

Chaudhary Charan Singh University, Meerut

## Course Structure and Syllabus

### B.Sc. Zoology Hons. (4 Years)

Academic Session 2024-25 onwards

(Updated syllabus in accordance with NEP 2020)



## DEPARTMENT OF ZOOLOGY

CHAUDHARY CHARAN SINGH UNIVERSITY, MEERUT

**B.Sc. Honors/Honors with Research (Zoology)**  
**A Four Year Program with Multiple Exits and Entries**  
**Semester-wise course structure and credits**

Year	Semester	Course code	MJDSCC/ MNGEC/AEC/ SEC/VAC	Paper Title	Credits L-T-P	Total Credits	
I	I	B050151T	MJDSCC I	Animal Diversity: Invertebrates	2L-1T-0P	3	
		B050152T	MJDSCC II	Fundamentals of Ecology	3L-0T-0P	3	
		B050153T	MJDSCC III	Biochemistry	3L-0T-0P	3	
		B050154P		Practical Based on Animal Diversity: Invertebrates, Fundamentals of Ecology and Biochemistry	0L-0T-3P	3	
		Q11018	MNGEC I (for students of other disciplines)	Basic Clinical Techniques	2L-1T-1P	4	
			AEC I*		3L-0T-0P	2	
		V1001016	SEC I	Vermiculture and Vermicomposting	1L-0T-1P	2	
		P0001021	VAC I	Environmental Policies and Laws	1L-1T-0P	2	
	II	II	B050251T	MJDSCC IV	Animal Diversity: Vertebrates	2L-1T-0P	3
			B050252T	MJDSCC V	Cell and Molecular Biology	3L-0T-0P	3
			B050253T	MJDSCC VI	Vertebrates Comparative Anatomy	3L-0T-0P	3
			B050254P		Practical's. Based on Animal Diversity: Vertebrates, Cell and Molecular Biology and Vertebrates Comparative Anatomy	0L-0T-3P	3
			Q21018	MNGEC II (for students of other disciplines)	Parasitic Diseases and Health	3L-1T-0P	4
			AEC II*			2	
V2001014			SECII	Aquarium Maintenance	1L-0T-1P	2	
			VAC II	From Swayam		2	

\*Any course from the pool for Personality Development with special emphasis on Language and

Communication Skills.

Year	Semester	Course code	MJDSCC/ MNGEC/ AEC/ SEC/ VAC	Paper Title	Credits L-T-P	Total Credits	
II	III		MJDSCC VII	Genetics	2L-1T-0P	3	
			MJDSCC VIII	Methods in Biostatistics	3L-0T-0P	3	
			MJDSCC IX	Animal Biotechnology	3L-0T-0P	3	
				Practical Based on Genetics, Methods in Biostatistics and Animal Biotechnology	0L-0T-3P	3	
			MNGEC III (for students of other disciplines)	Conservation and Management of Wildlife	2L-1T-1P	4	
			AEC III*		3L-0T-0P	2	
			SEC III	First Aid and Health	1L-0T-1P	2	
	IV						
			MJDSCC X	Developmental Biology	2L-1T-0P	3	
			MJDSCC XI	Neuroscience Biology	3L-0T-0P	3	
			MJDSCC XII	Animal Behavior	3L-0T-0P	3	
				Practical Based on Developmental Biology, Neuroscience Biology and Animal Behavior	0L-0T-3P	3	
			MNGEC IV (for students of other disciplines)	Aquatic Biology	3L-1T-0P	4	
			AEC IV*			2	
	SEC IV	Medical Diagnostic Techniques	1L-0T-1P	2			
	VAC III	From Swayam	1L-1T-0P	2			

**I. Program Outcomes:**

1. Students enrolled in B.Sc. (Hons.) degree program in Zoology will study and acquire complete knowledge of disciplinary as well as allied biological sciences.
2. At the end of graduation, they should possess expertise which will provide them competitive advantage in pursuing higher studies from India or abroad; and seek jobs in academia, research or industries.

3. They will also be able to describe economic, ecological and medical significance of various animals in human life.
4. The procedural knowledge about identifying and classifying animals will provide students professional advantages in teaching, research and taxonomist jobs in various government organizations; including Zoological Survey of India and National Parks/Sanctuaries.
5. Our students will be acquiring basic experimental skills in various techniques in the fields of genetics; molecular biology; biotechnology; qualitative and quantitative microscopy; enzymology and analytical biochemistry.
6. Students undertaking skill enhancement courses like aquaculture, sericulture and apiculture will inculcate skills involved in rearing fish, bees and silk moth which would help them in starting their own ventures and generating self-employment making them successful entrepreneurs.

## **II. Program Specific Outcomes**

1. Understand the nature and basic concepts of cell biology, genetics, taxonomy, physiology, ecology and applied Zoology
2. Analyse the relationships among animals with their ecosystems.
3. Perform procedures as per laboratory standards in the areas of Taxonomy, Physiology, Ecology, Cell biology, Genetics, Applied Zoology, Clinical science, tools and techniques of Zoology, Toxicology, Sericulture, Biochemistry, Fish biology, Animal biotechnology, Immunology and research methodology
4. Understand the applications of Zoology in Agriculture, Medicine and daily life.
5. Gains knowledge about research methodologies, effective communication and skills of problem-solving methods.
6. Contributes the knowledge for Nation building.

## **III. Course Outcomes**

1. The student will be able to understand, classify and identify the diversity of animals.
2. The student will understand the importance of classification of animals and classify them effectively using the six levels of classification.
3. The student knows his role in nature as a protector, preserver and promoter of life which he has achieved by learning, observing and understanding life.

This program helps to learn and understand the concepts regarding animal diversity to appreciate the variability in relation to their morphology, anatomy and behavior among different animals.

4. The Zoology degree program will also provide a platform to comprehend classical genetics in order to understand distribution of different traits among populations, their inheritance, ethnicity and correlate with contemporary and modern techniques like genomics, metagenomics, genome editing and molecular diagnostic tools.
5. Practical and theoretical skills gained in this course will be helpful in designing different public health strategies for social welfare.
6. The course has been designed to provide in-depth knowledge of applied subjects ensuring the inculcation of employment skills so that students can make a career and become an entrepreneur in diverse fields of aquatic biology, sericulture, apiculture etc. After completion of this course, students can contribute as policy makers in wild life conservation, animal preservation and environment protection.

