West Bengal State University

Draft UG syllabus for

Zoology as Major

Semester	Course structure	Name of paper	Credits	SEC
Semester I	DS-1 (5)	Non-Chordates I Non-Chordates I Lab	3 2	SE- 1(3)
Semester II	DS-2 (5)	Non-Chordates II Non-Chordates II Lab	3 2	SE -2(3)
Semester III	DS-3 (5)	Chordates Chordates Lab	3 2	SE-3(3)
Semester IV	DS-4 (5)	Comparative Anatomy and Physiology Comparative Anatomy and Physiology Lab	3 2	
	DS-5 (5)	Ecology Ecology Lab/Field	3 2	
	DS-6 (5)	Cell Biology Cell Biology Lab	3 2	
	DS-7 (5)	Biochemistry Biochemistry Lab	3 2	
Semester V	DS-8 (5)	Molecular Biology Molecular Biology Lab	3 2	
	DS-9 (5)	Genetics Genetics Lab	3 2	
	DS-10 (5)	Animal Behaviour and Chronobiology Animal Behaviour and Chronobiology Lab	3 2	
	DS-11 (5)	Endocrinology, Histology and Histochemistry Endocrinology, Histology and Histochemistry Lab	3 2	
Semester VI	DS-12 (5)	Biostatistics and Taxonomy Biostatistics and Taxonomy Lab	3 2	
	DS-13 (5)	Developmental Biology Developmental Biology Lab	3 2	
	DS-14 (5)	Evolutionary Biology Evolutionary Biology Lab	3 2	
	DS-15 (5)	Immunology Immunology Lab	3 2	
Semester VII	DS-16 (5)	Entomology and vector biology Entomology and vector biology Lab	3 2	
	DS-17 (5)	Biodiversity and Conservation Biodiversity and Conservation Field	3 2	
Semester VIII	DS-18(5)	Research Methodology and Scientific writing Research Methodology and Scientific writing Lab	3 2	
	DS-19(5)	Toxicology & Cancer Biology Toxicology & Cancer Biology Lab	3 2	
	DS-20(5)	Fisheries sciences Fisheries sciences Lab/Field	3 2	
	DS-21(5)	Parasitology Parasitology Lab	3 2	

Semester I

DS-1: Non-Chordates I (Theory, 3 credits = 45 classes):

Course Objectives:

Invertebrate animals have been used medicinally for 4,000 years and have served as models for research and teaching since the late 1800s. This course contents will introduce the students to the systematic and scientific studies of the various forms of invertebrate animals present on Earth. They will learn about the general characteristics of invertebrates. The course will discuss the classification, structural and functional aspects of invertebrates. Students can identify the relative importance of invertebrates in evolutionary processes. In the laboratory work, students will understand the morphological and anatomical features of invertebrate animals.

Unit 1: General introduction to Protista and Metazoa **15 classes**

General characteristics and Classification of Protozoa up to phylum (Levine, 1980)
General characteristics *Amoeba, Paramoecium and Euglena*
Life cycle and pathogenicity of *Entamoeba histolytica, Plasmodium vivax, Giardia intestinalis* and *Leishmania donovani*
Locomotion and Reproduction in Protista (*Amoeba, Paramoecium and Euglena*)
Evolution of symmetry and segmentation of Metazoa

Unit 2: Porifera **6 classes**

General organization and Classification up to classes Canal system and spicules in sponges

Unit 3: Cnidaria **5 classes**

General organization and Classification up to classes Metagenesis in *Obelia*
Polymorphism in Cnidaria
Corals and coral reefs: types, formation, distribution, conservation significance

Unit 4: Ctenophora **3 classes**

General organization and evolutionary significance

Unit 5: Platyhelminthes **6 classes**

General organization and Classification up to classes
Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*

Unit 6: Nematoda **10 classes**

General organization and Classification up to classes
Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*
Parasitic adaptations in helminths
Origin and evolution of parasitic helminths

Classification to be followed as per Barnes (1994)

Non-Chordates I Lab (Practicals, 2 credits = 30 classes):

1. Study of whole mount of *Amoeba, Paramoecium and Euglena* , Binary fission and Conjugation in *Paramoecium*

2. Examination of pond water collected from different places for protistan diversity.

3. Study of *Sycon* (T.S. and L.S.), *Hyalonema, Euplectella, Spongilla*

4. Sudy of *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora*

5. One specimen/slide of any Ctenophore

6. Study of adult *Fasciola hepatica, Taenia solium*

7. Study of adult male and female *Ascaris lumbricoides*

Note:
1. Only conspicuous characters required to identify the organism to be noted along with the known systematic positions of it (for Protozoans up to Phylum and others up to Class)
2. It is wise to study the coloured photographs of the organisms suggested for the study as available from internet sources along with the preserved specimens, if are there, or otherwise.

