Outline of NEP 4 year undergraduate syllabus: Department of Zoology, University of Lucknow

Year	Semester	Paper	Paper Type	Major Subject 1 (Zoology) @4 credits	Major Subject 2 (Another subject from any faculty) @4 credits	Minor 1 @4 credits (from another department	@4 credits
CERTIFICATE COURSE IN ANIMAL DIVERSITY							
Year 1	Sem 1	P1	Compulsory (Theory)	Diversity and Biology of Non-Chordata		Diversity of Non-Chordata	Curricular course 1
		P2	Compulsory (Practical)	Theory based practicals			
	Sem 2	P3	Compulsory (Theory)	Diversity and Biology of Chordata		Diversity of Chordata	Vocational course 1
		P4	Compulsory (Practical)	Theory based practicals			
DIPLOMA IN APPLIED ZOOLOGY AND ANIMAL CONSERVATION							
Year 2	Sem 3	P5	Compulsory (Theory)	Environmental Biology and Wildlife		Environmental Biology and Wildlife	Curricular course 2
		P6	Compulsory (Practical)	Theory based practicals			
	Sem 4	P7	Compulsory (Theory)	Applied Zoology		Applied Zoology	Vocational course 2
		P8	Compulsory (Practical)	Theory based practicals			
BACHELOR IN SCIENCE							
Year 3	Sem 5	P9	Compulsory (Theory)	Animal Physiology and Biochemistry			Internship/ Term paper
		P10	Compulsory (Practical)	Theory based practicals			
		P11X	Optional (Theory)	Biosystematics			
		P11Y	Optional (Theory)	Evolutionary Biology			
	Sem 6	P12	Compulsory (Theory)	Cytogenetics and Molecular Biology			Minor project
		P13	Compulsory (Practical)	Theory based practicals			
		P14X	Optional (Theory)	Toxicology			
		P14Y	Optional (Theory)	Biotechnology			
HONOURS IN ZOOLOGY							
Year 4	Sem 7	P15	Compulsory (Theory)	Developmental Biology and Immunology			Research Methodology
		P16	Compulsory (Theory)	Animal Behaviour and Chronobiology			
		P17	Compulsory (Practical)	Theory based practicals			
		P18X	Optional (Theory)	Endocrinology			
		P18Y	Optional (Theory)	Entomology			
		P19X	Optional (Theory)	Fisheries			
		P19Y	Optional (Theory)	Parasitology			
	Sem 8	P20	Compulsory	Major Project (24 credits)			

B. Sc. in Zoology

Program Objectives (POs):
Zoology as one of the subjects at undergraduate level, should be studied in an integrated and cross-disciplinary manner with a comprehensive understanding of all living systems and their relationship with the ecosystem. Within the broad-range skill sets related to the discipline, it is required to impart and assess the quality of critical thinking, analytical and scientific reasoning, and problem-solving capacity.
Our undergraduate program in Zoology is designed to prepare students to have:

Degree in Bachelor of Science		
Programme Outcomes (POs)		
PO 1	**Academic competence:**	Develop deeper understanding of key concepts of Zoology at biochemical, molecular, cellular, physiological, histological and systematic level.
PO 2	**Inspire Knowledge:**	From classical descriptive to modern analytical disciplines of Zoology.
PO 3	**Impart Science-based Entrepreneurship:**	Impart knowledge and skills through applied disciplines like Sericulture, Apiculture, and Aquaculture etc.
PO 4	**Develop Competency:**	To make our students competent to excel in competitive examinations.
PO 5	**Research Competence:**	Integrate and explore biological data. Use current laboratory setup, instrumentation, statistical and biological techniques in the collection, organization, analysis, interpretation and manipulating the data related to Zoology discipline and allied branches.
PO 6	**Entrepreneurial and Social competence:**	Empower the students by enhancing their self-sustainability capabilities through a thorough understanding of skill-based subjects and techniques by learning. Develop social competence including listening, speaking, observational, effective interactive skills and presenting skills to meet global competencies.
PO 7	**Environment and Sustainability**:	Understand the issues of environmental contexts and sustainable development.
PO 8	**Ethics**:	Aware students about ethical principles and commit to professional ethics and responsibilities.

B. Sc. I (Semesters I and II)

Degree in Bachelor of Science	
B.Sc. I (Semesters I and II) Programme Specific Outcomes (PSOs)	
PSO 1	Students will have a comprehensive knowledge of the Kingdom Animalia.
PSO 2	Students will learn the distribution, diversity, classification, physiology, and form and function of each major animal lineage within Non-chordates and Chordates.
PSO 3	Students will be able to apply fundamental principles of Zoology to make informed decisions on socio-scientific issues.
PSO 4	Students will be able to apply for various positions in museums, wildlife/ biodiversity data collection, conservation programs, health care, and zoos etc. in both government and private labs/institutes including NGOs. The student will be offered 'CERTIFICATE COURSE IN BIODIVERSITY' after completing Ist year or two semesters.

B. Sc. II (Semesters III and IV)

Degree in Bachelor of Science	
B.Sc. II (Semesters III and IV) Programme Specific Outcomes (PSOs)	
PSO 1	Students will gain knowledge of Agro based Small Scale Industries like sericulture, fish farming, apiculture, etc., which will help them in finding carrier opportunities.
PSO 2	Students will be able to analyse complex interactions among the various animals of different phyla, their distribution and their relationship with the environment.
PSO 3	Students will be able to develop understanding of environmental conservation processes and its importance, pollution control and biodiversity and protection of endangered species.
PSO 4	The inclusion of environmental biology and wildlife will help students to understand the importance of the environment and how to conserve it.
PSO 5	Students will understand the basic biology and life cycles of vectors, pests and parasites including epidemiology, diagnosis and treatment.
PSO 6	The basic concepts of biosystematics, evolutionary biology and biodiversity will enable students to solve the biological problems related to environment.
PSO 7	At the end of the course the students will be able to comprehend the reason behind maintaining the equilibrium between flora and fauna on earth. Will be able to appreciate the environment and the interdependence between human, wildlife and nature for food production, maintaining clean air and water and sustaining biodiversity in a changing climate.
PSO 8	Students can get subsidy and loan from state government to start Poultry, Pisciculture and Apiculture, under various schemes run by state govt. and become " AATMNIRBHAR" and generate jobs for others.
PSO 9	These Diploma courses will enable students to apply for various positions in museums, wildlife/biodiversity data collection, conservation programs, health care, and zoos etc. in both government and private labs/institutes including NGOs as environmental consultants, manager, educator, outreach specialist, wildlife law enforcement officer, zoo curator, museum curator. Besides this, the students can also take up higher studies and research as their career. The student will be offered 'DIPLOMA IN APPLIED ZOOLOGY AND ANIMAL CONSERVATION' after completion of 2 years of the programme or 4 semesters.

B. Sc. III (Semesters V and VI)

Degree in Bachelor of Science	
B.Sc. III (Semesters V and VI) Programme Specific Outcomes (PSOs)	
PSO 1	This programme aims to develop an understanding of structural, functional, biochemical and behavioral aspects of life.
PSO 2	The course in biosystematics is an integrative and unifying science and will help the students in studying the genotypic and phenotypic variation of species in relation to the environments in which they occur.
PSO 3	This course will provide students with the basic knowledge of evolutionary biology, both presenting the general principles of the discipline and exploring in details theoretical problems and case studies.
PSO 4	The students will understand the structure and function of the cell and the principles of genetics.
PSO 5	The course will provide an insight into the life processes at the subcellular and molecular levels
PSO 6	This course will provide theoretical and applied knowledge on the effects of chemical substances on human health.
PSO 7	The principles of genetic engineering, gene cloning and related technologies will enable students to play an important role in applications of biotechnology in various fields.
PSO 8	After completion of 3 years of the programme or 6 semesters, the student will be offered the 'BACHELOR DEGREE IN ZOOLOGY'. This programme will enable students to go for higher studies like Masters and then pursue Ph.D. in Zoology and allied subjects.

