ROYAL GLOBAL UNIVERSITY
GUWAHATI

ROYAL SCHOOL OF LIFE SCIENCE(RSLSC)

DEPARTMENT OF ZOOLOGY

LEARNING OUTCOME FOR CURRICULUM FRAMEWORK (LOCF)

SYLLABUS

&

COURSE STRUCTURE

M.Sc. Zoology

PREFACE

The Assam Royal Global University is upgrading its postgraduate programmes as per the current prerequisites. Higher education plays an extremely important role in promoting human as well as societal well-being and in developing India as envisioned in its Constitution - a democratic, just, socially conscious, cultured, and humane nation upholding liberty, equality, fraternity, and justice for all. Higher education significantly contributes towards sustainable livelihoods and economic development of the nation.

Zoology, also known as animal biology, concerns itself with the study of animals and animal kingdom. Zoology aims to delve into the details of animals by studying at the cellular and molecular level. Zoology is an interdisciplinary subject which tries to understand relationship of animals to each other, to plants, and to the non-living environment.

The Department of Zoology, Royal School of Life Science was established in the year 2018 and offers BSc, MSc and PhD degree. The department envisages to inculcate a keen interest and in-depth knowledge of the animal life and the associated inter-relationships among the student fraternity. The academic program and learning environment have been designed to contribute to the quality and intellectual development of the students. The department has a team of qualified and experienced faculties and staff members who continually strive to improve upon the quality of education and maintain its position of leadership in engineering and technology. The core values of the department help the students to develop their overall personality and make them worthy enough to compete at global level.

INTRODUCTION

Quality education plays an important role in enhancing knowledge, developing skills, building confidence, and creating a positive impact on students' life. It empowers students to grow not just professionally, but also lays a solid foundation of personal growth. Therefore, all the programmes being offered at the University follows the Choice Based Credit System (CBCS) which focuses on developing a balance between imparting education & promoting skill development by providing flexibility to explore various fields. This Choice Based Credit System in higher education provides flexibility in preparing the curriculum and granting credits based on the course intensity and teaching hours. This helps students to pursue courses of their choice, study at their own pace, learn extra courses, and acquire more than the required credits. The subjects can be at a basic or advanced level. CBCS emphasizes group discussions, assignments, class activities, and internal examinations thus creating a beneficial education environment. All the curricula under the CBCS system includes mandatory courses like English, Behavioural Science, Environmental Science, Constitution of India, interdisciplinary and ability enhancement courses.

The current syllabus aims at a new and forward-looking Vision for India's Higher Education System. At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation.

This policy envisions a complete overhaul and re-energising of the higher education system to overcome these challenges and thereby deliver high-quality higher education, with equity and inclusion, moving towards a more multidisciplinary education, revamping curriculum, pedagogy, assessment, and student support for enhanced student experiences etc. A university will mean a multidisciplinary institution of higher learning that offers undergraduate and graduate programmes, with high quality teaching, research, and community engagement.

Choice Based Credit System (CBCS)

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enable the potential employers in assessing the performance of the candidates.

Definitions:

(i) 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre

(ii) 'Course' means a segment of a subject that is part of an Academic Programme

(iii) 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an academic programme, specifying the syllabus, credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University rules, eligibility criteria for admission

(iv) 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course

(v) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre

(vi) 'Open Elective' means an elective course which is available for students of all programmes, including students of same department. Students of other Department will opt

these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course

(viii) 'SGPA' means Semester Grade Point Average calculated for individual semester.

(ix) 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) 'Grand CGPA' is calculated in the last year of the course by clubbing together of CGPA oftwo years, i.e., four semesters.Grand CGPA is being given in Transcript form. To benefit thestudent a formula for conversation of Grand CGPA into %age marks is given in the Transcript.

Learning outcomes-based frameworks (LOCF)

Learning outcomes-based frameworks in any subject must specify what graduates completing a particular programme of study are (a) expected to know, (b) understand and (c) be able to do at the end of their programme of study. To this extent, LOCF in Zoology is committed to allowing for flexibility and innovation in (i) programme design and syllabi development by higher education institutions (HEIs), (ii) teaching-learning process, (iii) assessment of student learning levels, and (iv) periodic programme review within institutional parameters as well as LOCF guidelines, (v) generating framework(s) of agreed expected graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes.

The key outcomes that underpin curriculum planning and development at the undergraduate level include Graduate Attributes, Qualification Descriptors, Programme Learning Outcomes, and Course Learning Outcomes. The LOCF for undergraduate education is based on specific learning outcomes and academic standards expected to be attained by

graduates of a programme of study. However, an outcome-based approach identifies moves way from the emphasis on what is to be taught to focus on what is learnt by way of demonstrable outcomes. This approach provides greater flexibility to the teachers to develop—and the students to accept and adopt—different learning and teaching pedagogy in an interactive and participatory ecosystem. The idea is to integrate social needs and teaching practices in a manner that is responsive to the need of the community. HEIs, on their turn, shall address to the situations of their students by identifying relevant and common outcomes and by developing such outcomes that not only match the specific needs of the students but also expands their outlook and values.

NatureandExtentofMaster'sDegreeProgrammeinZoology

A master's degree in Zoology is a 2 years degree course which isdividedinto4semesters. The credit division is as follows-

Sl. No.	Year	Semester	Credit division
1.	1st Year	1st Semester	25
2.		2nd Semester	27
3.	2nd year	3rd Semester	24
4.		4th Semester	26

PROGRAMME OUTCOMES (PO'S)

PO1: The learners shall acquire knowledge of the different branches and field of Zoology. The programme envisages to equip students with the knowledge of the recent advances in Zoology.

PO2: Appreciate the complexity of life processes, their molecular, cellular andphysiological processes, their genetics, evolution and behaviour and theirinterrelationships with the environment.

PO3: The programme MSc Zoology aims to equip learners regarding the structural, functional, behavioural and evolutionary aspects of different animals.

PO4: The learner will have a deep understanding of the ethical and moral aspects of animal research and comply with laws and regulations

PO5: The learner will be able to apply subject based skills for academic and societal advancement

PO6: The programme allows learners to opt from a range of discipline elective courses based on their interest in Zoology

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

PSO1: Apply wide range of knowledge acquired during the programme in the field of Agriculture, Health science, Environment management, wildlife Conservation, Biotechnology, etc

PSO2: Empowered to solve issues pertaining to the field of Zoology and allied areas

PSO3: Conduct basic research and understand the applied aspects of Zoological sciences

PSO4: Should be able to teach and publish.

PSO5: Will be able to take up positions in various laboratories, museums, research organizations, NGO's, animal breeding centres, etc.

PSO6: Maintenance of high standards of learning in animal sciences and contributes the knowledge for nation building.

TEACHING LEARNING PROCESS

Teaching and learning in this programme involve classroom lectures as well tutorials. It allows-

- The tutorials allow a closer interaction between the students and the teacher as each student gets individual attention.
- Written assignments and projects submitted by students
- Project-based learning
- Group discussion
- Home assignments
- Quizzes and class tests
- PPT presentations, Seminars, interactive sessions
- Socio-economic survey
- Co-curricular activity etc.
- Industrial Tour or Field visit

ASSESSMENT METHODS

Methods	**Weightage**
SemesterEndExamination	70%
InternalAssessment	30%
Total	**100%**

Internal assessment is based on – Mid-semester Examination, Class test, Assignment, Project, Viva-voce, attendance of the student, seminar, group discussion, field work etc.

1st semester							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	**ZOO144C101**	**Biosystematics & Taxonomy**	**3**	**1**	**0**	**4**	**4**
2	**ZOO144C102**	**Animal Physiology**	**3**	**1**	**0**	**4**	**4**
3	**ZOO144C103**	**Cell Biology**	**3**	**1**	**0**	**4**	**4**
4	**ZOO144C104**	**Genetics**	**3**	**1**	**0**	**4**	**4**
5	**ZOO144C115**	**Taxonomy, Animal Physiology, Cell Biology and Genetics (Practical)**	**0**	**0**	**8**	**4**	**8**
	Total credit of the core course					**20**	**24**
Ability Enhancement Compulsory Course (AECC)*							
6	**CEN984A101**	**Communicative English – I**	**1**	**0**	**0**	**1**	**1**
7	**BHS984A103**	**Behavioural Science – I**	**1**	**0**	**0**	**1**	**1**
Elective: Discipline Specific (DSE)							
8	**ZOO144D101**	**Parasitology**	**2**	**1**	**0**	**3**	**3**
	Total credit of the semester		**18**	**6**	**8**	**25**	**29**
2nd Semester							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	**ZOO144C201**	**Population Genetics and Evolution**	**3**	**1**	**0**	**4**	**4**
2	**ZOO144C202**	**Developmental Biology**	**3**	**1**	**0**	**4**	**4**
3	**ZOO144C203**	**Environmental Physiology**	**3**	**1**	**0**	**4**	**4**

4	**ZOO144C204**	**Biostatistics and Bioinformatics**	**3**	**1**	**0**	**4**	**4**
5	**ZOO144C215**	**Evolution, Developmental Biology, Environmental Physiology, Biostatistics and Bioinformatics (Practical)**	**0**	**0**	**8**	**4**	**8**
	Total credit of the core course					**20**	**24**
Ability Enhancement Compulsory Course (AECC)							
6	**CEN984A201**	**Communicative English – II**	**1**	**0**	**0**	**1**	**1**
6	**BHS984A203**	**Behavioural Science – II**	**1**	**0**	**0**	**1**	**1**
Ability Enhancement Elective Course (AEEC) (Skill Based)							
7	**ZOO144S222**	**Sericulture**	**2**	**0**	**0**	**2**	**2**
Discipline Specific Elective (DSE) (Any one to be selected)							
8	**ZOO144D201**	**Economic Zoology**	**2**	**1**	**0**	**3**	**3**
9	**ZOO144D202**	**Animal Behaviour**	**2**	**1**	**0**	**3**	**3**
10	**ZOO144D203**	**Research Methodology**	**2**	**1**	**0**	**3**	**3**
	Total credit of the semester		**18**	**5**	**8**	**27**	**31**
3rd Semester							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	**ZOO144C301**	**Molecular Biology**	**3**	**1**	**0**	**4**	**4**
2	**ZOO144C302**	**Basics of Biotechnology**	**3**	**1**	**0**	**4**	**4**