Text Books:

1. Biology of the Invertebrates by Jan A Pechenik
2. Invertebrates by Brusca and Brusca 2nd Ed
3. References:
4. An introduction to Invertebrates by Janet Moore 2nd ed.
5. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
6. Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson
7. Bose, Mala. Parasitoses and Zoonoses, New Central Book Agency , 2017.
8. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
9. Invertebrate Zoology : Third Edition; Paul A Meglitsch , Frederick R Schram January 2020 , OXFORD UNIVERSITY PRESS

Students are encouraged to explore authentic websites (for e.g. Wikipedia, different university websites, OCWs) on internet for reading/audio-visual materials on a particular topic if they do not find enough in the text books.

Course Outcome:

Students would appreciate the diversity of lower and higher invertebrates including arthropods, molluscs and echinoderms with a thorough understanding of the invertebrate animal architecture and functions during evolution. The major outcome is that the course would create awareness of the economic importance and significance of invertebrates. Students will be aware of the involvement of different invertebrate animals in human health and agriculture; diseases caused by invertebrates and the understanding of their modes of transmission by invertebrate animals.

Semester II

DS-2: Non-Chordates II (Theory, 3 credits = 45 classes):

Course Objectives:

Invertebrate animals have been used medicinally for 4,000 years and have served as models for research and teaching since the late 1800s. This course contents will introduce the students to the systematic and scientific studies of the various forms of invertebrate animals present on Earth. They will learn about the general characteristics of invertebrates. The course will discuss the classification, structural and functional aspects of invertebrates. Students can identify the relative importance of invertebrates in evolutionary processes. In the laboratory work, students will understand the morphological and anatomical features of invertebrate animals.

Unit 1: Introduction to Coelomates **3 classes**

Evolution of coelom and metamerism

Unit 2: Annelida **4 classes**

General organization and classification up to classes Excretion and osmoregulation in Annelida

Unit 3: Arthropoda **10 classes**

General characteristics and classification up to classes Respiration in Arthropoda
General organization and evolutionary significance: King Crab and Crustacean Larvae

Unit 4: Onychophora **2 classes**

General organization and evolutionary significance

Unit 5: Mollusca **10 classes**

General characteristics and classification up to classes Nervous System and respiration in Mollusca
Torsion and detorsion in Gastropoda
Evolutionary significance of trochophore larva

Unit 6: Echinodermata **8 classes**

General characteristics and Classification up to classes
Water-vascular system in Asteroidea
Larval forms in Echinodermata

Unit 7: Hemichordata **8 classes**

General organization of phylum Hemichordata.
Phylogenetic relationship with non-chordates and chordates (only recent concepts) *.
Filter feeding in *Balanoglossus*

Classification to be followed as per Barnes (1994)

Non-Chordates II Lab (Practicals, 2 credits = 30 classes):

1. Study of following specimens:

Annelids - *Aphrodita*, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria
Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus,*

Scolopendra, Julus, Bombyx, Periplaneta, termites and honey bees

Onychophora - *Peripatus*
Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus*
Echinoderms - *Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria and Antedon*
Hemichordates- *Saccoglossus*

2. Mount of mouth parts and dissection of digestive system,nervous system and reproductive system of *Periplaneta*

3. To submit a Project Report on any related topic on pond water invertebrate diversity Or life cycles of mosquitoes Or butterfly/moth etc Or coral and coral reefs.

Note:
1. Only conspicuous characters required to identify the organism to be noted. Along with it, the systematic positions of the organism are to be mentioned (up to Class).
2. It is wise to study the coloured photographs of the whole organisms or its parts suggested for the study as available from internet sources along with the preserved specimens, if are there, and otherwise. Dissections of animals other than common pests are discouraged.

Text Books:

1. Biology of the Invertebrates by Jan A Pechenik, Mcgrew-Hill, 2014 Or
2. Invertebrates by Brusca and Brusca 2nd Ed, Sinauer Associates

References:

1. An introduction to Invertebrates by Janet Moore 2nd ed.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
3. Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson
4. Chaudhury,S.(2017). Economic Zoology. New Central Book Agency
5. Invertebrate Zoology: Third Edition; Paul A Meglitsch, Frederick R Schram January 2020 , OXFORD UNIVERSITY PRESS
6. (https://www.nature.com/articles/nature16150) for hemichordate phylogenetic relationships*
7. Students are encouraged to explore authentic websites (for e.g. Wikipedia, different university websites and OCWs) on internet for reading/audio-visual materials on a particular topic if they do not find enough in the text books or otherwise).

Course Outcome:

Students would appreciate the diversity of lower and higher invertebrates including arthropods, molluscs and echinoderms with a thorough understanding of the invertebrate animal architecture and functions during evolution. The major outcome is that the course would create awareness of the economic importance and significance of invertebrates. Students will be aware of the involvement of different invertebrate animals in human health and agriculture; diseases caused by invertebrates and the understanding of their modes of transmission by invertebrate animals.

Semester III

DS-3: Chordates (Theory, 3 credits= 45 classes):

Course Objectives:

The students will be made aware of the distinguishing characters of chordates and their classification upto class. This section includes topics on the origin of the chordates , Dipleurula concept and the Echinoderm theory of origin of chordates and advanced features of vertebrates over Protochordata. Apart from this a more detail look into Agnatha, Pisces, Amphibia, Reptilia, Aves and Mammals is provided along with classification details. The course will discuss the classification, structural and functional aspects of choradtes. Students can identify the relative importance of chordates in evolutionary processes. This course ends with discussion on the zoogeographical realms. In the laboratory work, students will understand the morphological and anatomical features of chordate animals.