B. Sc. IV (Semesters VII and VIII)

Degree in Bachelor of Science	
B.Sc. III (Semesters V and VI) Programme Specific Outcomes (PSOs)	
PSO 1	This course will provide insight on embryonic development of animals. It will also develop understanding of the basic immune mechanism related to different Immunological diseases & disorders
PSO 2	The students will be introduced with intricacies of animal behavior in the context of evolution and ecology. Also the students will learn how the biological clock helps the organisms to perceive environmental cues that modulate the circadian physiology at molecular, cellular and systems levels.
PSO 3	The course in Endocrinology aims to develop an understanding of the endocrine glands; their structure, function, disorders and pathophysiology, which will be helpful for the student to pursue research and higher academic pursuits.
PSO 4	The course in Entomology will help the students to contribute in diverse fields as agriculture, biology, human/animal health, molecular science, criminology, and forensics and will also help him to pursue research and higher studies.
PSO 5	The course in Fisheries has been designed in such a way that the student will get the knowledge of both theory and practical. It aims to enable the students to study about Fish and Fisheries as an entrepreneur.
PSO 6	The course in parasitology has been designed in such a way that the student gets a basic understanding of the diversity of parasites of medical and veterinary importance which will be helpful for further research and higher studies.
PSO 7	Hands on training in the prospective field of interest/ employment
PSO 8	The Honours course will enable students to go for higher studies and research (Ph.D) in specialized fields of Zoology and allied subjects.

Semester I

P1: Diversity and Biology of Non-Chordata

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To create in the student an appreciation of non-chordate diversity
- To develop in the student an understanding of structural and functional diversity
- To develop in the student the understanding of evolutionary relationship amongst non-chordate groups

Classification relationship of various phyla up to order.

Unit I

Protozoa
General features and life history of: *Paramecium*, *Plasmodium* and *Leishmania* 10

Porifera 5
Skeleton, canal system, and reproduction in Porifera

Unit II

Cnidaria **5**
General features and life history: *Obelia*
Polymorphism
Coral reefs and their formation

Platyhelminthes 5
General features and life history: *Fasciola hepatica*
Parasitic adaptations

Aschelminthes 5
General features and life history of *Wuchereria bancrofti*
Parasitic adaptations

Unit III

Annelida
General features and life history: *Earthworm*, *Nereis* and *Hirudinaria* 7
Coelom and metamerism

Arthropoda 8
General features and life history: *Palaemon*
Mouth parts, vision, respiration, larval forms, metamorphosis and its hormonal regulation, parasitic crustaceans, social organization in honey bee and termites

Unit IV

Mollusca 7
General features and life history: *Pila* and *Lamellidens*
Torsion and detorsion

Echinodermata 5
General features and life history: *Asterias*
Larval forms of Echinodermata
Water-vascular system

Hemichordata 3

General characters, life history: *Balanoglossus*
Affinities

Course Outcomes:
At the completion of the course, the student will be able to:

- understand and appreciate the diversity of life with respect to non-chordate animals.
- describe the general characters of non-chordate animals.
- identify and classify non-chordate animals on the basis of their form and structure and classification.
- understand the life cycle and control of various representatives of non-chordate animals.
- explain evolutionary relationship amongst different non-chordate groups.

Suggested Readings

1. Ruppert, EE, Fox R.S., Barnes R.D. (2004) *Invertebrate Zoology*, 7th Edition. Cengage Learning
2. Thomas Jeffrey Parker, William A. Haswell (2016*). Parker & Haswell's A Textbook of Zoology Volume 1*. WENTWORTH Press
3. Brusca (2016). *Invertebrates*. Sinauer
4. Pechenik Jan (2014). *Biology of the invertebrates*. McGraw Hill
5. Barnes R. S. K., Calow P. P., Olive P. J. W., Golding D. W., Spicer J. I. (2009). *The Invertebrates: A Synthesis*. Wiley Blackwell
6. Kotpal R.L. (2018) *Modern Text Book of Zoology: Invertebrates*. Rastogi Publications
7. Nigam H.C. (2013) *Biology of non-chordates*. Vishal Publishing Co

Assignments(any one)

1. Project (500 words)/ presentation based on the above course content
2. Analytical MCQ based questions
3. Biological Crosswords
4. Charts
5. 500 words answer to analytical questions
6. Study based report of animals in nature

Practical Syllabus
Semester I

Course Code- P2
Practical 1: Diversity and Biology of Non-Chordata

Course outcome:

The student at the completion of the course will be able to:

- demonstrate comprehensive identification abilities of non-chordates diversity
- understand the taxonomic position and body organization of invertebrates
- make temporary and permanent preparations
- demonstrate various phenomenon

Protozoa
Observation and identification of common freshwater protozoans, with emphasis on *Amoeba, Arcella, Euglena, Paramecium, Vorticella.*
Demonstration of trichocyst discharge and cyclosis in *Paramecium*
Permanent preparation of *monocystis* to demonstrate its life history stages
Study of prepared slides

Porifera
Study of prepared slides and specimens
Glycerin preparation of spicules and spongin fibres
Permanent preparation of gemmules

Cnidaria
Study of prepared slides and specimens
Permanent preparation of *Hydra* and *Obelia*

Platyhelminthes
Study of prepared slides and specimens

Aschelminths
Study of prepared slides and specimens

Annelida
Study of prepared slides and specimens
Permanent preparation of parapodium of *Nereis,* ovary and septal nephridia of *Pheretima*
Glycerin preparation of setae *in situ* from *Pheretima*
Nerve ring of *Pheretima*

Arthropoda
Study of prepared slides and specimens
Glycerin preparation of mouth parts of housefly and mosquito (both sexes)
Permanent preparation of statocysts
Palaemon: Appendages, Hastate plate, Dissection of Central nervous system

Mollusca
Study of prepared slides and specimens
Permanent preparations of gill lamella of *Lamellidens* and *Pila*.
Pila: Dissection of Central nervous system

Echinodermata
Study of prepared slides and specimens

Hemichordata
Study of prepared slides and specimens

Semester II

P3: Diversity and Biology of Chordata

Course objectives

- To create in the student an appreciation of chordate diversity
- To develop in the student an understanding of structural and functional diversity
- To develop in the student the understanding of evolutionary relationship amongst chordates

Classification relationship of various phyla up to order.

Unit I

Protochordata 6

Origin of chordates

General features and life history: *Herdmania* and *Amphioxus*

Agnatha 3

General features: *Petromyzon* and *Myxine*

Pisces 6

Locomotion, respiration, osmoregulation and migration

General features and life history: *Scoliodon*

Unit II

Amphibia **3**

Origin of tetrapods

Paedogenesis, Parental care

Reptilia **5**

Origin of reptiles

Venomous & non-venomous snakes of India & their identification

Dinosaurs

Aves **4**

Origin of birds

Flight adaptations and mechanism of flight

Mammalia **3**

Origin of mammal

Dentition

Adaptive radiation

Unit III

Comparative functional anatomy: integument and its derivatives, endoskeleton, and locomotory organs 15

Unit IV

Comparative functional anatomy: digestive system, circulatory system, urinogenital system, nervous system and sense organs 15

Course Outcomes:

At the completion of the course, the student will be able to:

1. understand and appreciate the diversity of life with respect to chordate animals.
2. describe the general characters of chordate animals.
3. identify and classify chordate animals on the basis of their form and structure and classification.
4. explain evolutionary relationships amongst different chordate groups.

5. obtain an overview of economically important vertebrates.