Semester I	ZOOLOGY (HONS.)
Course	Animal Diversity: Invertebrates
Course Code: B050151T	
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12
Credits Allotted	4 Credits [60 hours]
Teaching Scheme	3 hours/week
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks
Course Objectives	<ol style="list-style-type: none"> <li>1. The course would provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life.</li> <li>2. It will help the student to understand the features of Kingdom Animalia and systematic organization of the animals based on their evolutionary relationships, structural and functional affinities.</li> <li>3. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.</li> </ol>
Course Outcomes	<p>Upon completion of the course, students should be able to:</p> <ol style="list-style-type: none"> <li>1. Learn about the importance of systematics, taxonomy and structural organization of animals.</li> <li>2. Appreciate the diversity of non-chordates living in varied habit and habitats.</li> <li>3. Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.</li> <li>4. Critically analyses the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.</li> <li>5. Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.</li> <li>6. Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.</li> </ol>

Course content	Lectures (60 Hours)
Unit I. Introduction to Non-Chordata: General characters; Outline	4 Hours

classification up to Classes	
<b>Unit II. Protozoa:</b> Salient features; Study of <i>Amoeba</i> , <i>Euglena</i> and <i>Paramecium</i> with reference to structure, locomotion, nutrition and reproduction (life history)	8 Hours
<b>Unit III.</b> Origin of Metazoa. <b>Porifera:</b> Salient features; Study of <i>Sycon</i> with reference to structure, reproduction (life history); Canal system in Syconoid sponge; Skeleton system	6 Hours
<b>Unit IV. Coelenterata:</b> Salient features; Study of <i>Aurelia</i> with reference to morphology and reproduction (life history); Alternation of generation in Coelenterates	6 Hours
<b>Unit V. Helminthes:</b> Salient features; Study of <i>Taenia</i> and <i>Ascaris</i> with reference to morphology, reproduction (life-cycle) and parasitic adaptations	6 Hours
<b>Unit VI. Annelida:</b> Salient features; Types and significance of coelom; Metamerism and its significance; Study of <i>Nereis</i> and <i>Hirudinaria</i> with reference to morphology and reproduction; Parasitic adaptations of <i>Hirudinaria</i> ; Trochophore larva and its significance	8 Hours
<b>Unit VII. Arthropoda:</b> Salient features; Study of <i>Palaemon</i> with reference to morphology, respiration, excretion and reproduction; Zoological importance of <i>Peripatus</i> and <i>Limulus</i> ; Economic importance of arthropods	8 Hours
<b>Unit VIII. Mollusca:</b> Salient features; Study of <i>Pila</i> and <i>Unio</i> with reference to morphology, respiration and reproduction (life-history)	8 Hours
<b>Unit IX. Echinodermata:</b> Salient features; Study of <i>Asterias</i> with reference to morphology, locomotion, water vascular system, mode of feeding and reproduction	6 Hours
<b>SUGGESTED READINGS:</b> 1. Barnes, RD: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980. 2. Barrington, EJW: Invertebrate Structure and Function, Nelson, 1987. 3. Hickman, Roberts & Hickman: Integrated Principles of Zoology (7th ed) Times-Mirror, Mosby, 1984. 4. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973. 5. Kotpal, RL: Modern Text Book of Zoology: Invertebrates, Rastogi Publications, 12 <sup>th</sup> edition, 2019 6. Marshall & William: Text Book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillan, 1972.	

<b>Animal Diversity: Invertebrates (Practical)</b>	<b>2 Credits</b>
<p>Study of museum specimens/slides:</p> <p><b>Protozoa:</b> <i>Amoeba, Euglena, Plasmodium, Paramecium, Trichomonas, Trypanosoma, Monocystis, Vorticella</i></p> <p><b>Porifera:</b> <i>Sycon</i> (including T.S. and L.S.), <i>Hyalonema, Euplectella, Euspongia</i></p> <p><b>Coelenterata:</b> <i>Obelia, Physalia, Aurelia, Tubipora, Metridium, Hydra, Gorgonia, Pennatula</i></p> <p><b>Platyhelminthes:</b> <i>Taenia solium</i> and study of its life history stages, <i>Schistosoma, Fasciola</i></p> <p><b>Nemathelminthes:</b> Male and female <i>Ascaris lumbricoides, Wuchereria, Ancylostoma</i></p> <p><b>Annelida:</b> <i>Aphrodite, Nereis, Pheretima, Hirudinaria, Polygordias</i></p> <p><b>Arthropoda:</b> <i>Palaemon, Cancer Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis, Musca</i></p> <p><b>Mollusca:</b> <i>Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus</i></p> <p><b>Echinodermata:</b> <i>Pentaceros, Ophiura, Echinus, Cucumaria, Antedon, Holothuria, Astreas</i></p>	

<b>Semester I</b>	<b>ZOOLOGY (HONS.)</b>
<b>Course</b>	<b>Fundamentals of Ecology</b>
<b>Course Code: B050152T</b>	
<b>Subject prerequisite</b>	<b>To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12</b>
<b>Credits Allotted</b>	<b>4 Credits [60 hours]</b>
<b>Teaching Scheme</b>	<b>3 hours/week</b>
<b>Examination Scheme</b>	<b>Internal Assessment: 25 Marks End of Semester: 75 Marks</b>
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. The primary aim of the syllabus is to sensitize the students about the paramount role and importance of nature.</li> <li>2. The study of Ecology imparts us the knowledge about the judicious use of existing ecological resources for sustainable development. Ecology is the only branch of science which briefs us on the ways and means of living with nature for mutual benefit.</li> <li>3. Study of ecology will provide students opportunity to understand its practical aspects and helps them to solve many contemporary ecological issues such as global warming, land degradation, habitat loss, desertification and pollution etc.</li> <li>4. The hands-on experiences of laboratory will also enable students to understand the ecosystem and ecology in a better way.</li> </ol>
<b>Course Outcomes</b>	<p>Upon completion of the course, students should be able to:</p> <ol style="list-style-type: none"> <li>1. Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.</li> <li>2. Comprehend the population characteristics, dynamics, growth models and interactions.</li> <li>3. Understand the community characteristics, ecosystem development and climax theories.</li> <li>4. Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.</li> <li>5. Apply the basic principles of ecology in wildlife conservation and management.</li> <li>6. Inculcate scientific quantitative skills, evaluate experimental design, read graphs, and analyses and use information available in scientific literature</li> </ol>

<b>Course content</b>	<b>Lectures (60 Hours)</b>
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<b>Unit I. Introduction to Ecology:</b> History and Scope of ecology, Autecology and synecology, Laws of limiting factors, Study of physical factors: Temperature and Light	5 Hours
<b>Unit II. Population:</b> Unitary and Modular populations; Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion; Exponential and logistic growth, equation and patterns, $r$ and $k$ strategies, Population regulation; Density-dependent and independent factors; Population interactions; Gause's Principle with laboratory and field examples; Lotka-Volterra equation for competition and predation; Functional and numerical responses	24 Hours
<b>Unit III. Community:</b> Community characteristics: species richness, dominance, diversity, abundance, Guilds, Ecotone and edge effect; Ecological succession with examples and types; Theories pertaining to climax community.	12 Hours
<b>Unit IV. Ecosystem:</b> Types of ecosystems with detailed study of any one: Forest Ecosystem, Pond or Lake ecosystem, Mangrove and Coral reef ecosystem. Vertical stratification in Forest and Aquatic ecosystem, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies, Nutrient and biogeochemical cycle with one example of Nitrogen cycle.	14 Hours
<b>Unit V. Unit 5: Applied Ecology:</b> Ecology in wildlife conservation and management, Biodiversity types, Importance & threats, Protected areas: National Parks, Bioreserves and Sanctuaries, Restoration ecology, Global climate change and its mitigation.	8 Hours
<b>SUGGESTED READINGS:</b>	
<ol style="list-style-type: none"> <li>1. Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole</li> <li>2. Smith, R. L. (2000). Ecology and field biology. Harper and Row publisher</li> <li>3. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.</li> <li>4. Ricklefs, R.E. (2000). Ecology. V Edition. Chiron Press.</li> </ol>	
<b>Fundamentals of Ecology (Practical)</b>	<b>2 Credits</b>
<ol style="list-style-type: none"> <li>1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided</li> <li>2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community</li> <li>3. Study of an aquatic ecosystem: phytoplankton and zooplankton, measurement of area, temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method), chemical oxygen demand and free CO<sub>2</sub>, alkalinity</li> <li>4. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary</li> </ol>	