Unit 1: Introduction to Chordates **2 classes**
General characteristics and outline classification of Phylum Chordata up to Class

Unit 2: Protochordata **4 classes**
General characteristics and classification of sub-phylum Urochordata and Cephalochordata up to Classes. Metamorphosis in *Ascidia*
Chordate Features and Feeding in *Branchiostoma*

Unit 3: Origin of Chordata **4 classes**
Dipleurula concept and the Echinoderm theory of origin of chordates
Advanced features of vertebrates over Protochordata

Unit 4: Agnatha **2 classes**
General characteristics and classification of cyclostomes up to order

Unit 5: Pisces **5 classes**
General characteristics and classification of Chondrichthyes and Osteichthyes up to Subclasses (Romer 1959).
Accessory respiratory organ, osmoregulation and swim bladder in fishes.

Unit 6: Amphibia **4 classes**
General characteristics and classification up to living Orders
Metamorphosis and parental care in Amphibia

Unit 7: Reptilia **4 clasees**
General characteristics and classification up to living Orders
Poison apparatus and biting mechanism in snake

Unit 8: Aves **8 classes**
General characteristics and classification up to Sub-Classes
Respiration in birds
Migration in birds
Principles and aerodynamics of flight

Unit 9: Mammals **8 classes**

General characters and classification up to living orders
Phylogenetic significance of Prototheria
Adaptive radiation in mammals with reference to locomotory appendages
Echolocation in Microchiropterans and Cetaceans

Unit 10: Zoogeography **4 classes**

Zoogeographical realms
Plate tectonic and Continental drift theory
Distribution of birds and mammals in different realms

Note: Classification schemes are to be followed as given in Kardong, 2004.

Chordates Lab (Practicals, 2 credits= 30 classes):

Lab/field study of –

1. Protochordata
Herdmania, Branchiostoma,
Colonial Urochordates; Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of Amphioxus through pharyngeal, intestinal and caudal regions, *Herdmania* spicules

2. Agnatha
Petromyzon, Myxine

3. Fishes
Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetraodon, Anabas, Flat fish

4. Amphibia
Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra

5. Reptilia
Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus
Key for Identification of poisonous and non- poisonous snakes

6. Aves
Study of six common birds from different orders (Stork, Owl/Falcon, Sun Bird, Jacana, Duck)- types of beaks and claws.

7. Mammalia
Sorex, Bat (Insectivorous and Frugivorous), *Funambulus, Loris, Herpestes, Erinaceous*.

8. Mount of weberian ossicles of *Mystus* or any Carp, Pecten from Fowl head

Note:
1. Only conspicuous characters required to identify the animal are to be noted. Along with it, the systematic positions of the animal mentioned (up to Class) and a short note on its habits and habitat are to be noted.
2. It is wise to study the coloured photographs of the whole animal and/or its parts mentioned above for the study, as available from internet sources along with the preserved specimens (if, they are already in the museum). New collection/purchase of animals or their body parts, especially for those which are protected by conservation laws are to be avoided. Dissections of animals other than common pests are discouraged.

Text Book:

1. Kardong, K. V. (2002). Vertebrates: Comparative anatomy, function evolution. McGraw Hill 4th Ed. 2005.
2. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
3. Pough H. Vertebrate life, VIII Edition, Pearson International.
4. Paul A Meglitsch and Frederick R Schram. (2020). Invertebrate Zoology. ISBN-13: 978-0197535783 ISBN-10: 019753578X

References:

1. Students are encouraged to explore authentic websites (for e.g. Wikipedia, different university websites and OCWs) on internet for reading/audio-visual materials on a particular topic if they do not find enough in the text books or otherwise).
2. Comparative Anatomy of the Vertebrates 9th Ed (2015) by Kent; McGrew-Hill
3. Elements of Chordate Anatomy by Weichert and Presch, 2017, Amazon.in

Course Outcomes

Students would appreciate the diversity of lower and higher vertebrates including the various specialties and diversities found in Agnatha, Pisces, Amphibia, Reptilia, Aves and Mammals with a thorough understanding of the chordate animal architecture and functions during evolution. The major outcome is that the course would create awareness of the economic importance and significance of chordates. Students will be aware of the involvement of different chordate features such as metamorphosis, regeneration, parental care, poison apparatus and biting mechanism in snake, migration in birds and others which shall help the student in research. A student perusing a career in research of wild life, experimental biology, zoological gardens will benefit from the knowledge and practical exposure from this course.

Semester IV

DS-4: Comparative Anatomy and Physiology of Vertebrates (Theory, 3 credits = 45 classes):

Course Objectives:

The basic "Comparative Anatomy and Physiology" is a powerful study to help the students to explore the functional logic of living systems. All organisms are made up of cells & systems. This course is designed to explore the fundamentals of body structure & its function and their evolution. We hope learners will develop a deep intuition to understand the functional logic of a basic anatomy & physiology. To underscore the importance of physiology in our lives, we will address anatomy of our body parts.