3	ZOO144C313	Molecular Biology and Basics of Biotechnology (Practical)	0	0	8	4	8
	Total credit for core papers					12	
Ability Enhancement Compulsory Course (AECC)							
3	CEN984A301	Communicative English III	1	0	0	1	1
Ability Enhancement Elective Course (AEEC) (Skill Based)							
4	ZOO144S321	Pest Management	2	0	0	2	2
Discipline Specific Elective (Special Paper)							
5	ZOO144D301	Fish Biology- I	2	1	0	3	3
6	ZOO144D302	Ecology and Wildlife Biology- I	2	1	0	3	3
7	ZOO144D303	Cell Biology and Genetics- I	2	1	0	3	3
8	ZOO144D304	Environmental Toxicology- I	2	1	0	3	3
9	ZOO144C321	PROJECT DISSERTATION (Based on Special Paper)	0	0	12	6	12
	Total credit of the semester		11	3	16	24	31
4th Semester							
Sl. No.	Subject Code	Names of subjects	L	T	P	C	TCP
Core Subjects							
1	ZOO144C401	Biochemistry of Metabolic processes	4	0	0	4	4
2	ZOO144C402	Immunology	4	0	0	4	4
3	ZOO144C413	Biochemistry and Immunology (Practical)	0	0	8	4	8
	Total credit for core papers					12	16

Ability Enhancement Compulsory Course (AECC)							
4	**CEN984A401**	**Communicative English IV**	**1**	**0**	**0**	**1**	**1**
Discipline Specific Elective (Special Paper)							
5	**ZOO144D401**	**Fish Biology- II**	**2**	**1**	**0**	**3**	**3**
6	**ZOO144D402**	**Ecology and Wildlife Biology- II**	**2**	**1**	**0**	**3**	**3**
7	**ZOO144D403**	**Cell Biology and Genetics- II**	**2**	**1**	**0**	**3**	**3**
8	**ZOO144D404**	**Environmental Toxicology- II**	**2**	**1**	**0**	**3**	**3**
Dissertation in their selected special paper							
9	**ZOO144C421**	**PROJECT DISSERTATION (Based on Special Paper)**	**0**	**0**	**20**	**10**	**20**
		Total				**26**	

SEMESTER-I
Paper/Subject Name: Biosystematics & Taxonomy **Subject Code:** ZOO144C101 **L-T-P-C**: 3-1-0-4 **Credit Units:** 4 **Scheme of Evaluation:** Theory

Course Objectives:

To provide basic concepts of biosystematics & taxonomy and to exercise various taxonomic characters in identification and categorization of animals among various taxonomic hierarchy.

Course Outcomes:

BT1: Identify the various taxonomic characters that are vital in identification and naming of animals.

BT2: Describe the various methods that govern the process of taxonomic categorization and biological classification.

BT3: Apply the basic knowledge to interpret the various taxonomic keys in identification and classification of animals among different taxa.

BT4: Analyze different methods that can be implemented to decipher biodiversity indices.

BT5: Summarize different components of taxonomic knowledge in identifying a new species in a natural ecosystem.

Detailed Syllabus:

MODULE	COURSE CONTENT	PERIODS
I	**Definition and basic concepts of biosystematics and taxonomy:** Historical resume of systematic. Importance and applications of biosystematics in biology. Material basis of biosystematics - different attributes. Trends in biosystematics - concepts of different conventional and newer aspects. Chemotaxonomy. Cytotaxonomy. Molecular taxonomy. Biodiversity and ecosystem process: theory, achievements and future directions.	16
II	**Dimensions of speciation and taxonomic characters:** Dimensions of speciation - types of lineage changes, production of	16

	additional lineage. Mechanisms of speciation in panmictic and apomictic species. Species concepts - species category, different species concepts; sub-species and other infra-specific categories. Theories of biological classification, hierarchy of categories.	
III	**Taxonomic characters &Procedures in taxonomy:** Different kinds of taxonomic characters. Origin of reproductive isolation – biological mechanism of genetic incompatibility. Taxonomic procedures-taxonomic collections, preservation, curetting process and identification. Taxonomic keys-different kinds of taxonomic keys, their merits and demerits.	16
IV	**Systematic publications &International code of Zoological Nomenclature (lCZN):** Different kinds of systemic publications. Process of typification and different Zoological types. ICZN: Its operative principles, interpretation and application of important rules, Zoological nomenclature; formation of scientific names of various taxa. Biodiversity: Concept & Importance; Evaluation of biodiversity indices. Dominance, Species diversity, Evenness, Association, Similarity and dissimilarity indices	16
	Total	64

Textbooks:

1. Simpson G.G (2012). Principle of animal taxonomy, Oxford IBH Publishing Company.
2. Wilson E.O. The Diversity of Life. The College Ed, W.W. Northern & Co.

References:

1. Mayr E. Principles of Systematic Zoology. 2nd Ed. McGraw Hill Education.
2. Mayer E & Ashlock P (1991). Principles of systemic Taxonomy. 2nd Ed. McGraw-Hill.

SEMESTER-I
Paper/Subject Name: Animal Physiology **Subject Code:** ZOO144C102 **L-T-P-C**: 3-1-0-4 **Credit Units:** 4 **Scheme of Evaluation:** Theory

Course Objectives:

To build understanding regarding various anatomical features of organs and elucidate the organ level functioning related to nervous, respiratory, cardiovascular, excretory, and digestive etc.

Course Outcomes:

BT1: Recall various processes that are vital in understanding the underlying concepts of physiology.

BT2: Describe the various methods that govern various life processes such as nervous, respiratory, cardiovascular, excretory, and digestive functions etc.

BT3: Apply the basic knowledge to interpret the various life processes such as functioning of nervous system, respiratorysystem, cardiovascular system, excretorysystem, and digestive system etc.

BT4: Analyze the acquired concepts of various physiologicalprinciples atthe basic and applied levels.

BT5: Relate physiological processes from the biochemical to the system level unto thefunction of the entire organism in its environment.

Detailed Syllabus:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Blood and circulation:** Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis. **Cardiovascular System:** Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.	16
II	**Respiratory system:** Comparison of respiration in different species,	16

	anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration. **Nervous system:** Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. **Sense organs:** Vision, hearing and tactile response.	
III	**Excretory system:** Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance. **Thermoregulation:** Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.	16
IV	**Digestive system:** Digestion, absorption, energy balance, BMR. **Endocrinology and reproduction:** Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation.	16
	Total	64

Textbooks:

1. John E. Hall (2016). Guyton and Hall: Textbook of medical physiology. 13th Ed, Elsevier.
2. Marieb E.N & Hoehn K.N (2022). Human Anatomy & Physiology. 12th Ed, Pearson Education.
3. Barrett K.E, Barman S.M, Brooks H.L, Yuan J.X.J (2019). Ganong's Review of Medical Physiology. 26th Ed, McGraw-Hill Education.

References:

1. Tortora G.J et al., (2016). Principles of Anatomy & Physiology. 14th Ed, John Wiley & Sons.
2. Dr Ian Kay (1998). Introduction to Animal Physiology. 1st Ed, Garland Science.

Semester-I
Paper/Subject Name: Cell Biology **Subject Code: ZOO144C103** **L-T-P-C- 3-1-0-4**

Credit Units: 4

Scheme of Evaluation: Theory

COURSE OBJECTIVE:

To help the students learn and develop an understanding of the cell as a basic unit of life, the functions of cellular organelles, how a cell carries out and regulates cellular functions and their role in disease condition due to malfunctioning of cellular processes.

LEARNING OUTCOMES:

Upon completion of the course, students should to be able to:

BT1: Identify the different structural and functional components of the cell.

BT2: Explain the structure and functions of cell organelles involved in diverse cellular processes.

BT3: Apply the knowledge of cellular process and its regulation in understanding the process of cancer and microbial physiology.

BT4: Point out the roles of various genes responsible for various kinds of cell signalling processes.

BT5: Construct a spider diagram indicating the involvement of various genes and their regulatory factors for a particular disease condition

Course Outline

Modules	Topics (if applicable) & Course Contents	Periods
I	Structure and differences between prokaryotic and eukaryotic cells. **Membrane structure and function:** Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. Chromatin structure- Euchromatin and Heterochromatin- Constitutive and Facultative heterochromatin. Regulation of Chromatin Structure and Nucleosome Assembly, **Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic	**16**

	reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.	
II	**Cell division and cell cycle:** Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle in yeast and multicellular organism. **Cancer:** Oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. **Microbial Physiology:** Growth yield and characteristics, strategies of cell division, stress response.	**16**
III	**Basics of Cell signaling:** Autocrine, endocrine, paracrine and juxtacrine signaling, signaling molecules and receptors. **Cell signaling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing.	**16**
IV	**Cytoskeleton:** Cell junction and cell adhesion, molecular organization of microtubules, microfilaments and intermediary filaments. Vesicular trafficking: secretory and endocytotic pathway. **Cellular communication:** Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.	**16**
TOTAL		**64**

Textbooks:

1. Lodish H, Berk A, Kaiser C.A, Krieger M, Bretscher A, Ploegh H, Amon A, Martin K.C (2016). Molecular Cell Biology, 8th Ed, W. H. Freeman.

2. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P (2018). Molecular biology of the cell. 6th Ed, Garland Science.
3. Hardin J & Bertoni G (2018). Becker's World of the Cell. 9th Ed, Pearson Education.

References:

1. Stephen R. Bolsover S.R, Jeremy S. Hyams J.S, Elizabeth A. Shephard E.A & Hugh A. White H.A (2011). CELL BIOLOGY: A Short Course. 3rd Ed, John Wiley & Sons.
2. Cooper G.M (2019). The Cell: A Molecular Approach. 8th Ed, Sinauer Associates.
3. Iwasa J & Marshall W (2016). Karp's Cell and Molecular Biology: Concepts and Experiments. 8th Ed, John Wiley & Sons.

Semester-I
Paper/Subject Name: Genetics
Subject Code: ZOO144C104
L-T-P-C- 3-1-0-4
Credit Units: 4
Scheme of Evaluation: Theory

Course Objectives:

To highlight extension of Mendelian Genetics, dosage compensation, evolution of the concept of gene and its amalgamation with molecular biology and study of genetic diseases.

Learning Outcome:

BT1: Describe how genetic information is passed on in eukaryotes and prokaryotes, how genes work together in a complex manner in biological system and any alteration can lead to major phenotypic change.

BT2: Review the various mechanisms of gene mutation and epigenetics.

BT3: Predict the mode of transmission of diseases with the help of pedigree analysis.

BT4: Identify the role of various physical and chemical factors in causing mutation in organisms

BT5: Devise a technique to detect mutagen induced genetic abnormalities in different animal models.