<b>Semester I</b>	<b>ZOOLOGY (HONS.)</b>
<b>Course</b>	<b>Biochemistry</b>
<b>Course Code: B050153T</b>	
<b>Subject prerequisite</b>	<b>To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12</b>
<b>Credits Allotted</b>	<b>4 Credits [60 hours]</b>
<b>Teaching Scheme</b>	<b>3 hours/week</b>
<b>Examination Scheme</b>	<b>Internal Assessment: 25 Marks End of Semester: 75 Marks</b>
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. Biochemistry is to understand the core biological phenomena at the molecular level. The aim of the course is to comprehend the fundamental principles of chemistry that govern complex biological systems.</li> <li>2. The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability.</li> <li>3. To make the study relevant, interesting, encouraging to the students to join the industry or to prepare them for higher studies including research.</li> <li>4. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.</li> </ol>
<b>Course Outcomes</b>	<p>Upon completion of the course, students should be able to:</p> <ol style="list-style-type: none"> <li>1. Upon completion of the course, students should be able to: Gain knowledge and skill in the fundamentals of biochemical sciences, interactions and interdependence of physiological and biochemical processes.</li> <li>2. Get exposed to various processes used in industries and gain skills in techniques of chromatography and spectroscopy.</li> <li>3. Demonstrate foundation knowledge in biochemistry; synthesis of proteins, lipids, nucleic acids, and carbohydrates; and their role in metabolic pathways along with their regulation.</li> <li>4. Know about classical laboratory techniques, use modern instrumentation, design and conduct scientific experiments, and analyze the resulting data.</li> <li>5. Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals.</li> </ol>

<b>Course content</b>	<b>Lectures (60 Hours)</b>
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<b>Unit I. Carbohydrates:</b> Structure and Biological importance: with emphasis on aldose, ketose, chiral centre, polarised light and Fischer nomenclature, Cyclization reaction of glucose, anomers, pyranose, furanose, glycosidic linkage; Reducing and non-reducing sugars: monosaccharides, disaccharides, polysaccharides and Glycoconjugates	8 Hours
<b>Unit II: Lipids:</b> Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids	8 Hours
<b>Unit III: Proteins:</b> Amino acids: Structure, Classification and General properties of $\alpha$ -aminoacids; Physiological importance of essential and non-essential $\alpha$ -amino acids; Proteins: Bonds stabilizing protein structure; Levels of organization in protein motifs, folds and domains; Denaturation; Introduction to simple and conjugate proteins. Immunoglobulins: Basic Structure	14 Hours
<b>Unit IV. Nucleic Acids: Structure:</b> Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids; Cot Curves: Base pairing, Denaturation and Renaturation of DNA; Types of DNA and RNA, Complementarity of DNA, Hypo-Hyperchromicity of DNA Origin of Metazoa.	12 Hours
<b>Unit V. Enzymes:</b> Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of $K_m$ and $V_{max}$ , Lineweaver- Burk plot; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme reaction	18 Hours
<p><b>SUGGESTED READINGS:</b></p> <ol style="list-style-type: none"> <li>1. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry. V Edition, W.H. Freeman and Co., New York.</li> <li>2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition, W.H. Freeman and Co., New York.</li> <li>3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.</li> <li>4. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry. II Edition, BIOS Scientific Publishers Ltd., U.K.</li> <li>5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene. VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.</li> </ol> <p><b>Online Tools and Web Resources:</b></p> <ol style="list-style-type: none"> <li>6. CEC Gurukul (<a href="http://www.cec.nic.in">www.cec.nic.in</a>)</li> <li>7. <a href="https://www.youtube.com/user/cecedusat/featured">https://www.youtube.com/user/cecedusat/featured</a>.</li> <li>8. National Institute of Science Communication and Information Resources (NISCAIR) (<a href="http://www.niscair.res.in/">http://www.niscair.res.in/</a>) and National Science Digital Library (NSDL)</li> </ol>	

([www.nsdl.niscair.res.in](http://www.nsdl.niscair.res.in)).

National Digital Library of India (NDL India; <https://ndl.iitkgp.ac.in/>).

<b>Biochemistry (Practical)</b>	<b>2 Credits</b>
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1. To understand the preparation and roles of two important biological buffer systems: phosphate and bicarbonate; Preparation of buffers and determination of pH
2. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
3. Quantitative Tests: Determination of Ascorbic acid – DCPIP method OR Estimation of Calcium–Titrimetric method.
4. Paper chromatography of amino acids.
5. Action of salivary amylase under optimum conditions.
6. Effect of pH, temperature and inhibitors on the action of salivary amylase.
7. Demonstration of proteins separation by SDS-PAGE.

Semester II	ZOOLOGY (HONS.)
Course	Animal Diversity: Vertebrates
Course Code: B050251T	
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12
Credits Allotted	4 Credits [60 hours]
Teaching Scheme	3 hours/week
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks
Course Objectives	<ol style="list-style-type: none"> <li>1. The course would provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life.</li> <li>2. It will help the student to understand the features of Kingdom Animalia and systematic organization of the animals based on their evolutionary relationships, structural and functional affinities.</li> <li>3. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.</li> </ol>
Course Outcomes	<p>Upon completion of the course, students should be able to:</p> <ol style="list-style-type: none"> <li>1. Learn about the importance of systematics, taxonomy and structural organization of vertebrate animals.</li> <li>2. Appreciate the diversity of non-chordates living in varied habit and habitats.</li> <li>3. Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.</li> <li>4. Critically analyses the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.</li> <li>5. Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.</li> </ol>