Suggested Reading

1. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.
2. Kenneth V. Kardong (2015). Vertebrates: Comparative Anatomy, Function, Evolution. McGraw Hill
3. Thomas Jeffrey Parker, William A. Haswell (2016) Parker & Haswell's A Textbook of Zoology Volume 2. WENTWORTH Press
4. Eroschenko, Victor P. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins
5. Kotpal R.L. (2018) Modern Text Book of Zoology: Vertebrates. Rastogi Publications
6. Nigam H.C. (2017) Biology of Chordates. Vishal Publishing Co

Assignment (Any one)

1. Project (500 words)/ presentation based on the above course content
2. Analytical MCQ based questions
3. Biological Crosswords
4. Charts
5. 500 words answer to analytical questions
6. Study based report of animals in nature
7. Outreach activities promoting dissolution of superstitions associated with animals
8. Photography, identification and listing of local fauna

Practical Syllabus
Semester II

Course Code- P4
Practical 1: Diversity and Biology of Chordata

Course outcome:
The student at the completion of the course will be able to:

- understand the vertebrate animal diversity around.
- understand the underlying principles of classification of vertebrates.
- identify the chordate specimen, their characteristics, modifications and adaptations
- make comparative analysis by studying the histological preparations of tissues of different class of vertebrates
- make comparative analysis of the endoskeleton of vertebrates

Protochordata
Study of prepared slides and specimens

Cyclostomata
Study of prepared slides and specimens

Pisces
Study of prepared slides and specimens
Permanent preparation of scales
Labeo rohita
Afferent branchial system
Efferent branchial system
V, VII, IX and X cranial nerves and their branches
Weberian ossicles
Air bladder

Amphibia
Study of prepared slides and specimens

Reptilia
Study of prepared slides and specimens
Study of carapace and plastron

Aves
Study of prepared slides and specimens
Beak modifications, feathers

Mammalia
Study of prepared slides and specimens

Comparative histology of Amphibia and Mammalia
Comparative endoskeleton of Reptilia, Aves and Mammalia.

Semester III

P5: Environmental Biology and Wildlife

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To develop in the student an understanding of environmental structure and function
- To develop in the student an understanding of global environmental issues, policies and practices.
- To make the students aware of natural resources, their protection and conservation
- To learn about the factors polluting the environment, their impacts and control measures
- To develop in the student an understanding of significance and conservation of wild life

Unit I

Biosphere, Biomes, Ecotones, Biogeochemical cycle	3
Ecosystem: concept, types, structure, components and function (energy flow, energy transformation)	5
Trophic levels, Food chain and Food web	3
Population: characteristics, dynamics and regulation	2
r- and k-strategies	2

Unit II

Interspecific interactions	3
Ecological succession	4
Ecological niche	4
Ecological adaptations (aquatic, volant, arboreal, cursorial, fossorial and desert)	4

Unit III

Environmental pollution and management: Air, water, soil, radiation, light etc.	5
The Green house effect, Ozone depletion, Acid rain	3
Environmental awareness including water and resource conservation and sanitation	3
Environmental legislation: The Environment Protection Act (1986), The National Green Tribunal Act (2010)	2
United Nations Environment Programme (UNEP)	2

Unit IV

Wildlife of India	3
Wildlife conservation: strategies (ex situ and in situ) and legislation (Wild Life (Protection) Act (1972)	6
National park, sanctuaries and Biosphere reserves	4
IUCN: Categories and Red Data book	2

Course Outcomes:

At the completion of the course, the student will be able to:

- understand the basic concept of ecology, structure and function of ecosystem and its management.
- understand, interpret and explain how interactions between organisms and their environments drive the dynamics of individuals, populations, communities, and ecosystems.
- apply the scientific method and quantitative techniques to describe, monitor and manage environmental pollutions.
- develop critical thinking for shaping strategies (scientific, social, and legal) for environmental protection and conservation of biodiversity and sustainable development.
- understand the characteristics of population and its dynamics and illustrate how population data can be analysed using statistics, graphs, life tables, and survivorship curves.

- differentiate between environmental conditions of aquatic, aerial, terrestrial and desert ecology and the adaptations of organisms.
- enable the student to understand, compare, think and evolve strategies for wildlife management, conservation and causes of wildlife depletion.
- evaluate the renewable and non-renewable resources, compile different measures for forest conservation and determine different energy sources.

Suggested Reading:

1. Odum E.P. (2005) *Fundamentals of Ecology*. Cengage Learning India Private Limited
2. Smith Thomas M., Smith Robert Leo (2014) *Elements of Ecology*. Pearson Education
3. Krebs, Charles J. 2009. *Ecology: the experimental analysis of distribution and abundance.* Pearson.
4. Sharma PD (2018). *Fundamentals of Ecology*. Rastogi Publications.
5. Sharma PD (2018). *Environmental Biology and Toxicology*. Rastogi Publications.
6. Pepper, I.L., Gerba, C.P. & Brsusseau, M.L. 2006. *Environmental & Pollution Science*. Elsevier Academic Press.
7. Gupta, K.R. 2006. *Environmental Legislation in India*. Atlantic Publishers and Distributors.
8. Purohit, S.S. & Ranjan, R. 2007. *Ecology, Environment & Pollution*. Agrobios Publications.
9. Thangavel, P. & Sridevi, G. 2015. *Environmental Sustainability: Role of Green Technologies*, Springer Publications.
10. Wooley, T. & Kimmins, S. 2002. *Green Building Handbook* (Vol. 1&2). Spon Press
11. Darlington. P.J., 1957. *The Zoogeography: The Geographical Distribution of Animals.* Wiley Publication.
12. Caughley, G., and Sinclair, A.R.E. (1994). *Wildlife Ecology and Management*. Blackwell Science.

Assignments (any one)

1. Project (500 words)/ presentation based on the above course content
2. Analytical MCQ based questions
3. Biological Crosswords
4. Charts
5. 500 words answer to analytical questions
6. Surveys of local ecosystems and submission of report.

Practical Syllabus
Semester III

Course Code- P6
Practical I: Environmental Biology and Wildlife

Course outcome:

The student at the completion of the course will be able to:

- understand the basic concepts, importance, status and interaction between organisms and environment.
- facilitate students to take up research in wildlife.

1. Measurement of temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO_2
2. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
3. Study of population dynamics through numerical problems.
4. Animal diversity assessment field studies in local areas following survey and sampling protocols
5. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.
6. Report applications of zoology in nearby localities
7. Wildlife surveys and reports in nearby localities

Semester IV

P7: Applied Zoology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To analyse the relationships among animals, plants and microbes
- To understand the applications of biological sciences in Lac culture, Sericulture, Apiculture, Aquaculture, Poultry and Vermicomposting
- To explain the tools and techniques used in various cultures
- To explain the modifications and adaptations in animals

Unit I

Major infectious and communicable diseases: (malaria, filaria, tuberculosis, cholera and AIDS), their vectors, pathogens and prevention. 15

Unit II

Cattle and livestock diseases, their pathogens (helminthes) and vectors (ticks, mites, *Tabanus, Stomoxys*). 10

Pests of sugarcane (*Pyrilla perpusiella*) and rice (*Sitophilus oryzae*) 5

Unit III

Lac culture 5
Sericulture 5
Apiculture 5

Unit IV

Aquaculture 6
Poultry 5
Vermiculture 4

Course Outcomes:

At the completion of the course, the student will be able to:

- understand the life history of vectors and pests, the diseases caused and their control
- understand the life history of parasites of domestic animals
- gain knowledge of Agro based Small Scale industries
- study the culture of various organisms for economic benefit
- have a broad array of career options and activities in human medicine, biomedical research and allied health professions

Suggested Readings

1. Nigam H C (2014) Emerging Trends in Biology & Economic Zoology. Vishal Publishing Co.
2. Shukla GS & Upadhyay VB (2017) Economic Zoology Rastogi Publications
3. Srivastava KP and Dhaliwal GS. Textbook of Applied Entomology Volume 1 & 2. Kalyani Publishers.
4. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
5. Simpson: Principles of Animal Taxonomy (1962, Oxford).
6. Mayer & Ashlock: Principles of Systematic Zoology (2nd Edition, McGraw Hill).
7. Kapoor: Theory and Practicals of Animal Taxonomy (1988, Oxford & IBH).
8. Zar JH (2010) Biostatistical Analysis. 5th Edition. Pearson.