CourseOutline

Modules	Topics (if applicable) & Course Contents	Periods
I	**Mendel's laws and their chromosomal basis:** Extension of Mendel's principles:allelic variation and gene function-incomplete dominance and co-dominance, allelicseries, testing gene mutations for allelism; gene action- from genotype tophenotype–penetrance and expressivity, gene interaction, epistasis, pleiotropy, lethal genes, multiple alleles; sex linked, sex influenced and sex limited inheritance; polygenic inheritance. **Linkage, Crossing Over and Chromosome Mapping in Eukaryotes:** Linkage, mechanism of linkage; methods of gene mapping; 2 point cross and 3- point test cross in *Drosophila*, pattern of inheritance by pedigree analysis and genemapping, Human genome and mapping.	**16**
II	**Genome and Genome complexity:** What is a genome?; C-value paradox; Genome Complexity; Repetitive sequences; highly repetitive sequences- satellite DNA,Microsatellites, Minisatellites; Moderately repetitive sequences **Gene mutation and Recombination:** Types of gene mutations, methods for detection of induced mutations; types of chromosomal aberrations, non-disjunctionsand variation in chromosomal number; molecular basis of mutations in relation to UV light and chemical mutagens, disorders due to mutation.	**16**
III	**Epigenetics:** Basics of epigenetics; introduction to histones, chromatin packing, transcription factors and gene expression; histone modification – acetylation, methylation, phosphorylation, sumoylation, ubiquitylation, ADP ribosylation; gene silencing and gene activation, genomic imprinting; X-inactivation; epigenetics and cancer. **Sex determination:** Sex determination in drosophila, sex determination in mammals, sex determination in birds; dosage compensation.	**16**
IV	**Human genetics:** Chromosome banding, karyotype and nomenclature of metaphase chromosome; chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma, "cry du chat" syndrome, cystic fibrosis and Wilms' tumor); oncogenes and tumor suppressor genes- genetic pathways to cancer; extra chromosomal inheritance;	**16**

	Human Genome Project. **Transposable elements of the gene:** Transposons; conservative and replicative transposition; bacterial transposons – IS elements, composite transposons; eukaryotic transposons – P element in Drosophilla, controlling elements; Retrotransposons- LTR transposons, non LTR transposons (LINES, SINES).	
TOTAL		**64**

Textbooks:

1. Snustad D.P &Simmons M.J (2015). Principles of Genetics. 7th Ed, John Wiley & Sons, USA.
2. Klug W.S, Cummings M.R, Spencer C.A, Palladino M.A (2019). Concepts of genetics. 11th Ed, Pearson Education.

References:

1. Tamarin R.H (2001). Principles of Genetics. 7th Ed, McGraw−Hill Education.
2. Russell P.J (2016). iGenetics: A Molecular Approach. 3rd Ed, Pearson Education.
3. Pierce B.A (2012). Genetics: A conceptual approach. 4th Ed, W.H. Freeman.
4. Griffiths A.J.F, Wessler S.R, Carroll S.B, Doebley J (2010). Introduction to Genetic Analysis. 10th Ed, W. H. Freeman.
5. Hartl D.L (2020).Essential Genetics and Genomics. 7th Ed, Jones & Bartlett Learning.
6. Brooker R.J (2019). Concepts of genetics. 3rd Ed, McGraw-Hill Education.

Semester-I
Paper/Subject Name: Taxonomy, Animal Physiology, Cell biology and Genetics (Practical) **Subject Code: ZOO144C115** **L-T-P-C- 3-1-0-4** **Credit Units: 4** **Scheme of Evaluation: Practical**

Course Objective

To provide the students basic hands on training on microscopy, their use in studying cells and their variability, basic understanding of different bioparameters of human physiological processes.

Course Outcomes

BT1: Recall the different vertebrate and invertebrate groups and the general characteristics of the phylum they belong to.

BT2: Identify the different vertebrate and invertebrate species based on their morphological characteristics.

BT3: Prepare taxonomic keys observing various naturally available organisms

BT4: Relate the concepts of various biodiversity indices and analyze the biodiversity of a particular region.

BT5: Summarize different components of taxonomic knowledge in identifying a new species in a natural ecosystem.

Course Outline:

Modules	Topics (if applicable) & Course Contents	Periods
I	1. To study of Museum Specimen (Non -chordates) 2. To study of Museum Specimen (Chordates) 3. To study of larval form of different Invertebrates. 4. To prepare taxonomic key- dichotomous and polyclave key from the museum specimen.	**16**
II	1. To dissect pituitary gland of *Labeo rohita* 2. To measure Blood Pressure using sphygmomanometer 3. To measure the haemoglobin content using haemometer 4. Estimation of different respiratory indices by spirometry	**16**
III	1. Understanding the basics and practical handling of microscope 2. To study various stages of mitosis in mouse bone marrow/ onion root tip 3. Meiotic chromosome preparation from rat/ grasshopper/ sand hopper testis 4. Cell variability assay of blood cells	**16**

IV	1. Preparation of human karyotype from two normal and two abnormal metaphase plates 2. To study the bar body from buccal smear 3. To study G/C Banding pattern from mitotic chromosome preparation of mouse/ rat bone marrow cells 4. To study chromosomal abnormalities from mouse/ rat bone marrow cells	**16**
TOTAL		**64**

Textbooks:

1. Textbook of Practical Zoology, S.S. Lal.

Semester-I
Paper/Subject Name: Parasitology
Subject Code: ZOO144D101
L-T-P-C- 2-1-0-3
Credit Units: 3
Scheme of Evaluation: Theory

Course Objective:

To provide students with knowledge concerning biological, epidemiological and ecological aspects of parasites causing diseases to humans enabling them to understand the pathogenesis, clinical presentations and complications of parasitic diseases and to reach diagnosis, prevention and control of parasitic infections.

Course Outcomes:

BT1: Recall the concepts of parasitism, zoonosis, host and host parasite interaction.

BT2: Describe the epidemiology of important parasitic infections and the effect of social and demographic patterns on parasitic disease.

BT3: Apply the knowledge of parasitology on life-threatening conditions caused by helminths and protozoans with regards to etiology and life cycle of parasites of medical importance.

BT4: Analyze the immunological and molecular methods used for diagnosis of parasitic infections and methods of recovery from parasitic infection.

BT5: Summarize host parasitic interaction and defence mechanism adopted by parasites and hosts against each other.

Modules	Topics (if applicable) & Course Contents	Periods
I	Introduction: Introduction to parasitology, animal associations and host – parasite relationship; distribution of diseases and Zoonosis caused by animal parasites. Types of parasites and type of hosts.	12
II	**Protozoan Parasites** Morphology, biology, life-cycle, mode of infection of Entamoeba, molecular biology of Entamoeba – drug targets, mechanism of drug resistance, vaccine strategies and proteomic approaches. Morphology, life-cycle, mode of infection of Plasmodium, molecular biology of Plasmodium – drug targets, mechanism of drug resistance, vaccine strategies and proteomic approaches. Morphology, life-cycle, mode of infection of Leishmania, molecular biology of Leishmania – drug targets, drug resistance and vaccine strategies. Morphology, life-cycle, mode of infection of Trypanosoma, molecular biology of Trypanosoma – drug targets, drug resistance and vaccine strategies.	12
III	**Helmintic Parasites**: Morphology, biology, life-cycles, mode of infection of Giardia; gastro-intestinal nematodes; Morphology, biology, life-cycles, modes of entry of *Schistosoma*; Morphology, biology, life-cycles, modes of entry of *Wuchereria*; Morphology, biology, life-cycles, modes of entry of *Ancylostoma*	12
IV	**Immune Response** Immune response and self-defence mechanisms, Immune evasion and biochemical adaptations of parasites and Parasites of veterinary importance.	12
TOTAL		48

Textbooks:

1. Roberts L.S, Janovy J & Nadler S (2013).Gerald D. Schmidt & Larry S. Roberts' Foundations of Parasitology. 9th Ed, McGraw-Hill Education.
2. Cox F.E.G (1993). Modern Parasitology: A Textbook of Parasitology. 2nd Ed, Blackwell Science.
3. Chatterjee K.D (2011).Parasitology. 13th Ed, CBS Publishers & Distributor Pvt. Ltd.

References

1. Watson J.M (1965). An Introduction to Parasitology. William Heinemann Medical Books Ltd. London.
2. Gunn A &Pitt S.J (2012). Parasitology: An Integrated Approach. 1st Ed, John Wiley & Sons.

Semester-II
Paper/Subject Name: Population Genetics and Evolution
Subject Code: ZOO144C201
L-T-P-C- 3-1-0-4
Credit Units: 4
Scheme of Evaluation: Theory

Course Objectives

To acquaint the students on concepts and theories of evolution and understand the importance of studying population genetics in realizing the mechanism of evolution

Course Outcome

BT1: Describe the process of origin of life on earth and the various theories put forwarded by researchers to understand the process leading to evolution.

BT2: Explain the concepts of Darwinism, Neo Darwinism, and Hardy Weinberg law to understand the concept of evolution of life.

BT3: Apply the concepts of Natural selection,mutation, genetic drift, migration, meiotic drive to understand evolution of eukaryotes and prokaryotes.

BT4: Analyze the roles played by genes and proteins in driving molecular evolution.

BT5: Relate the various concepts of evolution and molecular biology to understand the phenomenon of extinction.

Course Outline:

Modules	Topics (if applicable) & Course Contents	Periods
I	**Origin of life and Evolution** 1. Concepts of origin of life, molecule, evolution and theories of organic evolution with an emphasis on Darwinism, Neo-Darwinism 2. Hardy-Weinberg law of genetic equilibrium. 3. Evolution of Prokaryotes and Eukaryotes. 4. A detailed account of destabilizing forces: (i) Natural selection (ii) Mutation (iii) Genetic drift (iv) Migration (v) Meiotic drive, Quantifying genetic variability, Genetic structure of natural populations, Phenotypic variation,Sexual Selection	16

II	**Molecular population genetics** 1. Patterns of change in nucleotide and amino acid sequences, Ecological significance of molecular variations, 2. Emergence of Non-Darwinism-Neutral Hypothesis, 3. Genetics of quantitative traits in populations, Analysis of quantitative traits, Quantitative traits and natural selection, Estimation or heritability, Genotype-environment interactions, Inbreeding depression and heterosis, Molecular analysis of quantitative traits, Phenotypic plasticity	16
III	**Molecular evolution and concept of Speciation** 1. Phylogenetic and biological concept of species 2. Patterns and mechanisms of reproductive isolation, Mode of speciation-allopatric, sympatric, parapatric and peripetric 3. Molecular Evolution- Genetics of speciation, Gene Evolution, Evolution of gene families, Molecular drive, Assessment of molecular variation, 4. Origin of higher categories, Major trends in the origin of higher categories, Micro-and Macro-evolution.	16
IV	**Molecular phylogenetics** 1. How to construct phylogenetic trees? Phylogenetic inference-Distance methods, parsimony methods, maximum likelihoodMethod, 2. Immunological techniques, Amino acid sequences and phylogeny, Nucleic acid phylogeny-DNA-DNA hybridizations, Restriction Enzyme sites, Nucleotide sequence comparisons and homologies. 3. Population genetics and ecology. Metapopulations Monitoring natural populations. Why small populations become extinct? Loss of genetic variations. Conservation of genetic resources in diverse taxa	16
TOTAL		64

Textbooks:

1. Graur D &Li Wen-Hsiung (2000). Fundamentals of Molecular Evolution. 2nd Ed, Sinauer Associates.
2. Futuyma D. J & Kirkpatrick M (2017). Evolution. 4th Ed, Sinauer Associates.