Course content	Lectures (60 Hours)
<b>Unit I. Introduction to Chordata:</b> General characters and outline classification of Chordates up to Classes. <b>Hemichordata:</b> General characters and classification; <i>Balanoglossus</i> :	6 Hours

morphology and development	
<b>Unit II. Urochordata:</b> General characters and classification; <i>Herdmania</i> : Morphology, blood vascular system, reproductive system and development	6 Hours
<b>Unit III. Cephalochordata:</b> Classification and salient features; <i>Branchiostoma</i> (= <i>Amphioxus</i> ): Morphology, digestive, excretory, reproductive system and development	6 Hours
<b>Unit IV. Cyclostomata:</b> General characters and classification; External features of <i>Petromyzon</i> and <i>Myxine</i> ; Comparison between Lampreys and Hagfishes	4 Hours
<b>Unit V. Pisces:</b> General characters of cartilaginous and bony fish; <b>Dipnoi:</b> Distribution, General characters, and affinities; External features, Digestive, Respiratory, Blood vascular, Nervous and Urinogenital system of <i>Scoliodon</i> ; Scales and fins of fishes, respiratory organs in fish	11 Hours
<b>Unit VI. Amphibia:</b> General characters and classification, Elementary idea of parental care	3 Hours
<b>Unit VII. Reptilia:</b> Terrestrial Adaptations; General characters and distribution of Chelonia, Rhynchocephalia, Ophidia and Crocodilia; Poisonous and non-poisonous snakes; Biting mechanism in snakes; Venom and Antivenom	8 Hours
<b>Unit VIII. Aves:</b> General characters; Morphology, Digestive, Respiratory and Urinogenital System of <i>Columba</i> ; Feathers in Birds; Aerial adaptations in birds	8 Hours
<b>Unit IX. Mammalia:</b> General organization, salient features and distribution of Prototheria, Metatheria and Eutheria	8 Hours
<b>SUGGESTED READINGS:</b>	
1. Kotpal, R.L.: Modern Text-book of Zoology, Vertebrates. Rastogi Publication, 2007	
2. Jordan, E.L. and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd., 2013	
3. Hildebrand, M. Goslow, G.: Analysis of Vertebrate Structure, Wiley, 1998	
4. Romer, A.S., T.S. Parsons: Vertebrate Body, Saunders (W.B.) Co Ltd; 5th Revised edition, 1977	
<b>Animal Diversity: Vertebrates (Practical)</b>	<b>2 Credits</b>
Study of museum specimens/slides: <b>Study of museum specimens/slides:</b> <b>Protochordata:</b> <i>Balanoglossus</i> , <i>Herdmania</i> , <i>Branchiostoma</i> , <b>Agnatha:</b> <i>Petromyzon</i> , <i>Myxine</i> <b>Pisces:</b> <i>Sphyrna</i> , <i>Pristis</i> , <i>Torpedo</i> , <i>Exocoetus</i> , <i>Anguilla</i> , <i>Acipenser</i> , <i>Latimaria</i> , <i>Chimaera</i> <b>Amphibia:</b> <i>Ichthyophis</i> , <i>Ureotyphlus</i> , <i>Salamandra</i> , <i>Bufo</i> , <i>Hyla</i> <b>Reptilia:</b> <i>Chelone</i> , <i>Hemidactylus</i> , <i>Chamaeleon</i> , <i>Draco</i> , <i>Vipera</i> , <i>Naja</i> , <i>Crocodylus</i> , <i>Gavialis</i> ; Key for Identification of poisonous and non-poisonous snakes	

**Aves:** Study of six common birds from different orders

**Mammalia:** *Sorex*, Bat, *Funambulus*, Loris, Platypus, Opossum, Kangaroo, Manis, Dolphin, Whale, Lutra, Camel, Polar Bear (Photographs)

An "animal album" containing photographs, cut outs, with appropriate write up about the abovementioned taxa. Different taxa/ topics may be given to different sets of students for this purpose. These need not be repeated as drawings by the album maker.

Semester II		ZOOLOGY (HONS.)	
Course		Cell and Molecular Biology	
Course Code: B050252T			
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12		
Credits Allotted	4 Credits [60 hours]		
Teaching Scheme	3 hours/week		
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks		
Course Objectives	<ol style="list-style-type: none"> <li>1. The course aims to provide students with an introduction of the underlying molecular mechanisms of various biological processes in cells and organisms.</li> <li>2. The course aims to develop basic understanding of structure-function relationships of nucleic acids and proteins.</li> </ol>		
Course Outcomes	Upon completion of the course, students will be able to: <ol style="list-style-type: none"> <li>1. Describe the basic structure and chemistry of nucleic acids, DNA and RNA;</li> <li>2. Compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes.</li> <li>3. Explain post-transcriptional modification mechanisms for the processing of eukaryotic RNAs;</li> <li>4. Discuss general principles of transcription regulation in prokaryotes by exploring the structure and function of lactose and tryptophan metabolism operons; an overview of gene expression regulation in eukaryotes;</li> </ol>		

Course content	Lectures (60 Hours)
<b>Unit I. Introduction to Cell:</b> Basics of Cell Biology (structure & function): Discovery of cell and Cell Theory; Comparison between plant and animal cells; Cell wall; Plasma membrane; Modification of plasma membrane and intracellular junctions; Cytoskeleton; Protoplasm; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, endosome and microbodies; Ribosome;	12 Hours

Centriole; Nucleus; Chemical components of a cell.	
<b>Unit II. Cell Signaling:</b> Introduction to cell signalling pathways GPCR, cAMP, PKA, CREB, target gene and nuclear receptor pathway.	6 Hours
<b>Unit III. Cell Death and Renewal:</b> Apoptosis vs. necrosis; intrinsic and extrinsic pathways of programmed cell death; stem cells and maintenance of adult tissues; embryonic and induced pluripotent stem cells.	8 Hours
<b>Unit IV. DNA and its Replication:</b> DNA replication in prokaryotes and eukaryotes-replication machinery and mechanisms, semi-conservative, bidirectional and semi-discontinuous, Chromosomes: History, types and functions of chromosomes. Giant chromosomes, Polytene chromosome and Lampbrush chromosome	8 Hours
<b>Unit V. Cell Division:</b> Mitosis (cell cycle stages, cytokinesis) Meiosis (reproductive cycle stages, synaptonemal complex, recombination nodules). Comparison between meiosis and mitosis	6 Hours
<b>Unit VI. Transcription and Translation:</b> Machinery and mechanism of transcription in prokaryotes and eukaryotes-RNA polymerases, Transcription unit, Transcription factors, Synthesis of rRNA, Genetic code, Process of protein synthesis in prokaryotes: fidelity of protein synthesis, aminoacyl-tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Difference between prokaryotic and eukaryotic translation.	12 Hours
<b>Unit VII. Post Transcriptional Modifications:</b> Split genes: concept of introns and exons, splicing mechanism, alternative splicing, and RNA editing.	6 Hours
<b>Unit VIII. Gene Regulation:</b> Transcription regulation in prokaryotes: Lac operon; Overview of transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements.	4 Hours
<b>SUGGESTED READINGS:</b> <ol style="list-style-type: none"> <li>1. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene. VI edition. Cold Spring Harbour Lab. Press, Pearson Pub.</li> <li>2. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.</li> <li>3. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition John Wiley and Sons. Inc.</li> <li>4. Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.</li> </ol>	

