZGY 5010: Circadian Biology

L-3:C-3: 48 h

Course outcome:

Students who complete this course will be able to:

- Familiar with core concepts in circadian rhythm studies.
- Read, discuss and evaluate current research articles in the field of chronobiology.
- Choose a particular area of clock study of their interest and write a research proposal on the topic.

Unit No.	Topics	Hrs
01	Biological Clocks: Milestones in clock concept and research, Chronobiology in 21st century, Evolution of biological timing system, Adaptive functional significance of biological clocks, Terminolgy and Abbreviations in circadian biology, Biological Rhythms- Ultradian,Tidal/Lunar, Circadian and Circannual Rhythms, Temperature effects & compensation.	12
02	Biological clock in organisms: Concept of central and peripheral clock system, Circadian pacemaker system in multicellular organisms: invertebrates (Drosophila's Circadian System), vertebrates (rodents, fish), Suprachiasmatic nucleus (SCN) as the main vertebrate clock.	10
03	Diversity and complexity of the clock system: Melatonin: input or output signal of the signal system; Molecular basis of biological clock, Transcriptional regulation of circadian clocks, Post- translational regulation of circadian clock.	10
04	Roles for the clock: Photoperiodism, reproduction and migration, Clocks and metabolism, Human CNS disorders and clock parameters.	08
05	Living clockwork: Circadian clock in marine organisms such as *Acetabularia*, *Lingulodinium*, Crustaceans and Crayfish.	08

Suggested Literature:

1. Protein Reviews Vol 12: Series Editor M.Zouhair Atassi- The Circadian Clocks- Edited by- Urs Albercht- Springer
2. Biological clock in fish, Ewa Kulczykowska, Wlodizimierz Popek, BG Kapoor,Science publishers, Enfield, New Hampshire.
3. Chronobiology of Marine organisms, Ernest Naylor, Cambridge University Press, New York.
4. Time in the living world, MK Chandrashekharan, Universities Press, India.
5. The circadian clock, M Zouhair Atassi, Springer, New York.

ZGY 5011: Natural History

L-3:C-3: 48 h

Course outcome:

By the end of this course, students will be able to:

- describe the natural history practised in ancient Rome and Greece, and what primaeval human tendencies helped build the stage for natural history.
- gain a comprehensive historical understanding of natural history.
- compare the practice of natural history or natural philosophy across centuries.
- put the ancient Roman trade and the European transoceanic explorations in the context of the development of natural history as a discipline.
- describe the development of modern natural history in 19th century Europe.
- identify the role of natural history museums and collections in 21st-century science in general and conservation biology in particular.

Unit No.	Topics	Hrs
01	Folk taxonomy and faunal and floral references in epics, oral traditions, painting and poetry; remarks on flora and fauna and early thoughts on evolutionary change by pre-Socratic philosophers and physicians.	12
02	Emergence of philosophy; Aristotle and the birth of biology; attempts to classify knowledge into disciplines; logic, reasoning and scientific methods; the specialist and the generalist, Greek and Roman natural history.	10
03	Linnaeus and Buffon; age of discovery; European continental and transoceanic exploration; transformation of natural history into a scientific discipline; explanations on the origin of species; Lamarck and his works, natural history museums as centres of scientific knowledge and interpretation; structure as a powerful tool to explain the natural world.	10
04	Victorian period- the golden age of natural history; the collecting and mapping explorations; the great explorers of the nineteenth century; Darwin and Wallace and their collection journeys; empire and natural history.	08
05	Natural history museums in the digital era; natural history drawings; use of natural history collections in conservation biology and public understanding of the natural world.	08

Course textbooks:

1. Perrier, Edmond. *The Philosophy of Zoology Before Darwin*. Springer, 1884.
2. Farber, Paul Lawrence. *Finding Order in Nature The Naturalist Tradition from Linnaeus to E. O. Wilson.* The Johns Hopkins University Press, 2000.

Additional reading:

1. Fan, Fati. *British Naturalists in Qing China: Science, Empire and cultural encounter*. Harvard University Press, 2004.
2. Classical Natural History works available online in *Biodiversity Heritage Library*. Website is accessible at https://www.biodiversitylibrary.org.

ZGY 5012: Toxicology

L-3:C-3: 48 h

Course Outcomes:

After completing the course, the student can:

- Describe basic toxicological principles.
- Describe the importance of different organs for detoxification/ toxification of chemicals and mechanisms for chemically induced various toxicity.
- Be able to discuss when and how different chemicals can interact under the development to induce effects.
- Different testing methods and models used in testing various types of environmental pollutants.
- Apply different toxicological frameworks within the professional disciplines and have awareness about different risk assessment criteria.