References:

1. Hall B.K and Hallgrimsson B (2007). Strickberger's Evolution. 4th Ed, Jones &Bartlett Publishers.
2. Hamilton M (2009). Population Genetics. 1st Ed, Wiley-Blackwell.

3. Hartl D.L&Clark A.G (1997). Principles of Population Genetics. 3rd Ed, Sinauer Associates.
4. Hartl D.L (2020). A Primer of Population Genetics and Genomics.4th Ed, Oxford University Press.
5. Dobzhansky T (1959). Evolution, Genetics, and Man. John Wiley & Sons.

Semester-II
Paper/Subject Name: Developmental Biology
Subject Code: ZOO144C202
L-T-P-C- 3-1-0-4
Credit Units: 4
Scheme of Evaluation: Theory

Course Objective:

To learn about heterogamy in eukaryotes, fertilization, biology of sex determinationand understand the process of fertilization and other assisted reproduction techniques

Course Outcomes:

BT1: Recall the basic concepts of spermatogenesis, oogenesis , fertilization and sex determination.

BT2: Review the concepts of various fertilization events and identify the various techniques of In Vitro Fertilization.

BT3: Apply the knowledge of reproductive biology in understanding assisted reproductive technologies, generation of transgenic animals, contraceptive mechanisms and teratogenesis.

BT4: Analyze the various mechanisms of genetic and molecular regulation of gametogenesis and fertilization.

BT5: Summarize the various technological concepts of reproductive biology.

Course Outline:

Modules	Topics (if applicable) & Course Contents	Periods
I	**Basic concepts of development:** Potency, commitment, specification,	16

	induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development	
II	**Oogenesis and fertilization** 1. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, 2. Collection and cryopreservation of gametes and embryos, 3. Ovarian follicular growth and differentiation, Oogenesis and vitellogenesis, Ovulation and ovum transport in mammals	16
III	**Early development:** Cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. **Morphogenesis and organogenesis in animals :** Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.	16
IV	1. Multiple ovulation and embryo transfer technology (MOET), In vitro oocyte maturation, Superovulation, In vitro fertilization, 2. Transgenic animals and knock-outs, Production, Applications, Embryonic stems cells. 3. Assisted reproduction technologies, Embryo sexing and cloning Screening for genetic disorders, ICSI, GIFT etc., Cloning of animals by nuclear transfer, Teratological effects of Xenobiotics, 4. Immunocontraception, Gamete specific antigens, Antibody mediated fertilization block and termination of gestation. Other contraceptive	16

	technologies, Surgical methods, Hormonal methods, Physical barriers, IUCD	
TOTAL		64

Textbooks:

1. Gilbert S.F &Barresi M.J.F (2016). Developmental Biology. 11th Ed, Sinauer Associates.
2. Slack J.M.W (2012). Essential Developmental Biology. 3rd Ed, Wiley-Blackwell.

References:

1. Wolpert L (2002). Principles of Development. 2nd Ed, Oxford University Press.
2. Carlson B.M (2018). Human Embryology & Developmental Biology. 6th Ed, Elsevier, Inc.

SEMESTER-II

Paper/Subject Name: Environmental Physiology

Subject Code: ZOO144C203

L-T-P-C: 3-1-0-4

Credit Units: 4

Scheme of Evaluation: Theory

Course Objectives:

To make student's awareregarding the plethora of physiological adaptations that animals can show while responding to ever changing environmental stimuliand is basically an animal physiology course, taught from an ecological andevolutionary perspective.

Course Outcomes:

BT1: Recognize various ecological processes that govern the underlying concepts of environmental physiology.

BT2: Describe numerous natural processes and mechanisms for physiological adaptation of animals in environmental context.

BT3: Apply concepts (on gas exchange, acid-base regulation, water balance,ion/osmotic regulation, and temperature effects/thermoregulation) to explain therelationship between an animal's physiology and their environmental conditions.

BT4: Analyze and draw relationships among various physiological, biochemical and environmental adaptations of organisms that enable them to survive environmental extremes.

BT5: Write various examples of physiological solutions to problems, such as animals invarious and extreme environmental conditions or animals exhibiting unique lifehistory strategies.

Detailed Syllabus:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Adaptation:** 1. Adaptation: Levels of adaptation, Mechanisms of adaptation 2. Significance of body size. 3. Adaptation and acclimatization	18
II	**Physiological adaptations to different environments** 1. Marine, Shores and Estuaries, 2. Freshwater, Extreme aquatic environments, 3. Terrestrial Life, Extreme terrestrial environments, 4. Parasitic habitats	18
III	**Stress Physiology** 1. Basic concept of environmental stress and strain; concept of elastic and plastic strain; 2. Stress resistance, stress avoidance and stress tolerance. 3. Effects of pollutants in aquatic habitat, oxidative stress tolerance- free radicals, ROS and SOS. 4. Concept of homeostasis. Endothermy and physiological mechanism of regulation of body temperature	12
IV	1. Physiological adaptation to osmotic and ionic stress; mechanism of cell volume, regulation. 2. Osmoregulation in aqueous and terrestrial environments. 3. Physiological response to oxygen deficient stress. Physiological response to body exercise, Meditation, Yoga and their effects.	16
	TOTAL	64

Textbooks:

1. Randall D, Burggrenand W & French K (2002). Eckert Animal Physiology: Mechanisms and Adaptations. 5th Ed, W.H. Freeman and Company, New York.
2. Willmer P, Stone G & Johnston I (2005). Environmental Physiology of Animals. 2nd Ed, Blackwell Science Ltd.

References:

3. Hill R.W, Wyse G.A & Anderson M (2016). Animal Physiology. 4th Ed, Sinauer Associates, Inc.
4. Knut-Schmidt-Nielsen (1990). Animal Physiology: Adaptation and Environment, 4th Ed, Cambridge University Press.

SEMESTER-II
Paper/Subject Name: Biostatistics and Bioinformatics **Subject Code:** ZOO144C204 **L-T-P-C**: 3-1-0-4 **Credit Units:** 4 **Scheme of Evaluation:** Theory

Course Objectives:

To impart knowledge to students on the most important skill which is required to use computer programs for the daily design of experiments, data collection, and analysis of results as well as hands on practical exercises on various computer programming.

Course Outcomes:

BT1: State various computer applications that are employed to retrieve various biological data.

BT2: Describe various biological database namely EMBL, SWISS-PROT, Pub-Med etc. that are useful in the field of bioinformatics.

BT3: Apply knowledge to evaluate various sequence analysis and alignment techniques.

BT4: Illustrate different tools related to bioinformatics and also outline various biostatistical tools that can be used to arrange and analyze biological data.

BT5: Construct a Phylogenetic tree using the knowledge of bioinformatics and biostatistics.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Basics of bioinformatics:** Definition, Scope and Goal, Application in Computational Biology, Limitations. **Biological Database:** Types of databases, biological database: GenBank, EMBL, DDBJ, Uniprot-KB: SWISS-PROT, PDB, literature databases PubMed; Webtools: ExPASy server **Sequence Analysis and Sequence Alignment**: Basic concepts of	18

	sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues, Basic concepts of sequence alignment, Uses of Sequence Alignment, Pairwise, multiple, Database Similarity search, **Scoring matrices:** Basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, Sequence similarity search: BLAST and FASTA.	
II	**Molecular Phylogenetics:** Basic concepts, Methods in evaluation of phylogeny and steps in constructing alignments and phylogenetic Trees, Types of phylogenetic tree. **Structural bioinformatics:** proteins and its structure, Determination of protein 3 Dimensional structure, Protein structure visualization, comparision, Secondary and tertiary structure prediction, Chemiinformatics and Computer Aided Drug Designing (CADD): Introduction to cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Basics of medicinal chemistry. Drug targets, Drug solubility, Natural resources of lead compounds, Pharmacokinetics & drug metabolism	18
III	**Biostatistics-** population, sample, variable, parameter, primary and secondary data, screening and representation of data, frequency distribution, tabulation, bar diagram, histograms, pie diagram, mean, median, mode, quartiles and percentiles, variance, standard deviation, coefficient of variation.	12
IV	**Probability -** definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability, examples- poisson and normal distributions Bivariate distribution - correlation coefficient **Test of significance** - chi-square test for independence of attributes	16
	TOTAL	64

Textbooks:

1. Le C.T and Eberly L.E (2016). Introductory Biostatistics. 2nd Ed, John Wiley & Sons.
2. Pagano M and Gauvreau K (2000). Principles of Biostatistics. 2nd Ed, CRC Press.

References:

3. Mount D.W (2001). Bioinformatics: Sequence and Genome Analysis. 2nd Ed, ColdSpring Harbor Laboratory Press, New York, USA.
4. Krane D.E and Raymer M.L (2003). Fundamental concepts of bioinformatics. Benjamin Cummings.
5. Claverie J.M and Notredame C (2007). Bioinformatics for Dummies. 2nd Ed, WileyPublishing, Inc., New York, US.

Semester-II
Paper/Subject Name: Evolution, Developmental Biology, Environmental Physiology, Biostatistics and Bioinformatics (Practical) **Subject Code: ZOO144C215** **L-T-P-C- 0-0-8-4** **Credit Units: 4** **Scheme of Evaluation: Practical**

Course Objective

To provide the students basic hands-on training on microscopy, their use in studying cells and theirvariability, basic understanding of different bio parameters of human physiological processes.

Course Outcomes

BT1 : To understand about the embryological development in species.

BT2 : Identify the different allele frequency and genotype frequency

BT3 : Prepare phylogenetic tree for DNA and Protein

BT4 : Relate the nucleic acid and protein sequence databases.

Course Outline:

Modules	Topics & Course Contents	Periods
I	1. To study of Embryological development of amphibians through permanent slides. 2. To study of Embryological development of chick through permanentslides 3. To study of Sperm count and motility. 4. Visit to IHR	**16**
II	5. Estimation of gene and genotype frequency using Hardy-Weinberg lawbased on ABO blood group. 6. To estimate allele frequency for specific trait.	**16**
III	7. To test for Human Rh blood type. 8. To study of nucleic acid and protein sequence database	**16**
IV	9. Construction of phylogenetic tree for DNA and Protein. 10. To study of web-based tools for sequence searches and homology screening.	**16**

Textbooks:

1. Samal, Rout, Das and Mohanty (2014). Bioinformatics Practical Manual. Orissa University ofAgriculture and Technology
2. Baxevanis, A. D. (2010). Bioinformatics. A Practical Guide To The. Analysis Of Genes andProteins. Second Edition
3. Lal, S. S. (2016). Textbook of Practical Zoology,
4. Poddar T., Mukhopadhya S., Das S.K (2015) an advanced laboratory Manual of Zoology.
5. Amsath (2010). Practical Manual in Zoology

SEMESTER-II
Paper/Subject Name: Animal Behaviour **Subject Code:** ZOO144D202 **L-T-P-C**: 2-1-0-3 **Credit Units:**3 **Scheme of Evaluation:** Theory

Course Objectives:

To provide the basic foundations of the field of Behavioural biology as well as current theories and evidence pertaining broad range of behavioural topics.