9. Sokal, R. R., &Rohlf, F. J. (1981). Biometry: The principles and practice of statistics in biological research. San Francisco: W.H. Freeman

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

Practical Syllabus
Semester IV

Course Code- P8
Practical I: Applied Zoology

Course outcome:

The student at the completion of the course will be able to:

- learn the basic principles involved in the lac culture, sericulture, apiculture, aquaculture, poultry and vermicomposting.
- explain the tools and techniques used in various cultures
- identify various methodology and perspectives of applied branches of zoology

1. Study of permanent slides/photomicrographs and specimens of *Plasmodium vivax, Entamoeba histolytica, Trypanosoma gambiense, Ascaris lumbricoides, Ancylostoma duodenale* and *Wuchereria bancrofti*
2. Study of arthropod vectors associated with human diseases: *Pediculus, Culex, Anopheles, Aedes* and *Xenopsylla*.
3. Study of insect damage to different plant parts/stored grains through damaged products/photographs.
4. Visit to poultry farm or animal breeding centre.
5. Maintenance of freshwater aquarium.

Semester V

P9: Animal Physiology and Biochemistry

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To develop in the student an understanding of functioning of an organisms' body
- To develop in the student an understanding of the various homeostatic systems of the body
- To develop in the student an understanding of regulation of function in the body

Unit I

Digestion **4**

Physiology of digestion and absorption of protein, carbohydrates and lipid

Respiration

Transport of oxygen and carbon dioxide in blood 4
Respiratory volumes and capacities
Ventilators

Circulation **4**

Composition and constituents of blood
Blood groups and Rh factor
Factors and mechanisms of coagulation
Origin and conduction of the cardiac impulse
Cardiac cycle

Excretion **3**

Structure of nephron and urine formation
Regulation of water and acid-base balance

Unit II

Nerve Physiology **3**

Structure of neuron, conduction of nerve impulse
Synaptic transmission
Neurotransmittors

Muscles **3**

Types of muscles and mechanism of contraction of skeletal muscles
Effects of exercise on muscles

6

Endocrine glands

Structure and function of pitiutary, pineal, thyroid, parathyroid, pancrease and adrenal glands.

Reproduction **3**

Physiology of reproduction, puberty and menopause

Unit III

Proteins: Structure, transamination, deamination and urea cycle 4
Carbohydrates: Structure, Glycolysis, Krebs cycle, Electron transport chain, Glycogenolysis, gluconeogenesis 7
Lipids: Structure and Beta oxidation of palmitic acid 4

Unit IV

Enzymes: nomenclature and classification; cofactors, coenzymes, ribozymes, isozymes, abzymes; mechanism of action; kinetics 15

Vitamins and deficiency diseases

Course Outcomes:

At the completion of the course, the student will be able to:

1. understand various functional components of the body
2. understand the mechanism underlying maintenance of homeostasis of the body
3. have an enhanced knowledge and appreciation of mammalian physiology;
4. understand the functions of important physiological systems including the cardio-respiratory, renal, reproductive and metabolic systems;
5. understand how these separate systems interact to yield integrated physiological responses to challenges such as exercise, fasting and ascent to high altitude, and how they can sometimes fail;
6. understand structure and function of biomolecules.
7. have to a fundamental understanding of Proteins
8. explain Enzyme catalysis and kinetics

Suggested Reading

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons
3. Christopher D. Moyes, Patricia M. Schulte 2016 Principles of Animal Physiology. 3rd Edition, Pearson Education,
4. Boyer: Concepts in Biochemistry (3rd ed. 2006, Brooks/Cole)
5. Lehninger, Nelson & Cox: Principles of Biochemistry (4th ed, 2007, Worth),
6. Murray *et al*: Harper's Biochemistry (25th ed. 2000, Appleton & Lange)
7. Stryer: Biochemistry (5th ed. 2001, Freeman)
8. Conn E., Stumpf P. (2009) Outlines Of Biochemistry, 5th edition, John Wiley & Son

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions
7. Outreach activities promoting awareness of physiological and immunological diseases and disorders.
8. Surveys on health indices, disease spread in family, neighbours, communities.

Practical Syllabus
Semester V

Course Code- P10
Practical I: Animal Physiology and Biochemistry

Course outcome:

The student at the completion of the course will be able to:

- Perform basic hematological laboratory testing
- Distinguish normal and abnormal physiological/hematological laboratory findings to predict the diagnosis of hematological disorders and diseases.

1. Preparation of Haemin crystals
2. Preparation of neuron, cartilage, striated muscle and smooth muscle.
3. Demonstration of use of Respirometer
4. Study of blood film
5. Blood group demonstration
6. Rh factor
7. Bleeding time and clotting time
8. Haemoglobinometer
9. Haemocytometer
10. Kymograph
11. Qualitative tests for presence of glucose, acetone, amino acids and albumin.
12. Preparation of bead and stick models of amino acids and dipeptides
13. Action of salivary amylase under optimum conditions.
14. Effect of pH, and temperature on the action of salivary amylase
15. Demonstration of paper chromatography
16. Detailed description of Paper chromatograph and ph Meter

P11x: Biosystematics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

To develop:

- understanding of animal taxonomy and systematic and their application
- molecular basis of animal taxonomy.

Unit I

Introduction to taxonomy and biosystematics **15**

Definition and basic concepts of taxonomy and systematics
Types and operation of taxonomy
Importance of taxonomy and biosystematics
International Code of Zoological Nomenclature (ICZN)
Aims and tasks of a taxonomist.
Animal diversity: Aplha, Beta and Gamma

Unit II

Biological Classification **15**

Kinds of Zoological classification
Taxonomic (Linnean) hierarchy
Concept of species
Mechanism of speciation
Theories of biological classification
Kinds and components of classification.

Unit III

Taxonomic Procedures **15**

Collection, preservation, and preparation of specimen
Curation
Process of identification, Description
Process of typification, different zoological types and their significance

Unit IV

Molecular techniques in systematics **15**

Genetic polymorphism
Electrophoretic variations
Polymerase chain reaction,
DNA sequencing
Alignment
Phylogenetic construction
Molecular-evolutionary software and tools.

Student learning outcomes

Student will be able to understand:

- the fundamental principles of systematic,
- how to classify animals according to their characters, and
- what are the theories which have to followed to study the classification

Suggested reading

1. Alfred, J.R.B and Ramakrishna. 2004. Collection, Preservation and Identification of Animals. Zoological Survey of India Publications, Calcutta.
2. Anderson T.A.2001. Invertebrate Zoology (2edn). Oxford University Press, New
3. Kapoor V.C. 1991.Theory and Practice of Animal Taxonomy. Oxford and IBH Publishing Co., Pvt. Ltd. New Delhi.
4. Young J.Z. 1950. Life of Vertebrates. Clarendon Press, Oxford, UK.
5. Winston J.E.2000. Describing species: Practical Taxonomic Procedures for Biologists. Columbia University Press, Columbia, USA.
6. Simpson G.G. Principle of animal taxonomy. Oxford IBH Publishing company.
7. Mayer E. Eleements of Taxonomy. Oxford IBH Publishing company.
8. Minnelli A. (1993). Biological Systematics. Chapman & Hall.