**Online Tools and Web Resources:**

<https://swayam.gov.in/courses/5065-molecular-biology>

<https://swayam.gov.in/courses/4916-molecular-biology>

<https://www.youtube.com/user/cecedusa>

**Cell and Molecular Biology (Practical)****2 Credits**

1. Requirement of a Tissue culture laboratory, its equipment and its layout. Concept of cell culture and cell lines; Media preparation for mammalian tissue culture.
2. Preparation of permanent slides of mitosis/meiosis.
3. Study of Polytene chromosomes from *Chironomous/Drosophila* larva.
4. Inoculation and culture of *E. coli* in liquid culture medium (LB).
5. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
6. Estimation of the growth kinetics of *E. coli* from the data provided.
7. Study and interpretation of electron micrographs/photographs showing: DNA replication, Transcription, and Split genes.
8. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Semester II	ZOOLOGY (HONS.)
Course	Vertebrate Comparative Anatomy
Course Code: B050253T	
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12
Credits Allotted	4 Credits [60 hours]
Teaching Scheme	3 hours/week
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks
Course Objectives	<ol style="list-style-type: none"> <li>1. This course aims to provide the undergraduate students a thorough knowledge of structural details and comparative account of the different organ systems.</li> <li>2. It helps students propose possible homology between structures, and understand how they evolved as the vertebrates dwelled different habitats.</li> <li>3. The structural modifications of digestive, circulatory, respiratory and skeletal system relate to the distribution of animals in their different comfort zones of habitat and ecological niches.</li> </ol>
Course Outcomes	<p>Upon completion of the course, students should be able to:</p> <ol style="list-style-type: none"> <li>1. Explain comparative account of the different vertebrate systems</li> <li>2. Understand the evolution of heart, modification in aortic arches, and structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.</li> <li>3. Learn to analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.</li> <li>4. Understand the importance of comparative vertebrate anatomy to discriminate human biology.</li> </ol>

Course content	Lectures (60 Hours)
<b>Unit I. Integumentary System:</b> Structure and derivatives of integument, functions of skin.	6 Hours
<b>Unit II. Skeletal System:</b> Outline of axial and appendicular skeleton: basic plan of bones of skull, girdles and limbs. Classification of vertebrae, structure of a typical vertebra, Jaw suspensorium, Visceral arches.	8 Hours

<b>Unit III. Digestive System:</b> Alimentary canal and associated glands, dentition	6 Hours
<b>Unit IV. Respiratory System:</b> Skin, gills, lungs and air sacs; Accessory respiratory organs	8 Hours
<b>Unit V. Circulatory System:</b> General plan of circulation, Evolution of heart and aortic arches	8 Hours
<b>Unit VI. Urinogenital System:</b> Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri	8 Hours
<b>Unit VII. Nervous System:</b> Comparative account of brain; Autonomic nervous system, Spinal cord, Cranial nerves in mammals	8 Hours
<b>Unit VIII. Sense Organs:</b> Classification of receptors; Brief account of visual and auditory receptors in man	8 Hours
<b>SUGGESTED READINGS:</b>	
<ol style="list-style-type: none"> <li>1. Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.</li> <li>2. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.</li> <li>3. Leiem C.F., Bermis W.E, Walker, W.F, Grande, L. (2001). Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.</li> <li>4. C.K Weichert and W. Presch (1970). Elements of Chordate Anatomy, IV Edition, McGraw-Hill.</li> <li>5. Pough.H. (2018). Vertebrate Life.X Edition. Pearson International.</li> <li>6. SWAYAM (Functional anatomy and regulation of vision, hearing, taste, smell and touch, Link - <a href="https://www.swayamprabha.gov.in/index.php/program/upcoming/9">https://www.swayamprabha.gov.in/index.php/program/upcoming/9</a>).</li> </ol>	
<b>Vertebrate Comparative Anatomy (Practical)</b>	<b>2 Credits</b>
<ol style="list-style-type: none"> <li>1. Study of placoid, cycloid and ctenoid scales of fish through permanent slides/photographs.</li> <li>2. Study of different types of feathers of birds.</li> <li>3. Disarticulated skeleton of Frog, <i>Varanus</i>, Fowl, Rabbit (Skull, Limb bones, Vertebral Column, Sternum, Girdles, Ribs).</li> <li>4. Carapace and plastron of turtle/tortoise.</li> <li>5. Mammalian skulls: One herbivorous and one carnivorous animal.</li> <li>6. Study of digestive, circulatory and urinogenital system of frog/rat through videos on dissection or through virtual dissections.</li> <li>7. Study of anatomical details of any two organs (brain, heart, lung, kidney, eye and ear) through videos.</li> <li>8. Project on modifications in skeletal structures/GI tract/Respiratory organs in vertebrates.</li> <li>9. Documentary film show on vertebrates/Visit to Zoological Park, Biodiversity Park or Sanctuary.</li> </ol>	

Semester III	ZOOLOGY (HONS.)
Course	Genetics
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12
Credits Allotted	4 Credits [60 hours]
Teaching Scheme	3 hours/week
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks
Course Objectives	<ol style="list-style-type: none"> <li>1. This course aims to provide an overview of genetics starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutations.</li> <li>2. The course will help in building sound fundamental knowledge of the principles of genetics, to be used as a stepping stone for higher studies and research in this field.</li> </ol>
Course Outcomes	<p>Upon completion of the course, students should be able to:</p> <ol style="list-style-type: none"> <li>1. Have a deeper understanding of the varied branches of the biological sciences like microbiology, evolutionary biology, genomics and metagenomics.</li> <li>2. Analyze pedigree leading to development of analytical skills and critical thinking enabling the students to present the conclusion of their findings in a scientific manner.</li> <li>3. Find out the effects of indiscriminate use of various chemicals, drugs or insecticides in nature by studying their effect on various bacterial species in soil and water samples from different industrial or polluted areas.</li> </ol>

Course content	Lectures (60 Hours)
<b>Unit I. Mendelian Genetics:</b> Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, penetrance and expressivity, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance and concept of gene.	12 Hours
<b>Unit II. Linkage, Crossing Over and Chromosomal Mapping:</b> Linkage and crossing over, Cytological basis of crossing over, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Linkage map, coefficient of coincidence and Interference, Gene mapping by Somatic cell hybridization	8 Hours