Course Outcomes:

BT1: Define various fundamental processes that regulate behaviour.

BT2: Explain different theories and underlying principles of animal behaviour.

BT3: Apply knowledge to interpret the different behavioural mechanisms displayed by organisms.

BT4: Classify various behaviours performed by animals in their natural habitats.

BT5: Evaluate the underlying mechanisms of various kinds of behaviour such as aggression, territoriality, parental care, migration etc.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Introduction:** 1. Introduction of animal behaviour 2. Branches of Ethology 3. Significance of study of animal behavior	12
II	**Mechanism of Behaviour**: 1. Fixed Action Pattern, Action specific energy, action specific potential. 2. Instinct and learned behavior. 3. Proximate mechanism and ultimate mechanism.	12
III	**Types of Behaviour:** 1. Aggressive and territorial behaviour 2. Reproductive behaviour 3. Parental behaviour 4. Learning.	12
IV	**Chronobiology**: 1. Biological clocks,	12

	2. Pheromones and Hormones 3. Orientation 4. Bird Migration and Navigation, Fish Migration, 5. Communication, Feeding strategies.	
	TOTAL	48

Textbooks:

1. Dustin R. Rubenstein & John Alcock (2004). Animal Behaviour: An Evolutionary Approach. 11th Edition, Sinauer Associates.
2. Krebs J. R&Davies N. B (1997). Behavioural Ecology: An Evolutionary Approach, 4th Edition, Wiley-Blackwell.

References:

3. Aubrey Manning, Marian Stamp Dawkins (2012). An Introduction to Animal Behaviour, 6th Edition, Cambridge University Press.
4. Chris Barnard (2004). Animal Behaviour: Mechanism, Development, Function and Evolution, Pearson Education.
5. Graham Scott (2005). Essential AnimalBehaviour, Blackwell Publishing company.

SEMESTER-III
Paper/Subject Name: Molecular Biology **Subject Code:** ZOO144C301 **L-T-P-C**: 3-1-0-4 **Credit Units:**4 **Scheme of Evaluation:** Theory

Course Objectives:

To make students understand about nucleic acids, structures of DNA and RNA, mechanism of transcription, organization of chromosomes and introduce the students to the central dogma of the cell which includes replication, mRNA synthesis and the protein synthesis machinery of the cell.

Course Outcomes:

BT1: Recall the structure of nucleic acids and the structure of DNA double helix and the experiments leading to the discovery of various properties and functions of DNA.

BT2: Summarize the various cellular and molecular processes leading to various important phenomena of the cell which includes replication, transcription and translation.

BT3: Point out the structure and functions of various enzymes involved in replication, transcription and translation along with the regulation of those processes.

BT4: Differentiate between the processes of replication, transcription and translation between eukaryotes and prokaryotes.

BT5: To revise the various concepts of gene regulation such as gene silencing, splicing etc.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	1. Key experiments establishing DNA as genetic material, Watson and Crick model, Salient features of double helix, Types of DNA: A, B and Z DNA. 2. Denaturation and renaturation kinetics of DNA, cot curves. 3. DNA topology - linking number, topoisomerases, DNA supercoiling.	16

	4. Organization of genetic material in Prokaryotes, Viruses and Eukaryotes. Structure of RNA, Organelle DNA - mitochondrial and chloroplast DNA.	
II	1. Chemistry of DNA synthesis, general principles - bidirectional replication, Semi - rolling circle, D-loop (mitochondrial), Θ (theta) model of replication, linear DNA replication. 2. Enzyme involved in DNA replication – DNA polymerases, DNA ligase, helicase, Primase, Telomerase and other accessory proteins and reverse transcriptase. 3. Ribozyme- Structure and function	16
III	1. RNA polymerase, transcription unit, Transcription in Prokaryotes, Transcription in Eukaryotes, accessory proteins involved in transcription. 2. Split genes, concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, alternative splicing, exon shuffling, RNA editing, and mRNA transport. 3. Principles of transcriptional regulation in prokaryotes with examples from *lac* and *trp* operons. Conserved mechanism of regulation in eukaryotes, Eukaryotic activators, Signal integration, combinatorial control, transcriptional repressors, signal transduction and control of transcriptional regulator, Gene Silencing. 4. Riboswitches, RNA interference, mi RNA, si RNA, Regulatory RNA and X-inactivation.	16
IV	1. Genetic code and its properties, Wobble hypothesis, translational frameshifting. 2. Assembly line of polypeptide synthesis - ribosome structure and assembly, various steps in protein synthesis. Charging of tRNA, aminoacyl t RNA synthetases. 3. Proteins involved in initiation, elongation and termination of polypeptides. Fidelity of translation. Inhibitors of protein synthesis. 4. Regulation of translation - Translation-dependent regulation of mRNA and Protein Stability.	16
	TOTAL	64

Textbooks:

1. Lodish H, Berk A, Kaiser C.A, Krieger M, Bretscher A, Ploegh H, Amon A, Martin K.C (2016). Molecular Cell Biology, 8th Ed, W. H. Freeman.
2. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P (2018). Molecular biology of the cell. 6th Ed, Garland Science.

References:

3. Hardin J & Bertoni G (2018). Becker's World of the Cell. 9th Ed, Pearson Education.
4. Stephen R. Bolsover S.R, Jeremy S. Hyams J.S, Elizabeth A. Shephard E.A & Hugh A. White H.A (2011). CELL BIOLOGY: A Short Course. 3rd Ed, John Wiley & Sons.
5. Cooper G.M (2019). The Cell: A Molecular Approach. 8th Ed, Sinauer Associates.
6. Iwasa J & Marshall W (2016). Karp's Cell and Molecular Biology: Concepts and Experiments. 8th Ed, John Wiley & Sons.

SEMESTER-III
Paper/Subject Name: Basics of Biotechnology **Subject Code:** ZOO144C302 **L-T-P-C**: 3-1-0-4 **Credit Units:**4 **Scheme of Evaluation:** Theory

Course Objectives:

To gain a comprehensive understanding of the principles underlying the various techniques used in genetic engineering, molecular cloning ,cloning vectors, DNA amplification and analysis, various techniques used in bioprocess engineering and technology and bioinformatics.

Course Outcomes:

BT1: Recall the basic concepts of biotechnological tools used in molecular genetics such as restriction enzymes and their types, cloning vectors, fermentation, proteomics etc.

BT2: Discuss the mode of action of various restriction enzymes, nature and properties of various kinds of cloning vector and principles of operation of various techniques.

BT3: Apply the knowledge of biotechnology in understanding the processes of gene transfer, transformation genetics, microarray technology and bioprocess engineering.

BT4: Categorize the various types upstream and downstream processes in industrial biotechnology.

BT5: Formulate various techniques that may be used in industrial biotechnology in-order to facilitate the up streaming, mid stream and downstream of various products.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Introduction to Genetic engineering and Biotechnology:** 1. Definition, history and scope. 2. Molecular Genetic Tools: Restriction enzymes and their types (I, II, III), mode of action, cohesive and blunt end restriction, isoschizomers. Ligases, T4 kinase, Dnase-I, RNase H, Transformation in bacteria, animal and plant cells. 3. Gene cloning vestors: Plasmid vectors- nature and properties, pUC18, pBR322, M13 and high capacity vectors (BAC, YAC), marker genes. Gene transfer techniques.	16
II	**Molecular techniques:** 1. Southern, Northern, Western blotting and hybridization, Gel Retardation Assay (GRA); DNA finger printing techniques: RFLP, RAPD, AFLP, SNP etc. 2. Primer design; DNA polymerases; Types of PCR: multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR.	16
III	**Industrial Biotechnology:** 1. Basic principle of Bioprocess engineering, Up-stream, Mid-stream and Downstream processing. Basic design of fermenter/bioreactor, tower and photo bioreactor. Microbial growth curve and its significance. 2. Application of microbes in food process operations and production: Beer, wine, curd and cheese production. 3. Applications of enzymes in food processing: enzymatic bioconversions *e.g.*, starch and sugar conversion processes, High-Fructose Corn Syrup, and their downstream processing.	16

IV	**Proteomics and its techniques:** 1. Introduction to proteins to proteomes; Basics of proteomics and its applications; Types of proteomics; Approaches and techniques for proteomics study: Chromatography, 1-D & 2-D gel electrophoresis, in gel digestion, Protein sequencing, Mass spectrometry and analysis (ESI, MALDI), Functional proteomics: Yeast Two-Hybrid (YTH), Immunoprecipitation, Microarray technology.	16
	TOTAL	64

Textbooks:

1. Thieman W and Palladino M (2018). Introduction to Biotechnology. 4th Ed, Pearson Education.
2. Glick B.R, Pasternak J.J and Patten C.L (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Ed, ASM Press,Washington, DC.

References:

3. Brown T.A (2016). Gene Cloning and DNAAnalysis: An Introduction. 7th Ed, Wiley-Blackwell.
4. Primrose S.Band Twyman R (2006). Principles of Gene Manipulation and Genomics.7th Ed, Blackwell Publishing.
5. Brown T.A (2018). Genomes 4. Garland Science.

SEMESTER-III
Paper/Subject Name: Molecular Biology and Biotechnology (Practical) **Subject Code:** ZOO144C313 **L-T-P-C**: 0-0-8-4 **Credit Units:**8 **Scheme of Evaluation:** Practical

Course Objectives:

To understand the various processes relating to molecular biology and biotechnology.

Course Outcomes:

BT1: Recall the basic concepts and principles of microscopy, DNA and RNA structure and function**.**

BT2: Describe the principles of processes like PCR, gel electrophoresis, bacterial culture.

BT3: Apply the concepts and principles of DNA and its structure to isolate DNA from plant and animal sample.

BT4: Analyze the results of the experiments performed using statistical and graphical techniques.

BT5: Summarize the various techniques of PCR and bacterial culture.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	1. Histological analysis of liver tissue- identification of necrotic tissue. 2. Study of semi-conservative replication of DNA through micrographs/ photographs. 3. Cytochemical staining of DNA by Feulgen method. 4. Estimation of SOD, GSH, CAT, LPO in different organs of fish/Mice	16
II	1. Isolation of DNA and RNA from blood cells. 2. Isolation and separation of DNA fragments from the supplied sample using Agarose Gel Electrophoresis. 3. Protein expression study from the supplied tissue sample using SDS / Native PAGE.	16
III	1. Preparation of culture medium for *e.coli* (both solid and liquid) and raise culture of *e coli*. 2. Paper chromatographic separation of amino acids. 3. Polymerase Chain Reaction of isolated DNA.	16
IV	1. Demonstration of northern and southern blotting. 2. Preparation of wine from fruit juice. 3. Study of sequence similarity between two related and two non related species using bioinformatics tools.	16
	TOTAL	64

Textbooks:

1. Chaitanya, K. V. (2013). Cell and Molecular Biology: A Lab Manual Paperback. PHI Learning
2. Dash, S., Das, S. K. and Thatoi, H. N. (2017). Practical Biotechnology: Principles and Protocols. I K International Publishing House

SEMESTER-III

Paper/Subject Name: Pest Management.