Comparative Anatomy:

Unit 1: **2 classes**

Structure, function and derivatives of integument in amphibians, birds and mammals.

Unit 2: **3 classes**

Overview of axial and appendicular skeleton; Jaw suspension; Visceral arches.

Unit 3: **2 classes**

Dentition in mammals

Unit 4: **3 classes**

General plan of circulation, Comparative account of heart and aortic arches

Unit 5: **3 classes**

Respiratory organs in fish, amphibian, birds and mammals

Unit 6: **2 classes**

Succession of kidney, Evolution of urinogenital ducts

Unit 7: **3 classes**

Comparative account of brain in vertebrates: fish, bird and mammal

Physiology:

Unit 8: Tissues **2 classes**

Structure, classification and functions of epithelial tissues, connective tissues and muscular tissues

Unit 9: Digestive System **4 classes**

Structural organization and functions of Gastrointestinal tract and associated glands; modification of digestive tract in ruminants

Unit 10: Respiratory System **4 classes**

Mechanism of Respiration, Respiratory volumes and capacities, transport of Oxygen and Carbon dioxide in blood, Dissociation curves and the factors influencing it, respiratory pigments.

Unit-11: Muscular system **2 classes**

Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction.

Unit 12: Circulatory System **4 classes**

Structure and working of conducting myocardial fibers, Origin and conduction of cardiac impulses; Cardiac Cycle and cardiac output, Components of Blood and their functions (blood buffering mechanism); Haemostasis; Blood clotting system.

Unit 13: Nervous System **4 classes**

Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission and Neuromuscular junction.

Unit 14: Thermoregulation **3 classes**
Physiological classification based on thermal biology. Thermal biology of endotherms; Hibernation, torpor aestivation; anti-freezing mechanism in polar fish

Unit 15: Urinary System **2 classes**

Structure of Kidney and its functional unit, Mechanism of hyper tonic urine formation,

Unit 16: Reproductive System **2 classes**

Gametogenesis of mammals; histology of ovary and testis

Comparative Anatomy and Physiology Lab (Practicals, 2 credits= 30 classes):

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Study of disarticulated skeleton of Toad, Pigeon and Guineapig
3. Dissection of Tilapia: circulatory system, brain, pituitary, urinogenital system
4. Determination of ABO Blood group.
5. Total count and differential count of blood.
6. Preparation of Haemin crystals from fish and rat.

Text Books:

1. Comparative Anatomy of the Vertebrates 9th Ed (2015) by Kent; McGrew-Hill
2. Elements of Chordate Anatomy by Weichert and Presch, 2017, Amazon.in
3. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece , Published by Pearson Copyright © 2017.
4. Sembulingam K, Sembulingam P. 2012. Essentials of Medical Physiology. 6th Edn. Jaypee.
5. Ganong's Review of Medical Physiology by Barret; 25th Ed, McGrew-Hill, 2016

References:

1. Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons
2. Kardong, K. V. (2002). Vertebrates: Comparative anatomy, function evolution. McGraw Hill 4th Ed. 2005.
3. Elaine N. Marieb, 2006. Human Anatomy & Physiology, Pearson Education.
4. Eroschenko VP. 2008. diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott & Wilkins.
5. Fox SI. 2011. Human Physiology. 12th Edn. Mc Graw Hill
6. Gunstream SE. 2010. Anatomy and Physiology with integrated study guide. 4th Edn., Mc Graw Hill.
7. Guyton AC, Hall JE. 2006. Textbook of Medical Physiology. XI Edn. Hercourt Asia PTE Ltd.

W.B. Saunders Company.
8. Hill RW, Wyse GA, Anderson M. 2012. Animal Physiology. 3rd Edn. Sineuer Associaes.
Sembulingam K, Sembulingam P. 2012. Essentials of Medical Physiology. 6th Edn. Jaypee Pub, New Delhi
9. Sherwood L. 2013. Human Physiology from cells to systems. 8th Edn., Brooks & Cole
10. Tortora GJ, Grabowski S. 2006. Principles of Anatomy & Physiology. XI Edition John Wiley & son
11. Vander A, Sherman J, Luciano D. 2014. Vander's Human Physiology:The Mechanism of Body Function. XIII Edn. McGraw Hills

Course Outcome

The course will provide a advanced concept of the basic structural similarities, dissimilarities, uniqueness in terms of both anatomy in selected vertebrate groups. Students in physiology shall be introduced to the structure function relationship in terms of mammalian system which will aid them understand and interpret both medical and evolutionary observations. The combination of comparative anatomy and physiology will enable students analyze experimental outcomes in similar models and shall aid them in the fields of drug designing, toxicology, pharmaceutical science and clinical experimentations.