<b>Unit III. Mutations:</b> Types of gene mutations, Detection of mutations in <i>Drosophila</i> , Mutagens: Physical and Chemical, Molecular basis of spontaneous and induced mutations, Chromosomal aberrations: Variations in number and structure.	8 Hours
<b>Unit IV. Sex Determination:</b> Basis of sex determination: Genetic and environmental; Sex determination in <i>Drosophila</i> and Man; Mechanism of dosage compensation.	6 Hours
<b>Unit V. Extra-chromosomal Inheritance:</b> Comparison of nuclear and extra nuclear inheritance; Organelle inheritance: Antibiotic resistance in <i>Chlamydomonas</i> , Mitochondrial mutations in <i>Saccharomyces</i> and human disorders, Infective heredity in <i>Paramecium</i> . Maternal effects: Shell coiling in <i>Limnaea</i> , pigmentations in <i>Ephestia</i> , Polygenic inheritance with suitable examples and numericals	12 Hours
<b>Unit VI. Recombination in Bacteria and viruses:</b> Conjugation, Transformation, Transduction in bacteria, Complementation test in Bacteriophage	6 Hours
<b>Unit VII. Transposable Genetic Elements:</b> Transposons in bacteria, Ty elements in yeast, Ac-Ds elements in maize and P elements in <i>Drosophila</i> , Transposons in humans, Transposons as mutagens	8 Hours
<b>SUGGESTED READINGS:</b> <ol style="list-style-type: none"> <li>1. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons In.</li> <li>2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cumming</li> <li>3. Pierce B. A. (2012). Genetics-A Conceptual Approach. IV Edition. W. H. Freeman and Company</li> <li>4. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition. Benjamin Cummings</li> <li>5. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India</li> <li>6. <a href="https://swayam.gov.in/courses/4922-genetics-and-genomics">https://swayam.gov.in/courses/4922-genetics-and-genomics</a></li> <li>7. <a href="https://www.coursera.org/learn/genetics-evolution">https://www.coursera.org/learn/genetics-evolution</a></li> <li>8. <a href="https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/">https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/</a></li> <li>9. <a href="https://learn.genetics.utah.edu/">https://learn.genetics.utah.edu/</a></li> </ol>	

Genetics (Practical)	2 Credits
<ol style="list-style-type: none"><li>1. Simulation exercises using beads or seeds to study the Mendel's laws and gene interactions.</li><li>2. Verification of Mendelian ratios using Chi-square analysis/test.</li><li>3. Pedigree analysis.</li><li>4. Use of probability in solving problems in genetics.</li><li>5. Linkage maps based on data from conjugation.</li><li>6. Linkage maps based on data from <i>Drosophila</i> crosses.</li><li>7. Study of human karyotype (normal and abnormal).</li></ol>	

Semester III	ZOOLOGY (HONS.)
Course	Methods in Biostatistics
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12
Credits Allotted	4 Credits [60 hours]
Teaching Scheme	3 hours/week
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks
Course Objectives	<ol style="list-style-type: none"> <li>1. To provide an overview of the fundamental concepts of biostatistics.</li> <li>2. To apprise students to the various statistical methods and software tools for understanding data analysis in biological sciences.</li> <li>3. To familiarize students with basic training and develop skills required for analysis of experimental data in biological sciences.</li> <li>4. To encourage students to pursue higher studies or career in biostatistics as Data Analyst, Data Scientist, Software Developer, Machine Learning Analyst, Research Scientist, Academicians, etc.</li> </ol>
Course Outcomes	<p>By studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Better understand the basic concepts of Biostatistics and its various applications in different fields of biological sciences.</li> <li>2. Acquire basic skills to set up hypothesis and design research studies.</li> <li>3. Develop the skills to collect and represent data in tabular and graphical forms.</li> <li>4. Analyze data and interpret experimental results using calculator, spread sheets software and online/offline software tools.</li> </ol>

Course content	Lectures (60 Hours)
<b>Unit I. Biostatistics Introduction:</b> Aim and scope; applications in biological sciences.	8 Hours
<b>Unit II. Statistical Data:</b> Sampling methods; Primary and secondary data; Qualitative and quantitative data; Discrete and continuous data; Presentation of data- graphical representation of data.	12 Hours

<b>Unit III. Descriptive Statistics:</b> Concepts of statistical population and samples, parameter and statistics; Measures of Central tendency and Dispersion - Mean, Median and Mode (grouped and ungrouped data); Variance, Standard Deviation and Standard Error; Coefficient of Variance	12 Hours
<b>Unit IV. Probability and Distributions:</b> Normal, Binomial and Poisson; Skewness and Kurtosis.	8 Hours
<b>Unit V. Testing of Hypothesis and Statistical tests:</b> Null and Alternative hypotheses; Concepts of statistical errors - Type I and Type II errors; Confidence Intervals and Confidence levels, Chi Square tests; Z test, t Tests.	12 Hours
<b>Unit VI. Correlation and Regression:</b> Correlation Coefficient; Linear regression analysis.	8 Hours
<b>SUGGESTED READINGS:</b>	
<ol style="list-style-type: none"> <li>1. Daniel, W.W. and Cross, C.L. (2018) Biostatistics: Basic Concepts and Methodology for the Health Sciences 11<sup>th</sup> Edition, John Wiley &amp; Sons, Inc.</li> <li>2. Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc and Dorling Kindersley Publishing Inc. USA</li> </ol>	
<b>Methods in Biostatistics (Practical)</b>	<b>2 Credits</b>
<ol style="list-style-type: none"> <li>1. To learn calculation and graphical representation of data with computers (e.g. MS Excel/SPSS/Sigma Stat/Prism).</li> <li>2. To compute Coefficient of Variance from data collected and measure variability.</li> <li>3. To collect data on different parameters (e.g. height/weight) of animal/plant samples and test for significance, difference between mean, mode and median.</li> <li>4. To compute 'test of independence' and 'goodness of fit' with samples/data provided using Chi square test.</li> <li>5. To perform Z test/ F test (ANOVA) for given samples/data provided.</li> <li>6. Submission of Project report based on field studies (sample collection, data analysis and interpretation using above statistical tests).</li> </ol>	

Semester III	ZOOLOGY (HONS.)
Course	Animal Biotechnology
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12
Credits Allotted	4 Credits [60 hours]
Teaching Scheme	3 hours/week
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks
Course Objectives	The learning objectives of this course are as follows: <ol style="list-style-type: none"> <li>1. To provide an overview of the fundamental concepts of animal biotechnology.</li> <li>2. To apprise students to the various techniques for understanding concept of cell culture.</li> <li>3. To familiarize students with basic training and develop skills required for assisted reproductive technology.</li> <li>4. To encourage students to pursue higher studies or career in animal Biotechnology field, as Research Scientist, Academicians, etc.</li> </ol>
Course Outcomes	1. By studying this course, students will be able to Knowledge on the uses and features of various scientific methods in the study of animals, and how they are used for human welfare.