Unit No.	Topics	Hrs
01	Introduction to toxicology: Definition, history, scope & sub-divisions of toxicology. Dose-effect and dose-response relationship- acute toxicity, chronic toxicity reversible & irreversible effects.	08
02	Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins. Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms.	08
03	Absorption and distribution of toxicants-portals of entry-skin, gastro intestinal tract, gills and respiratory system.	10
04	Bio-distribution, biomagnification biotransformation of xenobiotics- brief introduction to Phase-I and Phase-II reactions. Reactions of toxins with target molecules- Covalent binding, Non-covalent binding, Hydrogen abstraction, Electron transfer, Enzymatic reactions	12
05	Elimination of toxicants-renal, hepatic, DMES, pulmonary systems, milk, egg and foetus	08

Suggested Literature:

1. Hodgson, E & R.C. Smart Introduction to Biochemical Toxicology, 3rd Edition, Wiley; New York, 2001.
2. Klaassen, C.D., Ed.: Casarett and Doull's Toxicology: The Basic Science of Poisons. 9th and 8th Editions, McGraw-Hill, (2018, 2013).
3. Hayes, A.W., Ed.: Principles and Methods of Toxicology. 6th Edition, CRC Press, (2014).
4. Torres, J. and Bobst, S. (eds.). Toxicological Risk Assessment for Beginners, Springer, (2015).
5. Gilman, A.G., Rall, T.W., Nies, A.S. and Taylor, P., Eds: Goodman and Gilman's The Pharmacological Basis of Therapeutics, 12th Edition (2011).

ZGY 5013:Translation Immunology

L-3:C-3: 48 h

Course Outcome: Immunology is an experimental science is rooted in the search for ways to manipulate immunity to prevent or cure disease. Fundamental immunology, coupled with powerful tools of molecular and cellular biology, has led to remarkable practical advances in fighting infectious diseases, organ transplantation, autoimmunity, and marshaling of the immune system to fight cancer. This course aims to provide an overview of tools, technologies, and approaches used to translate fundamental principles and immunological discoveries towards practical use.

Unit No.	Topics	Hrs
01	Overview of immune system: Importance of immunology in health/life sciences; Organs, tissues, cells and humoral components of the immune system; mucosal immunity, Terminology (Ag, Immunogen, hapten, adjuvant, antibody, cytokines, chemokines, CD, MHC, HLA etc.). Basic concepts of immune response (Innate and Adaptive) primary, secondary immune responses; immunological memory, hypersensitivity, tolerance, autoimmunity, vaccines and vaccinology).	08
02	Innate Immunity, characteristics, components and functions: Reticuloendothelial system: Biology of dendritic cells monocytes and macrophages, toll like receptors and other immune receptors. Granulocytes, Natural killer cells, Complement system, functions, activation and regulation.	08
03	Adaptive immunity, characteristics, components and functions: Cell mediated Immune Responses: MHC and Ag presentation, T-cell biology, induction of T-cells response and effector mechanisms. Humoral Immune Responses: Structure and functions of immunoglobulins, Generation of of Ab diversity, B-cell biology, Induction and effector mechanisms of humoral immune response.	10
04	Immune regulation, Immune-unrsponsiveness, tolerance and autoimmunity, Immuno-inflammatory mechanisms and Hypersensitivity reactions, Immuno-deficiency, AIDS a prototype, Infection and immunity, Tumor immunology, Key features of Immune signaling, cytokines, chemokines and their receptors	10
05	Basic and advanced Immunological Techniques: Transplantation immunology and stem cells, Immunological markers, diagnostics, Immunotherapy, Drug targeting. Principle and strategies of vaccine development against emergent pathogens. Principles and modalities of Immunodiffusion techniques; RIA; ELISA, ELISPOT and Western blotting. Flow-cytometry and Immuno-histochemistry. Animal models in Immunology Research.	12

Suggested Literature:

1. Abul Abbas Andrew H. Lichtman Shiv Pilla, Cellular and Molecular Immunology, 9th Edition (2017), Elsevier, USA

2. Immunobiology, 5th edition, (2001), Charles A Janeway, Jr, Paul Travers, Mark Walport, and Mark J Shlomchik., Garland Science, New York.
3. Kuby immunology (2007), Thomas J Kindt; Richard A Goldsby; Barbara Anne Osborne; Janis Kuby, W.H. Freeman, New York.
4. Seng-Lai Tan, Translational Immunology, 1st Edition, Mechanisms and Pharmacologic Approaches, Academic Press, 2015.
5. Abul K. Abbas, Andrew K. Lichtman & Jordan S. Pober (Eds.). Cellular and Molecular Immunolgy. 3rd Edn. W.B. Saunders Company, 2017.
6. Ivan Roitt,Essential Immunology, 10th Edn. Blackwell Scientific Publication, , 2002,
7. Weir DM and Stewart, J., Immunology, 10th Edn. Churchill Livingston, New York, 2000.
8. Brudce Alberts, Dennis Bray, Julian Lewis, Martin Raff, Keith Roberts and James D Watson (Eds.) Molecular Biology of the Cell (5th Edn), 2000.