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P11y Evolutionary Biology

Total Credit: 04 **Teaching Hours: 60**

Course objectives

- To provide students with the basic knowledge of evolutionary biology, both presenting the general principles of the discipline and exploring in details theoretical problems and case studies.
- To explore salient features of various theories of evolution comprising of Lamarckism, Darwinism and Neo-Darwinism
- To develop comprehensive knowledge regarding various sources of variations and their role in evolution
- To give detailed explanation of key concepts of Population Genetics in terms of Hardy-Weinberg Law, Genetic Drift and Types of Natural Selection.
- To provide adequate knowledge about Micro-evolutionary changes, Speciation and Adaptive Radiation

Unit 1

Evolutionary concepts **15**

Theories of evolution (Lamrckism, Darwinism, Modern synthetic theory),
Mechanism of evoliution: mutation, genetic drift, gene flow, non random mating, natural selection, Isolating mechanism, molecular drive
Evidences for evolution, Biogenetic law
Biological species concept, Mode of speciation (allopatric and sympatric)
Hardy-Weinberg law

Unit 2

Evidences of Evolution **15**

Paleobiological: Concept of Stratigraphy and geological timescale; fossil study (types, formation and dating methods).
Anatomical: Vestigial organs; Homologous and Analogous organs (concept of parallelism and convergence in evolution).
Taxonomic: Transitional forms/evolutionary intermediates; living fossils.
Phylogenetic: Fossil based (Phylogeny of horse as a model); Molecule based- (Protein model, Cytochrome C; Gene model, Globin gene family).

Unit 3

Animal distribution **15**

Zoogeographical Realms
Continental drift and distribution of animals
Animal dispersal and thier major barriers

Unit 4

Evolution in action **15**

Evolutionary patterns (Divergent, Convergent & Parallel evolution)
Evolution of horse, elephant and man

Course Outcomes:

At the completion of the course, the student will be able to:

1. understand the concept, process and patterns of evolution.
2. acquire knowledge and reasoning skills useful to interpret biological phenomena in the light of evolution.

Suggested Reading

1. Futuyma, Douglas J. and Kirkpatrick Mark. Evolution (4th Edition) Sinauer
2. Veer Bala Rastogi (2017) Organic Evolution. Med Tech
3. Darlington P.J. *The Geographical Distribution of Animals*, R.E. Krieger Pub. Co.
4. Hall B.K. and Hallgrimsson B. (2008). *Strickberger's Evolution*. IV Edition. Jones and Bartlett Publishers Inc.
5. Dawkins, Richard. "The selfish gene: with a new introduction by the author." UK: Oxford University Press.
6. Dawkins, R. (1996). The blind watchmaker: Why the evidence of evolution reveals a universe without design. WW Norton & Company.
7. Darwin, Charles (2003). The Origin of Species: 150th Anniversary Edition
8. Huxley Julian. Evolution: The Modern Synthesis. Harper and Brothers
9. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

Semester VI

P12: Cytogenetics and Molecular Biology

Total Credit: 04 **Teaching Hours: 60**

Course objectives

- To understand the structure and function of organelles in a cell
- To learn about cellular transport and protein trafficking
- To understand the arrangement of Genes and their interaction
- To understand extra nuclear inheritance, linkage & crossing over
- To understand the DNA structure & types, chromatin structure and organization
- The course will provide an insight into the life processes at the subcellular and molecular levels
- Other important aspects include DNA and molecular genetics including gene cloning, sequencing and gene mapping in addition to the powerful techniques that revolutionized the pharmaceutical, health and agricultural industries

Unit I

Structure and function of cell and cell organelles (Plasma membrane, Mitochondria, Nucleus, Endoplasmic reticulum, Golgi Complex, ribosome and lysosomes) 15

Unit II

Chromosome: types (polytene and lampbrush), organisation of chromatin. Heterochromatin and euchromatin 15
Cell division (Mitosis and Meiosis), mitotic spindle and mitotic apparatus, chromosome movement
Cell Cycle

Unit III

Mendel's law of inheritance and its extension (Incomplete dominance, Codominance, multiple alleles, sex-linked traits) 15
Recombination, linkage
Sex determination
Mutation: Chromosomal mutations (deletion, duplication, inversion, translocation, aneuploidy and polyploidy), Gene mutation and mutagenesis
Pedigree analysis
Hereditary diseases of men

Unit IV

Nucleic Acids: structure, replication, central dogma, genetic code 15
Protein synthesis (Transcription, Translation)
RNA processing
Gene regulation

Course Outcomes:

At the completion of the course, the student will be able to:

- understand the structure and function of the cell organelles and the process of cell division.
- understand the structure of gene, Mendelian principles and learn how the information contained within them gets transferred from one generation to another.
- have conceptual understanding of molecular processes viz. DNA to trait.
- develop an understanding of concepts, mechanisms and evolutionary significance and relevance of molecular biology in the current scenario.

- understanding of the processes of central dogma viz. transcription, translation etc. underlying survival and propagation of life at molecular level.
- Apply their knowledge in problem solving and future course of their career development in higher education and research.

Suggested Reading

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India
5. Brown, T.A. Genomes 4. 4th Edition. Garland Science
6. Krebs et al. Lewin's GENES XII, Twelfth Edition. Jones and Bartlett Learning.

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

Practical Syllabus
Semester VI

Course Code- P13
Practical I: Cytogenetics and Molecular Biology

Course outcome:

The student at the completion of the course will be able to:

- Understand structure of biomolecules
- Understand inheritance of traits and pedigree analysis
- Understand tools and techniques of biological importance

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
2. Study of permanent slides of meiosis
3. Staining of cheek epithelial cells using methylene blue
4. Study of Polytene chromosomes from *Chironomus* / *Drosophila* larvae
5. Study and interpretation of electron micrographs/ photograph showing
6. DNA replication
7. Transcription
8. Split genes
9. Preparation of models of nitrogenous bases, nucleosides and nucleotides
10. Study of mode of inheritance of the following traits by pedigree charts – attached ear lobe, widow's peak and tongue rolling.
11. Probability assessment of above traits for future generations.
12. Frequency of the following genetic traits in human: widow's peak, attached ear lobe, dimples in chin, hypertrichosis, colour blindness.
13. Experiments demonstrating genetic laws and their exceptions
14. Pedigree analysis

P14x: Toxicology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To provide theoretical and applied knowledge on the effects of chemical substances on human health.
- To introduce the students with the toxicological analysis and the signs and symptoms of important toxic syndromes.
- To learn and apply toxicity tests for terrestrial and aquatic animals
- To develop an understanding of xenobiotics, their mode of action and damage caused
- To explain specific responses of Toxicity

Unit I

Exposure of toxicants

Different routes/methods of exposure, frequency & duration of exposure
Human exposure 2
Dose-response relationship 1
Selective toxicity 2
concept, significance
Basic mechanisms of selective toxicity

Toxicity Tests

Bioassay 2
Acute toxicity tests for terrestrial and aquatic animals 2
Chronic toxicity tests 2
Concept of maximum acceptable toxicant concentration (MATC) and safe concentration 2

Factors affecting toxicity

Factors related to the chemical exposure 2
Surrounding medium and the organisms

Unit II

Toxic effects of Xenobiotics

Local and systemic effects 2
Immediate and delayed effects
Reversible and irreversible effects
Biochemical and physiological effects of xenobiotics 2
Nanotoxicology 2

Bioaccumulation of Xenobiotics

Concept of bioconcentration, bioaccumulation and biomagnifications;
Bioconcentration factor 2
Process of bioaccumulation in the biological system 1

Biotransformation of Xenobiotics

Concept of biotransformation and metabolism 2
Sites of biotransformation 1
Biotransformation enzymes and general biotransformation reactions 1
Factors affecting biotransformation 1

Antidotal therapy 1

Unit III

Toxic effects:

- Digestive system 2
- Cirulatory system 2
- Respiratory system 2
- Excretory system 2
- Reproductive system 2
- Endocrine system 3
- Nervous system 2

Unit IV

Mutagenicity 2
Teratogenicity 2
Carcinogencity 2
Toxicogenomics 2
Safety evaluation of xenobiotics 2
Regulatory Toxicity 5

Course Outcomes:

At the completion of the course, the student will be able to:

- examine the application how xenobiotics disrupt normal cellular processes of genomics, proteomics, and metabolomics data
- use clinical and laboratory findings in the treatment of acute toxic exposures
- understand the xenobiotics, their categories and effects on organisms
- understand mechanisms of systemic and organ toxicity induced by xenobiotics; and learn how to analyze and interpret complex data sets in toxicological research

Suggested Reading

1. Sharma PD (2018). Environmental Biology and Toxicology. Rastogi Publications
2. Klaassen, C. & Watkins, J. (2005) Casarett&Doull's Essentials of Toxicology, 3rd edition. Lange Publications
3. Ernest Hodgson (2010) A Textbook of Modern Toxicology. Wiley
4. Beddows, C. (2017) Comprehensive Toxicology. Elsevier

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

P14y: Biotechnology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To demonstrate the innovative utilization of manipulating enzymes, various cloning and expression vectors and analysis of genomic sequences.
- To provide an insight into the direct manipulation of DNA to alter the characteristics of an organism in a particular way.
- To learn techniques like PCR, DNA fingerprinting and cell culture.
- To interpret the applications of genetic engineering in biotechnological research.