Subject Code: ZOO144S321

L-T-P-C: 2-0-0-2

Credit Units:2

Scheme of Evaluation: Theory

Course Objectives:

To make the students aware of the basic pest species and to impart knowledge on biological control of pest.

Course Outcomes:

BT1: Identify and define basics concepts of pest management.

BT2: Distinguish and recognize various pest species affecting man and livestock.

BT3: Interpret the methods and demonstrate collection of pest

BT4: Examine the Integrated Pest Management technique and compare it with existing chemical management techniques.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	Introduction to pest, definition, causes of outbreak, Integrated Pest management.	8
II	Public Health pests, agricultural pests, stored grain pests.	8
III	Pest control: Significance, Bio-pesticides, Ill impacts of chemical pesticides.	8
IV	Methods of collection and culture of stored grain.	8
	TOTAL	32

Textbooks:

1. Singh R, Jindal V and Dhaliwal G.S (2013). A Textbook of Integrated Pest Management Paperback. Kalyani Publishers.
2. David B.V & Ramamurthy V.V (2016). Elements of Economic Entomology. 8th Ed, Brillion Publishing.

References:

1. Bhargava M.C& Kumawat K.C (2010). Pests of Stored Grains and Their Management. New India Publishing Agency.

SEMESTER-III
Paper/Subject Name: Fish Biology- I **Subject Code:** ZOO144D301 **L-T-P-C**: 2-1-0-3 **Credit Units:** 3 **Scheme of Evaluation:** Theory

Course Objectives: To give a general idea of fish and its various group and to know about different parameters thateffect the growth of fish.

Course Outcomes:

BT1 : Recall the basic idea about classification of Class Pisces.

BT2 : Review the different parameters that effect the growth of fish.

BT3 : Interpret the various concepts of fish physiology.

Detailed syllabus:

Module	Topics/Course content	Periods
I	**Introduction to fish**: General characters and classification of fish. Characteristics of Chondrioichthyes and Oesteoicthyes	12
II	**Evolution and Phylogeny**: Agnatha, Gnathostomata, Evolution of the cartilaginous fishes and bony fishes. Evolution trends within the teleosts	12
III	**Limnology**: Introduction to limnology, primary productivity in freshwater ecosystem. Introduction to freshwater zooplankton	12
IV	**Factors in limnology**: Physical factors –depth, temperature, light, turbidity, shore condition, pressure and movement of water	12

	Chemical factors- DO, CO_2, Total hardness of water, Dissolved solids.	

Textbooks:

1. Handbook of Fish Biology and Fishery, Paul J.B. Hart John D. Reynolds, 2002 Blackwell

2. A Textbook of Fish Biology and Fisheries, H. R. Singh and S. S. Khanna

SEMESTER-III
Paper/Subject Name: Ecology and Wildlife Biology- I **Subject Code:** ZOO144D302 **L-T-P-C**: 2-1-0-3 **Credit Units:**3 **Scheme of Evaluation:** Theory

Course Objectives:

To equip student with the basics of ecology, principles of community and population, various aspects of socio-biology and environment degradation and its impacts on the biodiversity.

Course Outcomes:

BT1: Recall the various scopes and aspects of Population and Community Ecology.

BT2: Review the various concepts of behavioural ecology.

BT3: Interpret the effects of various environmental contaminants on the ecosystem.

BT4: Analyze the various interspecific and intraspecific interactions existing in an ecosystem.

BT5: Develop a plan to summarise the roles of various bioindicators and biomarkers responsible for determining environmental health.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Concept of Ecology:** Introduction to ecology, Scope of ecology, Origins of Life, Adaptation to the physical environment, Ecotype and Ecads, Metabolic rate and size of individuals, Shelford's law of tolerance, Ecological amplitude.	12
II	**Population Ecology and Community Ecology:** Characteristics of population, population size and exponential	12

	growth, limits of population growth, population dynamics; Competition and coexistence, intraspecific and inter-specific interactions, Prey-predator interactions.	
III	**Behavioural Ecology:** Sociobiology- Animal Societies, Establishment of Hierarchies, Animal Communications, Territoriality, Co-existence. Feeding ecology; review of optimal foraging theory, concept of herbivore, frugivory, and predation. Food selection and pattern of habitat utilization.	12
IV	**Ecological Degradation:** Contaminants in the environment, Bioremediation: Applications and principles. Impact of chemicals on biodiversity of microbes, animals and plants. Bioindicator and biomarkers of environmental health. Biodegradation and bioremediation of chemicals.	12
	TOTAL	48

Textbooks:

1. Wilkinson D.M (2007). Fundamental Processes in Ecology: An Earth system Approach. Oxford University Press.
2. Barrick, Barrett and Odum (2005). Fundamentals of Ecology. 5th Ed, Cengage Publication.

References:

3. Sharma P. D (2017). Ecology and Environment. Rastogi Publication.
4. Kormondy E.J& Edward J (2017). Concepts of Ecology. 4th Ed, Pearson Education.
5. Chapman & Reiss (1992). Ecology: Principles and applications. Cambridge Univ. Press.

SEMESTER-III
Paper/Subject Name: Cell Biology and Genetics- I **Subject Code:** ZOO144D303 **L-T-P-C**: 2-1-0-3 **Credit Units:** 3 **Scheme of Evaluation:** Theory

Course Objectives:

To help the students to learn and develop an understanding of the cell as a basic unit of life, the functions of cellular organelles and regulation of its functions, chromosomal abnormalities and their pattern of inheritance of a particular character in lineages.

Course Outcomes:

BT1: Recall the structural and functional organization of cell membrane, cell organelles and microbial genes.

BT2: Describe the cellular and molecular processes involved in transport across plasma membrane, oxidative phosphorylation, cell cycle and gene mutation.

BT3: Illustrate the process of molecular regulation of cell cycle and apply the knowledge in understanding cancer and its progression.

BT4: Identify the various genes and proteins responsible for regulation of plasma membrane transport, apoptosis and cancer.

BT5: Reorganise the concepts of cell cycle regulation helping to identify various important biomarkers involved in cancer and its progression.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Cell architecture and cell membrane:** Cell theory. Structural organization of prokaryotic and eukaryotic cells. Plasma membrane- structure, composition and function of plasma membrane; lipid bilayer; fluid mosaic model; Transport across cell membrane- diffusion, osmosis, active and passive transport- channels, carriers and membrane pumps, symport and antiport; Exocytosis and endocytosis. **Mitochondria:** Mitochondria- Structure and function, electron transport chain and oxidative pathways.	12
II	**Cell organelles:** Structure and function of Golgi body, Endoplasmic reticulum, Ribosome, and Lysosome. **Nucleus and cell division:** DNA and other components of chromatin, nucleolus, nuclear envelope. Mitosis and meiosis; Overview of cell cycle, cyclins and cyclin dependent kinases; maturation promoting factors; Regulation of cell cycle; Checkpoints in cell cycle regulation; Apoptosis; Molecular basis of cancer and tumor suppressor genes.	12
III	**Mendelian principles:** Dominance, segregation, independent assortment, pleiotropy, genomic imprinting, phenocopy, linkage	12

	and crossing over, sex linkage **Concept of gene:** Allele, multiple alleles, pseudoallele, complementation tests, Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. **Extra chromosomal inheritance:** Mitochondrial and chloroplast genes. Chromosomes deletion, duplication, inversion, translocation, ploidy. **Gene mutation:** Mutation types, causes and detection, mutant types, lethal, conditional, biochemical, loss and gain of function, germinal verses somatic mutants, insertional mutagenesis.	
IV	**Microbial genetics:** Bacterial chromosomes and plasmids, conjugation, transduction and transformation in bacteria. Bacteriophages and their genetic systems. Lytic and lysogenic phases of λ phage. Genetic recombination and its molecular mechanism.	12
	TOTAL	48

Textbooks:

1. Lodish H, Berk A, Kaiser C.A, Krieger M, Bretscher A, Ploegh H, Amon A, Martin K.C (2016). Molecular Cell Biology, 8th Ed, W. H. Freeman.
2. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P (2018). Molecular biology of the cell. 6th Ed, Garland Science.

References:

3. Hardin J & Bertoni G (2018). Becker's World of the Cell. 9th Ed, Pearson Education.
4. Stephen R. Bolsover S.R, Jeremy S. Hyams J.S, Elizabeth A. Shephard E.A & Hugh A. White H.A (2011). CELL BIOLOGY: A Short Course. 3rd Ed, John Wiley & Sons.
5. Cooper G.M (2019). The Cell: A Molecular Approach. 8th Ed, Sinauer Associates.
6. Iwasa J & Marshall W (2016). Karp's Cell and Molecular Biology: Concepts and Experiments. 8th Ed, John Wiley & Sons.
7. Willey J.M, Sherwood L, Woolverton C.J (2008). Prescott, Harley, and Klein's Microbiology. 7th Ed, McGraw-Hill Higher Education.

SEMESTER-III
Paper/Subject Name: Environmental Toxicology I **Subject Code:** ZOO144D304 **L-T-P-C**: 2-1-0-3 **Credit Units:** 3 **Scheme of Evaluation:** Theory

Course Objectives:

To provide toxicological information at an introductory level while combining enough comprehensive information to meet the needs of more advanced applied knowledge as well as extend the expertise in the field of Environmental toxicology.

Course Outcomes:

CO1: Recall various fundamental principles of 'toxicology' as a scientific discipline.

CO2: Acquaint students with types of toxicants and factors affecting toxicity.

CO3: Cover mechanistic aspects of absorption & distribution of toxicity.

CO4: To enable students to develop critical thinking with regard to impact of various environmental contaminants on biosphere.