ZGY 5014: Science Communication

L-3:C-3: 48 h

Course objectives: To equip the students to communicate science to all stake holders through written, oral, and visual media
Target group: Master's students of any discipline

Unit No.	Topics	Hrs
01	Introduction. Types of communication	08
02	Communicating science for academia. Writing a story in 300 words. Writing a Full-length research article; Writing an abstract; Selecting key words; Developing key words; Writing an introduction; Writing Material and Methods; Writing Results; Writing discussion; Writing Conclusion; Presenting data in results; Tables and Figures; Electronic Supplementary Files. Writing a review article: writing a proposal for review article; identifying a topic for review; why a review is required? Are you eligible for writing a review? Identify the gaps; setting new questions and hypotheses. Communicating the article to journals; journal types; Identifying appropriate journals from the predatory journals. Plagiarism check.	08
03	Communicating science to peers: oral and poster presentation in scientific meetings; abstracts for scientific meetings; presentation of ppt for 20 minutes talk and 10 minutes discussion and 5 minutes talk and 2 minute discussions (flash/ speed presentation); basics of powerpoint presentation; parts of presentation; time investment and management for each part of the presentation in standard and speed presentation; a meaningful title; font type and size for headings and text in ppt; use of pictures and tables in ppt; use of video clips and animations in ppt. Posters for scientific meetings; poster size and orientation; effective use of space for optimum projection of matter in landscape and portrait type posters; background colors; font size and colors for various sections of posters; acknowledgement section in posters and PowerPoint presentation. Poster presentation and speed presentation competitions for evaluation.	10
04	Communicating science to printed media. Writing a story in 300 – 500 words. Language of popular printed media. Laymen language. Using photographs and multimedia in the report. Opportunities to grow as a science reporter. Practicing for a science reporting job; developing a story from a scientific article; group discussion to simulate an editorial board by the chief editor and all reporters; collaborative editing of science reports through sharing google docs; seeking permission and interviewing authors before reporting and covering a story. Use of multimedia from internet in popular reports. Practicing science communication through the medium of Cartoons.	10
05	Communicating science to social media and electronic media. Language in social media. Writing a story in 75-100 words. Tweeting the major aspect of research in	12

	social media. Twitter. Security including cyber security. Practicing for developing a newsletter or magazine, and zines.	
06	Communicating science to public. A talk without the support of a PowerPoint; what and what not to talk; language in public talks; Practicing for Ted talks and media interview.	

Suggested Literature:

1. Becker HS, Richards P (2008) Writing for Social Scientists – How to Start and Finish Your Thesis, Book, or Article: Second Edition University of Chicago Press
2. Dawkins R (2009) The Oxford Book of Modern Science Writing. Oxford Publishers.
3. Dhanavel SP (2009) English And Communication Skills For Students Of Science And Engineering. Orient Blackswan Publishers.
4. Mishra D. (2020) The art and science of writing a scientific paper CBS Publishers
5. Faulkers Z (2019) Better Posters: Plan, Design, and Present an Academic Poster. Pelagic Publishing
6. Tuhovsky I (2019) the science of effective communication: Improve Your Social Skills and Small Talk, Develop Charisma and Learn How to Talk to Anyone. Rupa Publications, India.

ZGY 5015: R for Biologists

L-2:T-2: C-3: 48 hr

Requirement: Master's students having basic knowledge in biostatistics or have taken a course in Biostatistics offering by the department of Zoology or sister departments in the University can join the course. A laptop/ desktop computer is compulsory.

Evaluation: computer-based in R platform

Unit No.	Topics	Hrs
01	Biostatistics platforms and softwares. Paid and open softwares. What is R? How is it different from other stat softwares? What we can do in R? Language of R. Requirements for installation of R.	08
02	Tidying the data. Data types. Saving data for loading into R. Loading options. Attaching and checking data in R. Opening and closing safely R after use.	08
03	R-scripts; practicing scripts for loading and running data in R. Grouping and subsetting data.	10
04	Inbuilt functions in R Gui or R Studio. Performing classical statistical tests in R. Scripts for parametric tests, non-parametric tests, chi-square test, t test, matched t-tests, Wilcoxon test, Kruskal-wallis rank ANOVA test, one-way ANOVA test; ANCOVA test; regression analysis; ordination and multivariate analyses. Preparing data for each of the statistical analyses; identifying response and predictive variables; identifying grouping, discrete, and continuous variables in the data. Collection of original data for statistical analyses.	10
05	Graphics using R. Historgram for frequency checking, barplots, box plots, scatter plots, ordination diagram.	12
06	R packages; installing and loading R packages. *Ggplot2* for advanced and sophisticated graphics; Practicing scripts for various plots using ggplot2. Practicing the package *vegan* for biodiversity data analyses and community ecology studies.	

Suggested Literature:

1. Crawley MJ (2012) The R Book. Wiley Publishers
2. Dobson AJ, Barnett AG (2018) An Introduction to Generalized Linear Models. Chapman & Hall/CRC Texts in Statistical Sciences.
3. Kamath et al. (2012) R Manual for Health Science Researchers. Manipal University Press.
4. Upton G. (2019) Measuring abundance: Methods for the estimation of population size and species richness. Pelagic Publishing.