DS-5: Ecology (Theory, 3 credits= 45 classes):

Course Objectives:

The aim of the course is that the students understand nature in the context of ecosystem dynamics, ecosystem functioning and provision of ecosystem services. The course would demonstrate a broad understanding of the processes that shape the distribution and abundance of organisms from the micro-habitat to the globe; recognize that the distribution of organisms is a product of positive and negative interactions within and across trophic levels, including competition, mutualism, predation, and parasitism. The course will provide information on key factors that influence the habitat including climate, energy input, spatial/temporal complexity, and resource availability. Students will develop an appreciation of the ecosystem services and would appreciate the modern scopes of scientific inquiry in the field of Ecology. They will develop an understanding of the differences in the structure and function of different types of ecosystems and will learn techniques of data analysis as well as methods of presenting scientific information in figures and tables. They will develop an appreciation of the natural world through direct experience with local ecosystems; learn techniques for gathering data in the field.

Unit 1: Introduction to Ecology **4 classes**

History of ecology, Autecology and synecology, Levels of organization, Laws of limiting factors, Study of Physical factors, biomes.

Unit 2: Population **20 classes**

Concept of population and metapopulation
Unique and group attributes of population: Demographic factors, life tables, fecundity tables, survivorship curves, dispersal and dispersion.
Geometric, exponential and logistic growth, equation and patterns, r and K strategies Population regulation - density- dependent and independent factors

Unit 3: Community **8 classes**

Population Interactions: Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition. Community characteristics: species diversity, measures of diversity; abundance, dominance, richness, Vertical stratification, Ecotone and edge effect. Ecological

succession and examples of it.
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Unit 4: Ecosystem **8 classes**

Food chains, Food web, Ecological pyramids, Energy flow through the ecosystem, Ecological efficiencies, Biogeochemical cycles (Nitrogen cycle and water cycle), Human modified ecosystem.

Unit 5: Applied Ecology **5 classes**

Introduction to Indian ecosystems (outline idea of mangrove, desert, wetland, montane);
Concept of Ramsar site; Ramsar sites of India; Ecosystem services with special reference to wetlands.
Sustainable environment; SDG goals; Outline ideas and objective of Indian Environmental Laws.

Ecology Lab/Field (Practicals, 2 credits = 30 classes):

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided

2. Determination of population density of a natural/hypothetical population. Study of species diversity of a community by quadrat or any other suitable sampling method and calculation of diversity indices.

3. Study of an aquatic ecosystem: Sampling of zooplankton, Measurements of temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), free CO2.

4. Field Study: Visit to a National Park/Wildlife Sanctuary/ any other Protected Forest/ any natural habitat. Report (including the actual field diary) on the study of the landscape and habitat features, Survey on: Types of Forests, Major Flora and Fauna, Man-animal conflicts and other problems.

Text Books:

1. Ecology: Theories and Applications by Peter Stiling; Pearson 4th Ed. 2001.
2. Ecology: The Experimental Analysis of Distribution and Abundance (Indian Paperback edition) by Charles Krebs
3. Ecology: Principles and Applications by J. L. Chapman, M. J. Reiss • 1999. Cambridge University Press
4. Townsend C and Michael Begon. (2008). Essentials of Ecology. Blackwell.
5. Michael Dobson and Chris Frid. (2008). Ecology of Aquatic Systems. OUP.
6. Charles J. Krebs. Ecology : The experimental analysis of distribution and abundance. (2009). Edition 6th ed. Benjamin Cummings.
7. Manuel Molles and Anna A Sher. (2009). Ecology: Concepts and Applications 8th Edition. McGraw-Hill.
8. William D. Bowman and Sally D. Hacker. (2009). Ecology, 5th Edition. Sinauer Associates.
9. David T. Krohne. (2009). Ecology: Evolution, Application, Integration 2nd Edition. Oxford University Press.
10. Nicholas B. Davies, John R. Krebs, Stuart A. West (2010). An Introduction to Behavioural Ecology 4th Edition. Wiley-Blackwell

Referrences:

1. A Primer of Ecology by Gotelli; 3rd Ed. Sinauer Associates. 2000.
2. Students are encouraged to explore authentic websites (for e.g. Wikipedia, different university websites and OCWs) on internet, for reading/audio-visual materials on a particular topic if they do not find enough in the text books or otherwise).

Course Outcome:

Students would be in a position to identify the relations between the abundance and distribution of organisms in nature. The course will make the students familiar with the variety of ways that organisms interact with both the physical and the biological environment. They would be able to analyze interactions within the context of specific habitats and judge how the habitat shapes the distribution and abundance of species. The course would equip the students to evaluate the relationships among ecological interactions and habitat context. Finally, the in-depth studies would surely help the students to distinguish how the evolution of organism form and function influences ecological interactions and habitat tolerance and judge how ecological processes, in turn, shape the evolution of organism form and function.

DS-6: Cell Biology (Theory, 3 credits= 45 classes):

Course Objectives:

This course will elevate a students' knowledge of structure and function of a cell. A more deeper and in-depth study of the organelles and their function shall help the student to understand how these building blocks function and respond. The first unit is a general brush up and additive of the class 12 understanding of different kinds of cellular organisms. Unit I2 to 6 deals with the understanding of the cellular organelles in an advanced level. The last two units is deal with the functional part of cell and the basis of life, multiplication of its own kind (cell division) and its functional logic (cell signaling).