Detailed Syllabus:

MODULE	COURSE CONTENT	PERIODS
I	**INTRODUCTION TO ENVIRONMENTAL TOXICOLOGY:** 1. Definition, history, scope & sub-divisions of toxicology. 2. Ecological Concepts: Relevance of Environmental toxicology to Human. 3. Toxicity: Toxicokinetics and Toxicodynamics.	12
II	**TOXICOLOGICAL CONCEPTS:** 1. Toxic agents: Natural toxins, Animal toxins, Plant toxins, Food additive toxicity, Chemical warfare agents, Biomarkers 2. Genetic Toxicity: DNA interaction, DNA adducts & Mutations, DNA repair. 3. Determination of Toxicity: Determining the Doses to Test (LC_{50} and	12

	LD_{50}); Factors Affecting Toxicity.	
III	**DOSE-RESPONSE RELATIONSHIPS:** 1. Causal and associative relationship; epidemiology in establishing associative relationships. 2. Relationship between dose and response; frequency and cumulative dose-response curves; Sub-threshold, threshold, and ceiling effect doses. 3. Effective, toxic, and lethal doses; Potency, efficacy, mixed or reversed toxicity.	12
IV	**ABSORPTION, DISTRIBUTION AND STORAGE OF TOXICANTS:** 1. Interaction of Toxicants with Cells; Processes of Cellular Absorption; Cellular Uptake of Toxicants; Routes of Absorption. 2. Distribution of Toxicants; Factors Affecting Distribution of Toxicants to Tissues. 3. Transfer of Toxicants through food chains & their subsequent bioaccumulation in the ecosystem. 4. Storage of Toxicants	12
TOTAL		**48**

Textbooks:

1. William HW. (1996). Essentials of Environmental Toxicology: The effects of environmentally hazardous substances on human health. Taylor & Francis.
2. Williams PL, James RC and Roberts SM. (2000). The Principles of Toxicology: Environmental and Industrial Applications. 2nd Ed, Wiley-Interscience.
3. Shaw I and Chadwick J. (1998). Principles of Environmental Toxicology. Taylor & Francis Ltd**.**
4. Hodgson E. (2004). A Textbook of Modern Toxicology. 3rd Ed, John Wiley & Sons.
5. Duffus JH and Worth HGJ. (2006). Fundamental toxicology. Royal Society of Chemistry.
6. Kumar A. (2023). Environmental Toxicology and Ecosystem. 1st Ed, CRC Press.

References:

1. Walker CH, Hopkin SP, Sibly RN and Peakall DB. (2012). Principles of Ecotoxicology. 4th Ed, Taylor & Francis Group.
2. Landis WG, Sofield RM and Yu MH. (2011). Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes. 4th Ed, Taylor & Francis Group.
3. Agarwal A and Gopal K. (2010). Principles of toxicology. Ibdc Publishers, India.
4. Matham VK. (2011). Essentials of Toxicology. New India Publishing Agency, New Delhi, India.

5. Timbrell JA. (2009). Principles of Biochemical Toxicology. 4th Ed, Taylor and Francis Ltd, London.
6. Cockerham LG and Shane BS. (1994). Basic Environmental Toxicology. CRC Press, London.

SEMESTER-IV
Paper/Subject Name: Biochemistry of Metabolic processes **Subject Code:** ZOO144C401 **L-T-P-C**: 3-1-0-4 **Credit Units:** 4 **Scheme of Evaluation:** Theory

Course Objectives:

To construct a concept map regarding the interaction, network and regulation of various important metabolic pathways and their role in health and diseases.

Course Outcomes:

1. Recall various fundamental metabolic processes and their regulation to maintain body homeostasis.
2. Explain different metabolic pathways and their underlying mode of action.
3. Apply knowledge to interpret the cross talk between various metabolic pathways.
4. Examine the role of different pathways and the network by which all of them are interconnected
5. Deduct the key pathways as well as key players that may lead to various diseased conditions.

Course Outline:

MODULE	COURSE CONTENT	PERIODS
I	**Introduction:** Fundamentals of Biochemistry: Structures and functions; Carbohydrates, Lipids and Protein. Catalysis and its Regulation: Nature of enzymes – kinetics, reaction mechanism of chymotrypsin and lysozyme, Inhibition of Enzyme activity, regulation of enzyme activity.	16
II	**Energetics and Design of Living Systems:** The living state, metabolism as the defining characteristic of living organisms,	16

	molecular approach to understanding life forms and living processes, Energetics (second law of thermodynamics, Free Energy and standard free energy change). Reducing power and Redox potential, Nernst equation, synthesis of ATP, structure and function of electron transport chain and synthesis of ATP through Fo-F1 ATP synthase.	
III	**Metabolic Pathways and its Network:** A broad outline of metabolic pathways and their linkage. Metabolism of primary metabolites: Monosaccharaides, lipids, essential amino acids and nucleotides.	16
IV	**Metabolic Homeostasis and Disease**: Regulation of appetite, energy expenditure and body weight. Role of insulin, glucagon, ghrelin and leptin in metabolic homeostasis. Inborn metabolic disease. Glycogen storage disease, phenylketonuria, alkaptonuria and gout. Lifestyle disease- Diabetes and obesity. Vitamin: Role of vitamin in metabolic process and various diseases resulting from the deficiency of vitamins.	16
	TOTAL	64

References:

1. Nelson D.L and Cox M.M (2008). Lehninger principles of biochemistry. 5th Ed, W.H. Freeman.
2. Voet D, Voet J.G andPratt C.W (2016). Fundamentals of biochemistry: Life at the molecular level. 5th Ed, Wiley.
3. Kennelly P.J, Botham K.M, McGuinness O, Rodwell V.W &Weil P.A (2022). Harper's Illustrated Biochemistry. 32nd Ed, McGraw Hill, New York, USA.
4. Berg J.M, Tymoczko J.L, Gatto G.J, Stryer L (2019). Biochemistry. 9th Ed, W.H.Freeman.
5. Garrett R.H and Grisham C.M (2010). Biochemistry. 4th Ed, Brooks/Cole, Cengage Learning.

SEMESTER-IV
Paper/Subject Name: Immunology

Subject Code: ZOO144C402

L-T-P-C: 4-0-0-4

Credit Units:4

Scheme of Evaluation: Theory

Course Objectives:

To help students develop skills necessary for critical analysis of essential elements of the immune system related to health and disease and molecular as well as cellular components and pathways that protect an organism from infectious agents or cancer, also emphasizes the research and development opportunities for therapeutic intervention arising from recent advances in immunology.

Course Outcomes:

BT1: Recall various concepts of immune system and related terminologies necessary to understand the course.

BT2: Explain the various mechanisms of immune cell responses and necessary activation of various arms of immune system.

BT3: Apply properly acquired knowledge to interpret the cross talk between various pathways of immune action.

BT4: Analyze the roles of cytokines and other chemical messengers in the proper regulation of immune action.

BT5: Explain the role of important therapeutic techniques and vaccines in the field immunobilogy.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Overview of the immune system:** 1. Components of the immune system, principles of innate and adaptive immunity, antigen and immunogenicity, haptens, clonal selection theory; Evolution of immune system. 2. Antigen recognition by immune cells: Innate Immunity-Pattern recognition in the innate immune system, TLRs and their role in innate immune response. 3. Adaptive immunity-Antibody structure, antigen-antibody interaction, monoclonal antibodies, hybridoma technology, antigen recognition by B lymphocytes; 4. Molecular mechanism behind BCR formation; B lymphocyte development and survival	16

II	**MHC and T cell Receptors:** 1. Structure and function of MHC complex: antigen processing cells, antigen processing and presentation to T lymphocytes, MHC restriction. 2. TCR structure and function: T-cell receptor gene rearrangement; T lymphocyte development and survival; Antigen recognition by T-cells, signaling through TCR and T-cell activation, co- receptors and their role in T –cell functioning; co-stimulation.	16
III	**Effector mechanisms and Regulation of immune responses**: 1. Induced innate response to infection, Innate memory, 2. Complement system, NK and NKT cell functions, 3. Humoral immune response, Production of effector T- cells, cytotoxic T- cell effector mechanisms. 4. Regulation of immune response: Leukocyte activation and migration, Cytokines, innate regulation of the immune response, T-cell mediated regulation of immune response, Immunological tolerance. Mucosal immunity.	16
IV	1. **Immunity in health and disease:**Allergy and hypersensitivity, Autoimmunity, Immunodeficiency diseases, Immunity and Infection, Tumour-immunology, Immunotherapy, Transplantation, Vaccines. 2. **Techniques Related to Immunology:**Radial Immunodiffusion, RIA, ELISA, Immunoelectrophoresis, Immunofluroscence, rocket immunoelectrophoresis.	16
	TOTAL	64

References:

1. Owen J.A, Punt J, Stranford S.A, Jones P.P. (2013). Kuby Immunology. 7th Ed, W.H.Freeman.
2. Delves P.J, Martin S.J, Burton D.R and Roitt I.M (2011). Roitt's Essential Immunology. 13th Ed, Wiley-Blackwell.
3. Coico R and Sunshine G (2015). Immunology: A Short Course. 7th Ed, Wiley-Blackwell.
4. Abbas A.K, Lichtman A.H and Pillai S (2018). Cellular and Molecular Immunology. 9th Ed, Elsevier.
5. Paul W.E (2013). Fundamentals of Immunology.7th Ed, Lippincott Williams & Wilkins Publishing.

6. Murphy K.P (2012). Janeway's immunobiology. 8th Ed, Garland Science.

SEMESTER-IV
Paper/Subject Name: Biochemistry and Immunology (Practical) **Subject Code:** ZOO144C413 **L-T-P-C**: 0-0-8-4 **Credit Units:**8 **Scheme of Evaluation:** Practical

Course Objectives:

To train students with various laboratories based skills like identification of biomolecules such as carbohydrates, proteins and amino acids along with several haematological parameters.

Course Outcomes:

BT1: Recall various handling techniques like microscope, preparation of reagents etc.

BT2: Explain various methods of separation of various biomolecules.

BT3: Apply knowledge to isolate biomolecules to carry out chromatography, gel electrophoresis etc.

BT4: Analyze different haematological parameters including, RBC and WBC count.

BT5: Summarize all the experimental records and evaluate the results.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	1. Qualitative tests of functional groups in carbohydrate, proteins and lipids. 2. Estimation of total protein in a given solution by Lowry's method. 3. Detection of SGOT and SGPT by Spectrophotometric analysis.	16
II	1. Preparation of Haemin crystal of human blood. 2. Estimation of Human blood group and Rh factor. 3. Demonstration of ELISA. 4. Study and counting of Splenocyte from spleen	16

	5. Histological identification of primary and secondary lymphoid organs	
.III	1. To measure the blood pressure of human. 2. To enumerate the total count of WBC. 3. To determine the bleeding time.	16
IV	1. Assessment of density, frequency and abundance of organism in a community using quadrate method. 2. Population estimation using Mark-recapture method- Using a suitable insect model, (e.g., rice weevil using - marker pen). 3. Culture and identification of paramecium from environmental sources 4. Identification of birds and butterflies in and around RGU campus.	16
	TOTAL	64

Textbooks:

1. Jayaraman J (2011). Laboratory Manual in Biochemistry. New Age International Publishers.
2. Sadasivam S and Manickam A (2009). Biochemical Methods. New age publishers.

References:

3. Varley H (2006). Practical Clinical Biochemistry. 6th Ed, CBS.
4. Sawhney S.K and Singh R (2005). Introductory Practical Biochemistry. 2nd Ed, Alpha Science International.

SEMESTER-IV
Paper/Subject Name: Fish Biology- II **Subject Code:** ZOO144D401 **L-T-P-C**: 2-1-0-3 **Credit Units:**3 **Scheme of Evaluation:** Theory

Course Objectives:

To understand the basic principles of genetics and breeding and their applicationto fisheries management and aquaculture.

Course Outcomes:

BT1: What are the underlying genetic principles that cause diversification of fishes?