Unit I

Recombinant DNA technology 15
Cloning Vectors (Plasmid, Cosmid, Lambda bacteriophage)
Restriction enzyme
Construction of genomic and cDNA libraries

Unit II

Molecular gene techniques **15**
Transformation techniques (calcium chloride method and electroporation)
PCR, RFLP, RAPD, AFLP, and DNA fingerprinting
DNA microarray
DNA sequencing
Southern, northern, western blotting

Unit III

Culture Techniques and Applications **15**
Animal cell culture, Expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia)
Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy

Unit IV

Genetically Modified Organisms **15**
Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection.
Applications of transgenic animals: Production of pharmaceuticals, donor organs, knock out mice.
Human Genome Project

Course Outcomes:

At the completion of the course, the student will be able to:

- understand principles of animal culture, DNA fingerprinting, etc.
- learn and exhibit transformation techniques, embryo transfer technology, etc.
- get insight in applications or recombinant DNA technology in agriculture, production of therapeutic proteins
- use biotechnology in finding cure of animal diseases
- understand how transgenic animals can be useful for improving the welfare of humans and animals
- understand the ethical implications of animal biotechnology

Suggested Readings

1. Brown, T. A. (2010). Gene cloning and DNA analysis: An introduction. Hoboken: Wiley-Blackwel
2. Primrose, Sandy B. and Twyman Richard (2016). Principles of Gene Manipulation and Genomics, 8th Edition. Wiley-Blackwell

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical questions

Semester VII

P15 Developmental Biology and Immunology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The objective of this course is to provide insight on:

- The key events related to early embryogenesis including fertilization, cleavage, compaction. implantation, gastrulation and formation of body plan.
- how the single cell formed at fertilisation forms an embryo and then a fully formed adult organism.
- integration of genetics, molecular biology, biochemistry, cell biology, anatomy and physiology during embryonic development, and.
- To develop basic understanding about Immunity, its organization and their mechanisms.
- To understand in detail the basic immune mechanism related to different Immunological diseases & disorders.
- To create and develop the ideology about different vaccines, immune treatment mechanisms, autoimmunity and hypersensitivity.

Unit I

Gametogenesis (spermatogenesis and oogenesis) 15
Fertilization (external and internal)
Egg: structure and types
Morphogenesis and morphogens
Cleavage
Blastulation
Fate Maps
Gastrulation
Stem cells
Cell lineage
homeotic genes

Unit II

Chick embryo development upto primitive streak formation	4
Embryonic induction and organizers	3
Extra embryonic membranes	2
Placenta: types and physiology	2
Modes and mechanisms of regeneration	2
Genes in development of chick	2

Unit III

Immunity: concept and types 15
Cells and organs of immune systems
Immunoglobulins: types and structure of different classes
Antigen and antibodies and their interactions
Autoimmunity

Unit IV

Immunpological mechanisms and applications 15
Major Histocompitability Complex
Cytokines: properties and functions
Vaccines of different duseases and immunological reactions
Hybridoma technologies
Monoclonal antibodies

Course Outcomes:

At the completion of the course, the student will be able to:

1. understand how the single cell formed at fertilization forms an embryo and then a full adult organism
2. a variety of interacting processes, which generate an organism's heterogeneous shapes, size, and structural features,
3. how a cell behaves in response to an autonomous determinant or an external signal, and
4. an in depth understanding about Immune System &it's elaborate mechanisms.

Suggested Reading

1. Gilbert, Scott F. and Barresi, Michael J. F.. Developmental Biology. Eleventh Edition. By . Sunderland (Massachusetts): Sinauer Associates
2. Carlson BM. (1988) . Patten's Foundations of Embryology. 5th ed . New York: McGraw-Hill.
3. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby (2007) Kuby Immunology. W H Freeman
4. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. (2017). Roitt's Essential Immunology, 13th Edition. Wiley Blackwell
5. Chatterjee C C (2016) Human Physiology Volume 1 & 2. 11th edition. CBS Publishers
6. Nandini Shetty (2005) Immunology Introductory Textbook. New Age International.

Assignments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical question
7. Outreach activities promoting awareness of developmental disorders
8. Projects observing metamorphosis in insects and amphibians

P16 Animal Behaviour and Chronobiology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The course is so designed that students will learn:

- animal behaviour in the context of evolutionary and ecological biology,
- historical background and theory for animal behaviour concepts,
- recent approaches in animal behaviour,
- how the rhythmic geophysical environment impacts the internal rhythms,
- how environmental cues are perceived by the organisms and modulate the circadian physiology at molecular, cellular and systems levels, and
- the relevance of biological clock

Unit I

Behaviour: stereotypic (orientation, reflexes), instinct, learning, memory, imprinting, habituation, sensory filtering, responsiveness	6
Associative learning: classical and operant conditioning	3
Role of pheromones in alarm spreading	3
Predator detection and tactics, crypsis	3

Unit II

Territorial behaviour, migration in animals	5
Social hirerchies in primates	2
Methods of studying animal behaviour including sexual conflict, selfishness, kinship and altruism	5
Control of behaviour: hormonal, neurobiological, genetical and environmental	3

Unit III

Biological clocks	2
Biological rhythms: circadian, tidal, lunar, circannual rhythms and their characteristics	5
Zeitgebers	2
Concept of entrainment and masking	3
Photoreception	3

Unit IV

Suprachiasmatic nucleus (SCN)	3
Molecular mechanism underlying clock function	3
Regulation of seasonal migration	2
Brain waves and Electro Encephalogram (EEG)	2
Jet lag, SAD, Internal desynchronisation	2
Relevance of biological rhythms	3

Course Outcomes:

At the completion of the course, the student will be capable of:

- Understanding and identify behaviours in a variety of taxa
- discussing the proximate and ultimate causes of various behaviours
- designing and implementing experiments to test hypotheses relating to animal behaviour
- understanding about the molecules, cells, and systems of biological timing systems
- conceptualizing how species profitably inhabit in the temporal environment and space out their activities at different times of the day and seasons.
- studying and analysing the scientific literature
- contributing to public understanding of biological timing

Suggested Reading

1. Alcock John (2013). Animal Behavior: An Evolutionary Approach. Sinauer
2. Manning & Dawkins: An Introduction to Animal Behaviour (5th ed. 1998, Cambridge).
3. Mcfarland : Animal Behaviour, Psychology, Ethology and Evolution (1985, Pitman).
4. Mathur Reena (2018). Animal Behaviour. Rastogi Publications
5. Dunlap Jay. C., Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004,Chronobiology: Biological Timekeeping: Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
6. Saunders, D.S., C.G.H. Steel, X., Afopoulou (ed.)R.D. Lewis. (3rdEd) 2002 Insect Clocks Barens and Noble Inc. New York, USA
7. Moore et al. 1982. The Clock that times us.