Unit 1: Overview of Cells **3 classes**

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions

Unit 2: Plasma Membrane **10 classes**

Various models of plasma membrane
Transport across membranes: Active and Passive transport, Facilitated transport Cell junctions: Tight junctions, Desmosomes, Gap junctions
Extracellular Matrix-Cell Interactions

Unit 3: Endomembrane System **4 classes**

Structure and Functions: Golgi Apparatus, Endoplasmic Reticulum, Lysosomes

Unit 4: Mitochondria and Peroxisomes **8 classes**

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis; Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis; Peroxisomes

Unit 5: Cytoskeleton **2 classes**

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments

Unit 6: Nucleus **6 classes**
Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus, Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome)

Unit 7: Cell Division **8 classes**
Mitosis and Meiosis
Cell cycle and its regulation
Cancer (Concept of oncogenes and tumor suppressor genes) Mechanisms of cell death: brief overview

Unit 8: Cell Signaling **4 classes**

Cell signaling transduction pathways; Types of signaling molecules and receptors GPCR and Role of secondary messenger (cAMP)

Cell Biology Lab (Practicals, 2 credits = 30 classes):

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
2. Study of various stages of meiosis (in pre-prepared slides and/or in photographs obtained from websites).
3. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
4. Preparation of permanent slide to demonstrate: DNA by Feulgen reaction
5. Cell viability study by Trypan Blue staining
6. Mitochondrial staining from cheek cells.
7. Blood Smear preparation and Identification of blood cells

Text Books:

1. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece , Published by Pearson Copyright © 2017
2. Cell Biology by Gerald Karp; Wiley, 7th Ed. 2013

References:

1. Essentials of Cell Biology by Bruce Albert et al.; W.W. Norton Co., 4th Ed, 2013 Or
2. Molecular Cell Biology by Hurvey Lodish et al.; W. H. Freeman, 6th Ed.2013

Course Outcome:

The knowledge of cell biology will help the student understand the function unit of life. It will also lay the foundation for understanding the importance of cell biology in our lives, and address questions of cellular disorders, and associated health implications in the human society. Cell biology is an important subject in research and related to basic science, pharmaceutical industry, pathology and allied fields.

DS-7: Biochemistry (Theory, 3 credits= 45 classes):

Course Objectives:

Biochemistry finds it application in any and every stream of biology. It is important that a student understands the chemical basis of life which forms the axis of principal organization of prokaryotic and eukaryotic cells. Living organisms (a cell to the entire organism) is made out of molecules. Ultimately it's the interactions between different chemical molecules/motifs that underline basic function of living organisms. Biochemistry helps in delineating these chemical interactions in living organism to perform its basic live-sustaining functionaries. This course will deal with the different classes of biomolecules, their structure and function coupled with their interaction with each other. This stream is the bridge between the physical/chemical science and its application in biological processes.

Unit 1: Fundamentals of biochemical reactions and metabolism 4 classes

Thermodynamics, concept of Free energy changes, Ionization of water, weak acids and bases, buffering and pH changes in living systems

Unit 2: Carbohydrates **5 classes**

Basic Structure of carbohydrate structure, isomerism. Carbohydrate metabolism: Glycolysis, Citric acid cycle, Pentose phosphate pathway, Gluconeogenesis

Unit 3: Lipids **6 classes**

Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Triacylglycerols, Phospholipids, Sphingolipid, Glycolipids, Steroids, Eicosanoids and terpenoids.
Lipid metabolism: β-oxidation of fatty acids; Fatty acid biosynthesis

Unit 4: Proteins **8 classes**

Amino acids Structure, Classification, General and Electro chemical properties of α-amino acids; Physiological importance of essential and non-essential amino acids
Proteins Bonds stabilizing protein structure; Levels of organization
Protein metabolism: Transamination, Deamination, Urea cycle, Fate of C-skeleton of Glucogenic and Ketogenic amino acids

Unit 5: Nucleic Acids **8 classes**

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids
Types of DNA and RNA, Complementarity of DNA, Hypo- Hyperchromaticity of DNA, Outlines of nucleotide metabolism

Unit 6: Enzymes **10 classes**

Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes;
Mechanism of enzyme action; Enzyme kinetics; Derivation of Michaelis-Menten equation, Lineweaver- Burk plot; Factors affecting rate of enzyme-catalyzed reactions;
Enzyme inhibition; Allosteric enzymes and their kinetics; Strategy of enzyme action- Catalytic and Regulatory (Basic concept with one example each)

Unit 7: Oxidative Phosphorylation **4 classes**

Redox systems; Review of mitochondrial respiratory chain, Inhibitors and un-couplers of Electron Transport System

Biochemistry Lab (Practicals, 2 credits = 30 classes):

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.