Course content	Lectures (60 Hours)
<b>Unit I. Concept of cell culture:</b> types of animal cell lines; sterilization methods; culture media; culture process.	8 Hours
<b>Unit II. Assisted reproductive technology:</b> Cryopreservation; intra-cytoplasmic sperm injection; in vitro fertilization. Concept of stem cells and its application.	14 Hours
<b>Unit III. Genetically modified animals:</b> Principle, techniques, and notable examples. Cloning– Principle, techniques, and notable examples.	12 Hours
<b>Unit IV. CAR T cell therapy. CRISPR and management of genetic diseases. Bioterrorism and biological weapons, Oncogene- Antisense RNA I-Technology.</b>	14 Hours

<b>Unit V. Current Indian Scenario in Biotechnology:</b> Centers, Activities and bio-industries in India and challenges for the Indian biotechnology research and industries	12 Hours
<p><b>SUGGESTED READINGS:</b></p> <ol style="list-style-type: none"> <li>1. Kammermeyer, K., and Clark, V. L. (2019). <i>Genetic Engineering Fundamentals: An Introduction to Principles and Applications</i>. CRC Press.</li> <li>2. Lewis, R. (2020). <i>Human Genetics: Concepts and Applications</i> (12th edition). McGraw Hill.</li> <li>3. Rastogi, S. C. (2019). <i>Bioinformatics Concepts Skills And Applications</i> (2nd edition). CBS Publishers &amp; Distributors Pvt. Ltd.</li> <li>4. Srivastava, A. K., and Singh, R. K. (2018). <i>Animal Biotechnology</i>. Rastogi Publications.</li> <li>5. Tourte, Y., and Tourte, C. (2019). <i>Genetic Engineering and Biotechnology: Concepts, Methods and Agronomic Applications</i>. Science Publishers Inc.</li> </ol>	
<b>Animal Biotechnology (Practical)</b>	<b>2 Credits</b>
<ol style="list-style-type: none"> <li>1. Preparation of nutrient agar broth</li> <li>2. TECHNIQUES OF STERILIZATION USING AUTOCLAVE/PRESSURE COOKER</li> <li>3. ESTIMATION OF DNA &amp; RNA</li> <li>4. ESTIMATION OF PROTEIN.</li> <li>5. BLOTTING TECHNIQUES – OBSERVATION OF PHOTOGRAPH</li> <li>6. ISOLATION OF DNA AND RNA– DEMONSTRATION ONLY</li> <li>7. ELECTROPHORESIS – DEMONSTRATION ONLY</li> </ol>	

Semester IV	ZOOLOGY (HONS.)
Course	Developmental Biology
Subject prerequisite	To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12
Credits Allotted	4 Credits [60 hours]
Teaching Scheme	3 hours/week
Examination Scheme	Internal Assessment: 25 Marks End of Semester: 75 Marks
Course Objectives	The learning objectives of this course are as follows: <ol style="list-style-type: none"> <li>1. To provide an in-depth knowledge on the embryonic and post embryonic developmental processes.</li> <li>2. to understand morphogenesis in Sea urchin, Drosophila, Frog and Chick.</li> <li>3. by understanding the developmental processes, the students can relate to errors occurring during development leading to congenital disorders and human diseases.</li> <li>4. to familiarize the students with the technique of IVF and pre-diagnostic methods to identify any abnormality arising during development.</li> <li>5. To make the students aware of the areas of great interest including stem cell therapy, tissue engineering and regenerative medicine.</li> </ol>
Course Outcomes	By studying this course, students will be able to <ol style="list-style-type: none"> <li>1. Appreciate the events that lead to the formation of a multicellular organism from a single fertilized egg.</li> <li>2. Acquire basic knowledge and importance of latest techniques like stem cell therapy, <i>in vitro</i> fertilization and amniocentesis etc.</li> <li>3. Develop the skill to raise and maintain culture of model system- <i>Drosophila</i> in the laboratory.</li> </ol>

Course content	Lectures (60 Hours)
<b>Unit I.</b> Historical perspectives and basic concepts: Phases of development, Pattern formation, Differentiation and growth, Cytoplasmic determinants.	10 Hours
<b>Unit II. Early Embryonic Development:</b> Gametogenesis: oogenesis, spermatogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal), Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps; Gastrulation in frog and chick, Embryonic induction and	14 Hours

organizers.	
<b>Unit III. Late Embryonic Development:</b> Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, structure, types, and functions of placenta.	12 Hours
<b>Unit IV. Post Embryonic Development:</b> Metamorphosis and its hormonal regulation in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration; Ageing: concepts and theories.	12 Hours
<b>Unit V. Consequences of Developmental Biology:</b> Teratogenesis: Teratogenic agents and their effects on embryonic development; <i>in- vitro</i> fertilization, Embryonic stem cell (ESC), Amniocentesis.	12 Hours
<b>SUGGESTED READINGS:</b>	
<ol style="list-style-type: none"> <li>Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.</li> <li>Gilbert, S. F. (2010) Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA</li> <li>Baweja, V. and Misra, M. (2021) E-book on Practical Manual of developmental Biology.</li> <li>Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand &amp; Company.</li> <li>Wolpert, L. (2002) Principles of Development. II Edition, Oxford University Press.</li> <li>Kalthoff, K. (2001) Analysis of Biological Development. II Edition, McGraw Hill Publishers.</li> </ol>	
<b>Developmental Biology (Practical)</b>	<b>2 Credits</b>
<ol style="list-style-type: none"> <li>Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula (Neural plate, Neural fold and Neural tube stages), tail-bud stage, tadpole (external and internal gill stages)</li> <li>Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7- 24 hours, Stage 8-28 hours, Stage 10- 33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19- 72 hours and Stage 24-96 hours of incubation</li> <li>Study of indirect development and metamorphosis by rearing any one insect.</li> <li>Study of different sections of placenta (photomicrographs/ slides).</li> <li>Project report on <i>Drosophila</i> or any insect culture/Visit to Poultry Farm/IVF Centre</li> </ol>	

<b>Semester IV</b>	<b>ZOOLOGY (HONS.)</b>
<b>Course</b>	<b>Neuroscience Biology</b>
<b>Subject prerequisite</b>	<b>To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12</b>
<b>Credits Allotted</b>	<b>4 Credits [60 hours]</b>
<b>Teaching Scheme</b>	<b>3 hours/week</b>
<b>Examination Scheme</b>	<b>Internal Assessment: 25 Marks End of Semester: 75 Marks</b>
<b>Course Objectives</b>	<p>The learning objectives of this course are as follows:</p> <ol style="list-style-type: none"> <li>1. To understand the structure and function of the nervous system at the molecular, cellular, and systems levels.</li> <li>2. To gain an insight into how membrane excitability elicits functional effects in individual neurons and neuronal networks and how different parts of the brain control various behavioral patterns by releasing neurohormones/neuropeptides.</li> <li>3. To have a thorough knowledge of neuroimaging techniques and a comprehensive understanding of the kinds of information each technique provides about the brain.</li> <li>4. To gain knowledge about the neural mechanism and pathogenesis of common neurodegenerative disorders such as Alzheimer's, Parkinson's disease etc.</li> </ol>
<b>Course Outcomes</b>	<p>By studying this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the fundamentals of neuroscience, key concepts, and the relationship between the nervous system and behavior/cognition.</li> <li>2. Have a detailed understanding of how different neuroimaging techniques are used to assess brain function and explore questions in clinical and behavioral neuroscience.</li> <li>3. Explore potential developments to current research, design, execute and communicate a substantive research project in the field of neuroscience or its application.</li> </ol>