BT2: Explain various genetic and molecular techniques that are employed to improve the quality of the cultured fishes.

BT3: Identify various factors that determine fish growth and the methods of assessment of the growth rate in fishes.

BT4: Examine the various biochemical and molecular techniques in fishery and their applications in cultured fisheries.

BT5: Evaluate different factors that can affect the fish growth and development during fish genetic engineering.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Cytogenetics of fishes:** Chromosomal mutations, polyploidy, mutation and fish evolution, sex chromosome and sex determination	12
II	**Selection:** Scope, application, role of genetics in fish selection and breeding, Stock improvement: sex-reversal, Hybridization, Gynogenesis, Androgenesis, hybridization	12
III	**Biochemical and molecular techniques in fishery and their application:**Cryopreservation of gametes, Gene transfer and production of transgenic fish, hormonal biotechnology in Aquaculture	12
IV	**Fish Growth:** Factors controlling fish growth, length weight relationship, condition factors, hepatosomatic index, Gonadosomatic index.	12
	TOTAL	48

References:

1. Naik J.K& k.g. ananda Rao K.G.A. Fish biotechnology. Pacific Books International, New Delhi.
2. Singh K.K (2011). Fish Genetics, Sonali Publications.

3. Van der Zijpp A.J et al., (2007). Fishponds in farming systems. Wageningen Academic Publishers, Netherlands.
4. Pillay T.V.R (2005). Aquaculture Principles and Practices. 2nd Ed, Blackwell Publishing Ltd.
5. Dunham R.A (2011). Aquaculture and Fisheries Biotechnology: Genetic Approaches. 2nd Ed, CABI Publishing, USA.

SEMESTER-IV
Paper/Subject Name: Ecology and Wildlife Biology- II **Subject Code:** ZOO144D402 **L-T-P-C**: 2-1-0-3 **Credit Units:**3 **Scheme of Evaluation:** Theory

Course Objectives:

To introduce the various important issues related to wildlife such as habitat destruction, endangered species,wildlife management practices, conservation and public awareness and positive ethics and support.

Course Outcomes:

BT1: Recall some of the burning issues related to ecology and wildlife management.

BT2: Explain scientific and biological principles as they pertain to wildlife.

BT3: Identify, formulate, and solve complex environmental issues.

BT4: Examine the in-depth knowledge of niche requirements, home range and habitat ecology and identify the governing principles influencing it.

BT5: Evaluate the reasons for current biodiversity loss and identify the conflicts between wildlife and humans.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Biogeography and Natural History:** 1. Biogeographical- an outline, realms; Global distribution of animals- factors affecting distribution. Island Biogeography- Types, Speciation 2. Ecological History of India & NE India; History of tea and forest fragmentation, Colonialism and its impact on natural	12

	resources of NE India	
II	**Habitat Ecology**: 1. Concept of Biome- Biome types of India –a general account; Forest Types of India; Ecological Succession & climax ecosystems; Concept of Home range; Territoriality and Habitat utilization in animals.	12
III	**Biodiversity Conservation:** 1. Conservation and management of natural resources, Biodiversity- need and benefits. Threats to biodiversity- logging, fragmentation, linear infrastructures, animal agriculture, rise of mono-plantations, human induced climate change and Local Extirpations. Understanding drivers of hunting and poaching in developing and underdeveloped countries.	12
IV	**Wildlife Management and Conflict:** 1. Wildlife Health: Zoonosis, Wildlife trade and diseases, Understanding wildlife corridors. 2. Forest (Conservation) Act, 1980, Conservation of Biological Diversity Act, 2002 & Rules; The Wildlife (Protection) Act, (WLPA), 1972; Human Wildlife Conflict (HWC)- causes, implications and mitigation measures,	12
	TOTAL	48

References:

1. Singh S. K (2015). Textbook of Wildlife Management. CBS Publishers & Distributors.
2. Mayr E (1991). Principles of Systematic Zoology. McGraw-Hill Inc.
3. Carson R (2000). Silent Spring, Penguin UK; New Ed.
4. Maclaurin J (2008). What is Biodiversity? University of Chicago Press.
5. Silvy N.J (2012). The Wildlife Techniques Manual. Johns Hopkins University Press.
6. Berwick S.H and Saharia V.B(1995). Wildlife Research and Management. OUP, New Delhi.

SEMESTER-IV
Paper/Subject Name: Cell Biology and Genetics- II

Subject Code: ZOO144D403

L-T-P-C: 2-1-0-3

Credit Units:3

Scheme of Evaluation: Theory

Course Objectives:

To provide knowledge about the complex organization of eukaryotic cell and the molecular mechanisms of the cellular processes that exist in all cell types.

Course Outcomes:

BT1: Recall various fundamental principles that regulate the functionality of a cell.

BT2: Classify various organizational attributes that helps a cell to grow, divide, survive and finally to die.

BT3: Identify various finely tuned processes such as Cell signalling, cell cycle regulation, apoptosis etc. and illustrate how they are pivotal cell growth and survival.

BT4:Analyze the molecular mechanism responsible for cell movement and how it is being accomplished.

BT5: Conclude how defects in functioning of cell organelles and regulation of cellular processes can develop into diseases.

Course Outline:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Chromatin Structure and organization:** Chromatin structure- Euchromatin and Heterochromatin- Constitutive and Facultative heterochromatin. Regulation of Chromatin Structure and Nucleosome Assembly, Organization of Chromosomes. **Organization of genes and chromosomes:** Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons.	12
II	**Cytoskeleton:** Structure and function of microtubule, microfilament and intermediate filament. Role of cytoskeleton in motility in eukaryotes and prokaryotes- cilia and flagella. **Cell signaling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two- component systems, light signaling in plants,	12

	bacterial chemotaxis and quorum sensing.	
III	**Human genetics:** The human chromosome, chromosome abnormalities, Mendelian pedigree pattern, Hardy-Weinberg equilibrium, genotype and allelic frequencies; Inborn-errors of metabolism, polygenic and multifactorial inheritance; Sex-determination, role of Y chromosome, sex chromosome anomalies; Instability of the genome: Mutation-types, chromosomal aberrations, gene mutation, molecular basis of mutation.	12
IV	**Cancer Biology:** Cell Cycle and its regulation. Virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. DNA and RNA Tumor viruses.Oncogenes, mechanism of activation of proto-oncogenes. Tumor suppressor genes and immortalisation.	12
	TOTAL	48

References:

1. Lodish H, Berk A, Kaiser C.A, Krieger M, Bretscher A, Ploegh H, Amon A, Martin K.C (2016). Molecular Cell Biology, 8th Ed, W. H. Freeman.
2. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P (2018). Molecular biology of the cell. 6th Ed, Garland Science.
3. Hardin J & Bertoni G (2018). Becker's World of the Cell. 9th Ed, Pearson Education.
4. Stephen R. Bolsover S.R, Jeremy S. Hyams J.S, Elizabeth A. Shephard E.A & Hugh A. White H.A (2011). CELL BIOLOGY: A Short Course. 3rd Ed, John Wiley & Sons.
5. Cooper G.M (2019). The Cell: A Molecular Approach. 8th Ed, Sinauer Associates.
6. Iwasa J & Marshall W (2016). Karp's Cell and Molecular Biology: Concepts and Experiments. 8th Ed, John Wiley & Sons.
7. De Robertis E.D.P. and De Robertis E.M.F. Cell and Molecular Biology. 9th Ed, Lippincott Williams and Wilkins, Philadelphia.

SEMESTER-IV
Paper/Subject Name: Environmental Toxicology II **Subject Code**: ZOO144D404

L-T-P-C: 2-1-0-3
Credit Units: 3
Scheme of Evaluation: Theory

Course Objectives:

To provide toxicological information at an introductory level while combining enough comprehensive information to meet the needs of more advanced applied knowledge as well as extend the expertise in the field of Environmental toxicology.

Course Outcomes:

CO1: Recall previous knowledge towards more advanced avenues of the subject.

CO2: Acquaint students with various processes of biotransformation and elimination of the toxicants.

CO3: Mechanistic aspects of organ target toxicity and diseases.

CO4: To enable students to develop critical thinking about the interconnected web of interactions of contaminants with the environment.

Detailed Syllabus:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**BIOTRANSFORMATION AND ELIMINATION OF TOXICANTS:** 1. Biotransformation Reactions; Factors Affecting Biotransformation; Phase I and Phase II Reactions. 2. Lipid peroxidation: ROS and RNS, Superoxide, Hydrogen Peroxide and Hydroxyl radicals in toxicity of Xenobiotics. 3. Xenobiotic induced alterations in intracellular calcium distribution, disruption of cellular energy production. 4. Elimination of Toxicants; Additional Routes of Elimination.	12
II	**TARGET ORGAN TOXICITY AND DISEASES:** 1. Introduction to Target Organ Toxicity. 2. Hematotoxicity, Hepatotoxicity, Nephrotoxicity, Neurotoxicity, Dermatotoxicity, Pulmonotoxicity etc. 4. Teratogenesis and Carcinogenesis.	12
III	**ENVIRONMENTAL TOXICANTS:** 1. Introduction to Environmental Toxicants. 2. Pesticides, Plastics, Heavy metals (Hg, Pb, Cd, As etc). 3. Fate of pesticides residue & their evaluation.	12
IV	**RISK ASSESSMENT:**	12

	1. Introduction to Risk: Risk Assessment & Management. 2. Toxicology and exposure guidelines. 3. Occupational hazard, safety & health.	
TOTAL		**48**

Textbooks:

1. William HW. (1996). Essentials of Environmental Toxicology: The effects of environmentally hazardous substances on human health. Taylor & Francis.
2. Williams PL, James RC and Roberts SM. (2000). The Principles of Toxicology: Environmental and Industrial Applications. 2nd Ed, Wiley-Interscience.
3. Shaw I and Chadwick J. (1998). Principles of Environmental Toxicology. Taylor & Francis Ltd**.**
4. Hodgson E. (2004). A Textbook of Modern Toxicology. 3rd Ed, John Wiley & Sons.
5. Duffus JH and Worth HGJ. (2006). Fundamental toxicology. Royal Society of Chemistry.
6. Kumar A. (2023). Environmental Toxicology and Ecosystem. 1st Ed, CRC Press.

References:

1. Walker CH, Hopkin SP, Sibly RN and Peakall DB. (2012). Principles of Ecotoxicology. 4th Ed, Taylor & Francis Group.
2. Landis WG, Sofield RM and Yu MH. (2011). Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes. 4th Ed, Taylor & Francis Group.
3. Agarwal A and Gopal K. (2010). Principles of toxicology. Ibdc Publishers, India.
4. Matham VK. (2011). Essentials of Toxicology. New India Publishing Agency, New Delhi, India.
5. Timbrell JA. (2009). Principles of Biochemical Toxicology. 4th Ed, Taylor and Francis Ltd, London.
6. Cockerham LG and Shane BS. (1994). Basic Environmental Toxicology. CRC Press, London.