2. Paper chromatography of amino acids.

3. Quantitative estimation by Lowry Method.

4. Demonstration of separation of proteins by SDS-PAGE.

5. Study of the enzymatic activity of amylase: effect of temperature and pH

6. Performing Acid and Alkaline phosphatase assay from serum/tissue.

Textbooks:

1. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece , Published by Pearson, 2017.
2. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H.

Freeman and Co., New York

References:

1. Principles of Biochemistry by Voet, Pratt and Voet; Wiley International Student Ed. 2012
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
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.
4. 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.

Course outcome:

Understanding Biochemistry enables students to understand and analyse the central theme of life and its associated mechanisms. Students can intermingle with the different streams of science to create unison of understanding of any topic of biology. Knowledge of this course will help a student understand the chemical interpretation of biological principles. This branch of inter- disciplinary science finds its application in basic and clinical research. It expands the understanding of biological experiments especially molecular deciphering of biological situation. This course finds it application in understanding basic science, environment, ecology, physiology, drug action/discovery, agricultural science etc. in industry, pharmaceutical science, medical science, evolutionary science but to name a few.

Semester V

DS-8: Molecular Biology (Theory, 3 credits= 45 classes):

Course Objectives:
Principle aim of the course is to equip a students understanding with a basic knowledge of the structural and functional aspects of biological macromolecules, viz., DNA, RNA and proteins and their interactions in vivo and in vitro conditions. The course is multidisciplinary in nature and aims to explain and understand the molecular interactions of life. The emphasis is on understanding the structure, function and regulation of the genetic molecules viz. DNA and RNA. The course ends with the application of the knowledge in various techniques used to understand/decipher life processes.

Unit 1: Nucleic Acids **4 classes**

Salient features of DNA and RNA; Watson and Crick Model of DNA

Unit 2: DNA Replication **6 classes**

Mechanism of DNA Replication in Prokaryotes, Semi-conservative, bidirectional and discontinuous replication, RNA priming, Replication of telomeres

Unit 3: Transcription **6 classes**

Mechanism of Transcription in prokaryotes and eukaryotes, Transcription factors, Difference between prokaryotic and eukaryotic transcription.

Unit 4: Translation **8 classes**

Mechanism of protein synthesis in prokaryotes, Ribosome structure and assembly in prokaryotes, fidelity of protein synthesis, aminoacyl tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Genetic code, Degeneracy of the genetic code and Wobble Hypothesis; Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation

Unit 5: Post Transcriptional Modifications and Processing of Eukaryotic RNA **6 classes**

Capping and Poly A tail formation in mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of tRNA

Unit 6: Gene Regulation **6 classes**

Regulation of Transcription in prokaryotes: lac operon and trp operon; Regulation of Transcription in eukaryotes: Activators, enhancers, silencer, repressors, miRNA mediated gene silencing, Genetic imprinting

Unit 7: DNA Repair Mechanisms **4 classes**

Types of DNA repair mechanisms, RecBCD model in prokaryotes, nucleotide and base excision repair, SOS repair

Unit 8: Molecular Lab Techniques **5 classes**

PCR, Western and Southern blot, Northern Blot, Sanger DNA sequencing, cDNA technology

Molecular Biology Lab (Practicals, 2 credits= 30 classes):

1. Demonstration of polytene Chromosome from Drosophila /Chironomid larvae

2. Isolation and quantification of genomic DNA using spectrophotometer (A260 measurement)
3. Agarose gel electrophoresis for DNA

Text Book:

1. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece , Published by Pearson Copyright © 2017.
2. Molecular Biology of The Gene by Watson. 7th Edition. Pearson.

References:

1. Molecular Cell Biology by Harvey Lodish. 7th Edition. W.H. Freeman.
2. iGenetics: A Molecular Approach by Peter. J. Russell. 3rd edition. Pearson Benjamin Cummings.
3. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, Cambridge Univ. Press, Paperback

Course outcome:

Apart from information the student will understand and analyse the molecular process that occur inside living organisms (cellular). This knowledge will help in designing experiments to understand the decipher/manipulate/improvise molecular puzzles. Molecular biology now centers around in more important gene manipulation in various fields of basic and clinical sciences and find huge application in bio-tech companies, crop science, medical therapeutics, diagnosis and research in general.

DS-9: Genetics (Theory, 3 credits= 45 classes):

Course Objectives:

This course aims to provide a proper foundation for understanding and applying knowledge of genetics – the study of heredity, i.e., how characters are passed down from one generation to the next. Genetics is a subject of fundamental importance in biology, and without genetics, knowledge of biology remains largely incomplete. Genes specify the biological properties of organisms. Hence it is important to have an informed understanding of genetics to have a good understanding of biology. The course lays stress on various aspects of classical genetics and also touches upon some aspects of molecular genetics. Without this course a student's training in zoology will remain fundamentally incomplete.

Unit 1: Mendelian Genetics and its Extension **8 classes**

Background of Mendel's experiments, Principles of Mendelian inheritance,
Incomplete dominance and co-dominance, Epistasis, Multiple alleles, Lethal alleles, Pleiotropy, Sex-linked, sex- influenced and sex-limited inheritance, Polygenic Inheritance.