Assigments (any one)

1. Project (500 words) highlighting recent advancements.
2. Presentation highlighting recent advancements.
3. Analytical MCQ based questions
4. Biological Crosswords
5. Charts
6. 500 words answer to analytical question.
7. Ethological observations in the form of photographs or video with scientific background of the behaviour observed

Practical Syllabus
Semester VII

Course Code- P17

Practical I: Developmental Biology, Immunology, Animal Behaviour and Chronobiology

Course outcome:

The student at the completion of the course will be able to:

- Understand embryological developmental
- Understand different behavioural patterns
- Understand the properties of biological clock

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Habituation in earthworms/mosquito larvae
4. Locomotory behaviour of bird and data analysis
5. Locomotory behaviour of dipteran larvae (Housefly/blowfly/fruitfly)
6. Locomotion on different types of substrata (writing paper, plastic sheet and sand paper)
7. Effects of light intensity and light quality on the rate of locomotion
8. Study of circadian functions in humans (daily eating, sleep and temperature patterns)

P17x Principles of Endocrinology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The objective of this course is to focus on:

- helping the students to understand the basics of endocrinology
- knowing the structure and function of endocrine glands.
- imparting knowledge about the endocrine regulation of different body functions.
- understanding the integrative working of signaling system in maintaining homeostasis.
- the endocrine disorders, their causes and symptoms

Unit I

Introduction to Endocrinology

Definition, classification and characteristics of chemical messengers (hormones, neurohormones, neurotransmitters)	04
Endocrine signaling: Endocrine, paracrine and autocrine modes	03
General mechanism of hormone action	04
Endocrine hypothalamus	04

Unit II

Hypothalamo-hypophysial system

Structure of the hypothalamo-hypophysial system	03
Hormones of the adenohypophysis	03
Hypothalamic control of adenohypophysis	03
Neurohypophysial hormones	03
Neuroendocrine integration of hormones	03

Unit III

Endocrine glands: their Structure and functions

Pituitary	02
Thyroid	02
Parathyroid	02
Endocrine pancreas	02
Adrenal	02
Gastrointestinal Tract	02
Sex glands	03

Unit IV

Endocrine disorders and pathophysiology

Diabetes insipidus	02
Dwarfism, gigantism and acromegaly	03
Goitre	01
Tetany	01
Addison’s disease	01
Cushing’s syndrome	01
Diabetes mellitus (Type I and II)	02
Osteoporosis	02
Polycystic ovary syndrome	02

Student learning outcome

The course will enable the students:

- To develop an understanding of the basic endocrinology

- To study the endocrine regulatory molecules mediating physiology and behavior
- To study the neural and endocrine components of physiological function and neuroendocrine regulation
- To understand the role of hormones in metabolic regulation, seasonality and maintaining homeostasis
- To understand the integrative working of signaling system

Suggested readings:

1. Endocrinology: Mac E. Hadley, Jon E. Levine, 2009, 6th Edition, Pearson Education
2. Vertebrate Endocrinology: David O. Norris, James A. Carr, 2013, 5th Edition, Academic Press
3. Williams Textbook of Endocrinology: H. M. Kronenberg, S. Melmed, K. S. Polonsky and P. R. Larsen, 2008, 11th Edition, Saunders, Elsevier
4. An Introduction to Neuroendocrinology: Richard E. Brown, 2005, Cambridge University Press

P18x Fundamentals of Entomology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The objective of this course is to:

- Develop understanding of Insect taxonomy, diversity and identification
- Introduce students with the morphology, anatomy and physiology of insects
- Introduce students with the significance of insects
- Make students aware of pest management

Unit I

Insect taxonomy I

General organization of the insect body	4
General Organization of insect head, thorax and abdomen	6
Overview of insect classification with emphasis on economically important insects	5

Unit II

Insect Physiology I

Integument	3
Digestive system	3
Circulatory system	3
Respiratory system	3
Endocrine system	3

Unit III

Insect Physiology II

Nervous system and sense organs	3
Reproductive system	3
Various modes of reproduction	3
Insect Development	2
Communication in insects	4

Unit IV

Applied Entomology

Insects of Medical and Veterinary Importance	4
Components of Insect Pest Management including Mechanical, Physical, Cultural, Chemical, Legal, Ecological, Biological, Microbial, Recent trends.	5
Concept and Procedure of Integrated Pest Management	2
Mode of action of organochlorine, organophosphorous and carbamate pesticides,	2
Pyrethroids and neem products.	2

Student learning outcomes

At the end of the course the students will be able to demonstrate:

- Classification and identification of insects
- Understand morphology, anatomy & physiology of insects
- understanding of pest population dynamics
- understanding of pest management measures

Suggested references

1. Richards, O. W., & Davies, R. G. (1997). Imms' General Textbook of Entomology, Volume I: Structure, Physiology and Development. London, Chapman and Hall.
2. Imms, A. D., Richards, O. W., & Davies, R. G. (Eds.). (2012). Imms' General Textbook of Entomology: Volume 2: Classification and Biology. Springer Science & Business Media.
3. B. Danforth& C. Marshall. 2003. Eickworth's Manual of Insect Morphology. (Posted PDF files on Carmen.osu.edu.
4. Snodgrass, R.E. 1993 (originally 1935). Principles of Insect Morphology (with new forward by George Eickwort). Cornell University Press. 667pp.
5. Grimaldi, D.A. and M.S. Engel. 2005. Evolution of the Insects. Cambridge University Press. 755 pp.
6. Triplehorn, C.A. and N.F. Johnson. 2005. Borror and DeLong's Introduction to the Study of Insects, 7th edition. Thomson Brooks/Cole, Belmont, CA.
7. McGavin: Essential Entomology (2001, Oxford Univ Press)
8. Srivastava: A Text Book of Applied Entomology (Vol. I & II, 2nd ed.) Kalyani Publ., 2001
9. A Textbook of Applied Entomology Vol. I and II by Srivastava and Dhaliwal

P18x Fisheries

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- The course has been designed in such a way so that the students get the knowledge of both theory and practical. It aims to enable the students to study about Fish and Fisheries as an entrepreneur.
- The professional areas such as fish farming, aquaria management, integrated fish farming has been included to make the study more interesting and job oriented.
- The course has been designed in such a way that it will act as platform for research and development.

Unit-I

Fish Morphology, Anatomy and Physiology

Fins, Scales & Tail: Types, structure and function	02
Food, feeding habits and digestion	02
Excretion & osmoregulation	02
Respiratory system: gills, physiology of respiration, air breathing organ, swim bladder	03
Circulatory system	02
Nervous system	01
Reproductive system: Gonads, reproductive cycle	02
Endocrine glands: structure and functions	01

Unit-II

Fish Biodiversity & Ecology of Teleostean Fishes

Fish Biodiversity	03
Stock (concept and structuring	03
Fish Chromosome, Karyotyping and Chromosome manipulation	03
Water quality requirements	02
Exclusive economic zone	01
Aquarium fish and their maintenance	01
Induced breeding and Bundh Breeding (Indigenous and Exotic)	02

Unit – III

Aquaculture and Fish Pond Management

Problems and prospects of aquaculture	01
Polyculture and Monoculture	02
Integrated fish farming and their management	02
Construction and lay-out of different types of ponds (Nursery, Rearing and Stocking)	02
Formulation and operation of different types of Hatcheries	02
Productivity of the pond (Planktons and Live food organism)	02
Stocking materials (Spawn, Fry and Fingerlings)and their Culture	02
Manuring, liming, eradication of predatory and weed fishes, predatory aquatic insects and their control	02

Unit – IV

Fisheries, Fish products and Fish diseases

Freshwater fisheries, Cold water fisheries and Brackish water fisheries	03
Marine fish resources of India	02
Crustacean and Molluscan Fisheries	02
Fish preservation and processing (traditional and advanced methods)	02
Fish by-products	02

Fish diseases: prevention, prophylaxis and treatment of Fungal, Bacterial, Viral and Protozoan Diseases	03
Fish in relation to Man and Human Welfare	01

Student learning outcomes

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

- know the basic concepts of fish biology and fisheries which will enable the students to utilize the knowledge in fish biology researches and also to manage the fish under controlled conditions.
- understand the status of fish resources of India.
- have the concept of fish stocks, which will be helpful to mark the fast-growing individuals of the fish after correlation of morphometric and meristic characters to the growth potential and fecundity of the different groups of the fish belonging to the same species in order to have higher yield under pond culture.
- culture the fish in ponds which would generate job and livelihood.