<b>Course content</b>	<b>Lectures (60 Hours)</b>
<b>Unit I. Nervous System Introduction:</b> Origins of Neuroscience; Neuron	10 Hours

doctrine; Classification of the nervous system, Gross anatomy of the human brain, Meninges, ventricular System, Blood-brainBarrier, Cranial nerves.	
<b>Unit II. Cellular and Molecular Neurobiology:</b> Classification of neurons; Structure of prototypical neuron; Electrophysiology of membrane potentials- resting and action potentials, generation, and propagation; Ion Channels and Membrane Ion Currents; Types of Synapses, synaptic transmission and integration; Post synaptic potentials - EPSPs and IPSPs; tripartite synapse.	18 Hours
<b>Unit III. Neurotransmitters:</b> Types of neurotransmitters; transmitter-gated channels; neurotransmitter receptors Ionotropic and metabotropic receptors; G-protein coupled receptors and effectors.	10 Hours
<b>Unit IV. Cognitive and Behavioural Neuroscience:</b> Neurobiology of visual perception; Molecular basis of learning and memory, Long-term potentiation (LTP), Long-term depression (LTD); Memory consolidation, Neurophysiology of sleep and wakefulness, electroencephalogram rhythms (EEG).	12 Hours
<b>Unit V. Neuroimaging and Neuropathology:</b> Computed Tomography Scan (CT), Magnetic Resonance Imaging (MRI), functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET); Neurological disorders (in brief)- Epilepsy, Schizophrenia; Aetiology and Molecular pathogenesis - Parkinson's, Alzheimer's.	10 Hours
<b>SUGGESTED READINGS:</b>	
<ol style="list-style-type: none"> <li>1. Purves, D. et al., (2017) Neuroscience, VI Edition. Oxford University Press.</li> <li>2. Bear, M. F., Connors, B. W. and Paradiso, M. A. (2016). Neuroscience: Exploring the Brain. IV Edition. Philadelphia: Wolters Kluwer.</li> <li>3. Squire, L., Berg, D., Bloom, F. E., du-Lac, S., Ghosh, A., Spitzer, N. C. (2012) Fundamental Neuroscience, IV Edition, Academic Press Publications.</li> <li>4. Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (2000) Principles of Neural Science. IV Edition, McGraw-Hill Companies.</li> <li>5. Carter, R. (2014). The Human Brain Book. D. K. Publishers.</li> <li>6. Ramachandran, V. S. and Blakeslee, S. (1998). Phantoms in the Brain: Probing the Mysteries of the Human Mind. William Morrow, New York.</li> </ol>	

<b>Neuroscience Biology (Practical)</b>	<b>2 Credits</b>
<ol style="list-style-type: none"><li>1. Study of brain coordinates using stereotaxis instrument (video demonstration).</li><li>2. Study of anatomy of mammalian brain (from slaughter house or) using brain models (Medical anatomical teaching models, graphics, videos etc., can be used).</li><li>3. Histological study of neurons and myelin sheath (Nissl and Luxol Fast Blue staining).</li><li>4. Study of anxiety, and spatial learning in mice.</li><li>5. Study of neurodegenerative diseases (Parkinson's and Alzheimer's) with the help of brain scan images or brain tissue images.</li></ol>	

<b>Semester IV</b>	<b>ZOOLOGY (HONS.)</b>	
<b>Course</b>	<b>Animal Behaviour</b>	
<b>Subject prerequisite</b>	<b>To study zoology in undergraduate, a student must have studied Biology, Biotechnology and Life Science in class 12</b>	
<b>Credits Allotted</b>	<b>4 Credits [60 hours]</b>	
<b>Teaching Scheme</b>	<b>3 hours/week</b>	
<b>Examination Scheme</b>	<b>Internal Assessment: 25 Marks End of Semester: 75 Marks</b>	
<b>Course Objectives</b>	<p>The learning objectives of this course are as follows:</p> <ol style="list-style-type: none"> <li>1. To explain the natural behaviour patterns, how the behaviour varies among individuals and species (wild, domestic, and captive).</li> <li>2. To explain how current and past environments and ecology influence not only behaviour, but also the underlying gene-environment interactions that shape it.</li> <li>3. The course would provide an insight to the learner about the existence of different behavioural forms shown by animals on the Earth.</li> </ol>	
<b>Course Outcomes</b>	<p>By studying this course, students will be able to</p> <ol style="list-style-type: none"> <li>1. On completion of the course the student should be able to understand stereotyped and social behaviors of animals and know about the biological rhythms governing the behaviour of animals.</li> <li>2. Understand and be able to objectively evaluate the role of behaviour in the protection and conservation of animals in the wild.</li> </ol>	
<b>Course content</b>		<b>Lectures (60 Hours)</b>
<b>Unit 1: Introduction to Animal Behaviour</b> Origin and history of Ethology; Brief profiles of Karl Von Frish, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen.		08 Hours
<b>Unit 2: Patterns of Behaviour</b> Stereotyped Behaviours (Orientation, Reflexes); Individual Behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting.		12 Hours

<p><b>Unit 3: Social and Sexual Behaviour</b>  <b>Social Behaviour:</b> Aggregations - Schooling in fishes, flocking in birds, herding in mammals; group selection, kin selection, altruism, inclusive fitness, and social organization in insects; Foraging in honey bee and advantages of the waggle dance.  <b>Sexual Behaviour:</b> Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Sexual conflict in parental care. Hormones and behaviour, pheromones and behaviour.</p>	18 Hours
<p><b>Unit 4: Introduction to Chronobiology</b>  Historical developments in chronobiology; Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks</p>	10 Hours
<p><b>Unit 5: Biological Rhythm and Clocks</b>  Circadian, circannual, tidal/lunar, ultradian, infradian rhythms, synchronization of biological rhythms, phase shift. Concept of synchronization and masking; Photic and non-photic zeitgebers; Photoperiod and Sasonality. Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy.</p>	12 Hours
<p><b>SUGGESTED READINGS:</b></p> <ol style="list-style-type: none"> <li>1. David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.</li> <li>2. Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge, University Press, UK.</li> <li>3. John Alcock, Animal Behaviour, Sinauer Associate Inc., USA.</li> <li>4. Paul W. Sherman and John Alcock, Exploring Animal Behaviour, Sinauer Associate Inc., Massachusetts, USA.</li> <li>5. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J.</li> <li>6. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA</li> <li>7. Insect Clocks D.S. Saunders, C.G.H. Steel, X., Afopoulou (ed.) R.D. Lewis. (3rd Ed) 2002 Baren and Noble Inc. New York, USA</li> <li>8. Biological Rhythms: Vinod Kumar (2002) Narosa Publishing House, Delhi/ Springer-Verlag, Germany.</li> </ol>	
<b>Animal Behaviour (Practical)</b>	<b>2 Credits</b>
<ol style="list-style-type: none"> <li>1. To study nests and nesting habits of the birds and social insects.</li> <li>2. To study the behavioural responses of wood lice to dry and humid conditions.</li> <li>3. To study geotaxis behaviour in earthworm.</li> <li>4. To study the phototaxis behaviour in insect larvae.</li> <li>5. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.</li> <li>6. Study and actogram construction of locomotor activity of suitable animal models.</li> <li>7. Study of circadian functions in humans (daily eating, sleep and temperature patterns).</li> </ol>	