Suggested Readings:

1. Lagler KF, Bardach, JE, Miller, RR, Passino DRM. 1977. Freshwater Fishery Biology byIchthyology, 2nd Ed. John Wiley & Sons, New York
2. Santosh Kumar and Manju Tembhre. 2011. Fish and Fisheries.
3. Moyle PB. 1982. Fishes: An introduction to ichthyology. Prentice-Hall, Englewood cliffs.
4. Jayaram KC. 2008. Fundamentals of Fish Taxonomy.
5. Gopal Ji Srivastava. 1995. Fishes of U.P. and Bihar.
6. Paul J.B. Hart and John D. Reynolds. 1979. Handbook of Fish Biology and Fisheries.
7. Brown ME. 1966. Physiology of fishes. Vol. I and II Academic Press. New York.
8. Hoar WS, Randall DJ and Donaldson EM. 1983. Fish Physiology. Vol. IX. Academic Press, New York
9. Jhingran VG. 1991. Fish and Fisheries of India, Hindustan Publishing Corporation.
10. A Hatchery Manual for the Common, Chinese and Indian Major Carps by V.G. Jhingran and R.S.V. Pullin, Asian Development Bank, ICLARM, Manila, Philippines
11. Reid GR.1961. Ecology and Inland waters and Estuaries. Rein Hold Corp., New York.
12. Pilley, TVR and Dill, WMA. 1979. Advances in Aquaculture. Fishing News Books, Ltd. England. 11.
13. Pillay TVR and Kutty MN. 2005. Aquaculture- Principles and Practices. Blackwell.
14. Nikolsky GV. 1963. Ecology of Fishes, Academic Press.
15. Norman JR and Greenwood PH. 1975. A History of Fishes, Halsted Press.
16. Potts GW and Wootten RJ. 1984. Fish Reproduction: Strategies and Tactics, Academic Press.
17. De Silva SS & Anderson TA. 1995. Fish Nutrition in Aquaculture. Chapman & Hall Aquaculture Series.
18. Ojha JS. 2005. Aquaculture Nutrition and Biochemistry. Daya Publ.
19. Rath RK. 2000. Freshwater Aquaculture. Scientific Publ.

P18y Parasitology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To give the students a basic understanding of the diversity of parasites of medical and veterinary importance.
- To make the students familiar with the fundamentals of parasite physiology, immunology, and ecology

Unit 1

Introduction to Parasitology

General introduction; Basic definitions and concepts	03
Types of hosts and parasites	04
Types of parasite associations (phoresy, symbiosis, mutualism, symbiosis, parasitism)	05
Classification of parasites	03

Unit 2

Morphology, biology, lifecycle and control of protozoan and arthropod parasites

Parasitic protozoans 08

- *Entamoeba*
- *Giardia*
- *Plasmodium*
- *Trypanosoma*

Parasitic arthropods 07

- Ticks and mites
- Sucking lice
- Crustaceans & parasitic castration

Unit 3

Morphology, biology, lifecycle and control of helminth parasites

Parasitic trematodes (*Fasciola, Schistosoma*)	05
Parasitic cestodes (*Taenia, Echinococcus*)	05
Parasitic nematodes (*Ascaris*, *Ancylostoma*)	05

Unit 4

Physiology, immunology and ecology of parasites

Fundamentals of digestion, excretion and respiration in parasites	03
General principles of parasitic immunity and immune response, Host defence	03
Parasite immune evasion, Parasitic granuloma	02
General concepts on parasite ecology, co-evolution of hosts and parasites	03
Population and community ecology	02
Parasites as bioindicators	02

Course learning outcomes

By the end of the semester, students will be able to:

- identify the most common parasites of medical and veterinary importance.
- discuss the parasite-host relationship and describe the effects parasites have on their hosts.
- describe the basic biology, life history, physiology, immunology, and ecology of selected parasites.

Suggested text books:

1. Animal Parasitology by JD Smyth. Cambridge University Press.
2. Essentials of Parasitology by GD Schmidt. Brown Publishers
3. Foundation of Parasitology by GD Schmidt LS Roberts. McGraw Hill Publishers.
4. General Parasitology by TC Cheng. Academic Press
5. Helminths, Arthropods and Protozoa of domesticated animals by EJL Soulsby. ELBS and Bailliere Tindall. London.
6. Human Parasitology by BJ Bogitsh, CE Carter, TN Oeltmann. Academic Press.
7. Parasitology by Chaterjee K.D. Medical Publisher Calcutta.

Research Methodology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The objective of this course is to make students:

- learn and imply good laboratory practices as they are essential ingredient of a quality system
- learn the techniques and working of various equipments used for research purpose
- study the basics and application of Biostatistics
- know the principle and working of instruments in a biology laboratory

Unit-I

- **Good Laboratory Practices** **15**

Techniques and methods in Histology and Histochemistry

Fixation and preservation techniques
Tissue sectioning techniques: Microtomy, Cryosectioning
Dehydration and mounting
Histochemical techniques to demonstrate carbohydrate, lipid, collagen, nucleic acid and nerve cell

Unit-II

Microscope (Compound, Fluorescence, Phase contrast, Transmission, Confocal) 15
pH meter
Centrifuges (Ultra and Refrigerated)
Colorimeter and Spectrophotometer
HPLC
ELISA
Radioactive tracer
FISH

Unit-III

Basic Laboratory Methods: Preparation of Reagents, Chemicals & Buffers 15
Gel Electrophoretic apparatus
Gel documentation system
Transilluminator
Thermocycler
SDS PAGE
Southern blotting
Western blotting

Unit-IV

Biostatistics 15
Designing of experiments
Null hypothesis, probability
Correlation, regression
Distribution and measurement of central tendency
Chi Square test
Student t test
F- test (one way ANOVA, two way ANOVA)
Usage of statistical software (SPSS)

Student learning outcome

After successfully completing this course, students will be able to:

- Understand and ensure uniformity, consistency, reliability and reproducibility of his experimental data
- Understand the principles and applications of basic laboratory methods and instruments
- Imply appropriate tools and techniques to solve the problems and figure out the downstream events in biological sciences

Suggested readings:

- Seiler, J.P. (2005). Good Laboratory Practice: the Why and the How. Springer
- Webster, J. G. (2004). Bioinstrumentation. John Wiley & Sons Incorporated
- Enderle, J. (2005). Bioinstrumentation. In Introduction to Biomedical Engineering (pp. 403-504). Academic Press
- Reilly, M.J. (2016) Bioinstrumentation. CBS Publishers & Distributor
- Ross, M.H. and Reith, E.J. (1995). Histology A Text and Atlas. Harper International Edition
- Kiernan j.A. (2015) Histological and Histochemical Methods: Theory and Practice. Pergamon Press
- Sundar Rao P.S.S. and Richard J. (2012). Introduction to Biostatistics And Research Methods. PHI Learning Private Limited
- Sokal R.R. and Rohlf F.J. (2009). Introduction to Biostatistics. Dover Publications.

Semester VIII

P120: Major Project

Total Credits: 24

Course objectives

Students who complete a Major Project will:

- apply fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study
- demonstrate skill and knowledge of current information and technological tools and techniques specific to the professional field of study