Unit 2: Linkage, Crossing Over and Chromosomal Mapping **8 classes**

Linkage and Crossing Over, molecular basis of crossing over, Measuring Recombination frequency and linkage intensity using three factor crosses, Interference and coincidence.

Unit 3: Mutations **10 classes**

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification with one suitable example of each), Chromosomal aberrations, gene mutations and human diseases (Down's, Klienfelter's, Turner's, Cri du Chat, Sickle cell, Haemophilia, Thallassimia, Albinism – only genetical aspects here, details of physiological consequences not required), Sex chromosomes and sex-linked inheritance
Non-disjunction and variation in chromosome number; Molecular basis of mutations in relation to UV

light and chemical mutagens

Unit 4: Sex Determination **6 classes**

Mechanisms of sex determination in Drosophila with reference to alternative splicing
Sex determination in mammals
Dosage compensation in Drosophila & Human

Unit 5: Extra-chromosomal Inheritance **6 classes**

Criteria for extra chromosomal inheritance, Antibiotic resistance in Chlamydomonas, Kappa particle in Paramecium, Shell spiraling in snail

Unit 6: Recombination in Bacteria and Viruses **5 classes**

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage

Unit 7: Transposable Genetic Elements **2 classes**

Transposons in bacteria,
Ac-Ds elements in maize and P elements in Drosophila, LINE, SINE, Alu elements in humans

Genetics Lab (Practicals, 2 credits= 30 classes):

1. Chi-square analyses
   Statistical tests of data and decision making
   Chi square test for goodness of fit

2. Pedigree analysis of some inherited traits in human

3. Identification of chromosomal aberration in Drosophila from photographs

Text Books:

1. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece , Published by Pearson Copyright © 2017.
2. Principles of Genetics by Robert Tamarin; McGraw Hill, 7th Ed. 2017 Or

Principles of Genetics by Snustad, D.P., Simmons, M.J. (2009). 5th Ed. John Wiley and Sons Inc

References:

1. Developmental biology by Scott. F. Gilbert, 9th edition.
2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings
3. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition. Benjamin Cummings

Course Outcomes:

At the end of this course a student should have a broad knowledge about various aspects of genetics and know about the classical and molecular approaches towards understanding genes. This will enable them to have a holistic understanding of biology. They will achieve skills in analysing, comparing and explaining results of genetics experiments, and possess knowledge about various techniques used to study genetics. This will help them to undertake research work or higher studies related to genetics in future and will also help them in competitive examinations for higher studies.

DS-10: Animal Behaviour and Chronobiology (Theory 3 Credits = 45 classes):

Course Objectives

The subject of Animal Behaviour and Chronobiology has made recent advances and occupies an important aspect of study of animals. This course shall introduce the student a brief history of the various schools of animal behavior and enable the student to relate animal behavior to ecology, social/sexual adaptation and evolutionary biology as well as genetic basis of the disciple. A student shall also methods of studying behaviours. Chronobiology deals with the relationship of internal biological rhythms with geophysical and environmental cues. These controls relate to behavioural as well as social responses of animals. Perturbations of such rhythms are associated with perturbed internal homeostasis of the organism. A student shall be introduced and made aware of the science and its recent developments.

Unit 1: Introduction to Animal Behaviour **8 classes**

A brief history and schools of animal behaviour studies including the works of Fabre, Darwin, Von Frisch, Lorenz, Tinbergen, Jane Goodal, Biruté Galdikas, Dian Fossey, Salim Ali, Gopal Bhattacharyya, M. K. Chandrashekhar, Raghavendra Gadagkar.
The objectives of modern animal behaviour studies: Tinbergen's four questions.
Methods of studying behaviours: Observation vs Watching, Ad libitum observations, Focal animal studies, Instantaneous scan, etc.

Unit 2: Behaviours of Individuals **10 classes**

Reflexes and Orientations
Instinct
Learning: Imprinting and other Programmed Learning, Habituation, Innovations and Cultural Transmission / Social Learning

Unit 3: Social and Sexual Behaviour **14 classes**

Social Behaviour: Concept of Sociality, Types of animal Society with examples, Altruism
Communications in animals- different types (e.g. pheromones, visuals, tactile, acoustics, etc) with common examples
Insects' society with Honey bee as example; Foraging in honey bee and advantages of the waggle dance.
Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Sexual conflict in parental care.

Unit 4: Introduction to Chronobiology **7 classes**

Historical developments in chronobiology;
Biological oscillation: the concept of Average, amplitude, phase and period
Adaptive significance of biological clocks

Unit 5: Biological Rhythm **6 classes**

Types and characteristics of biological rhythms: Short- and Long- term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms;
Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms;
Photoperiod and regulation of seasonal reproduction of vertebrates; Role of melatonin.

Animal Behaviour and Chronobiology Lab (Practical, 2 Credits=30 Classes):

1. Study of nests (non-invasively) and nesting habits of birds and social insects (e.g. social

wasps).

2. Study of the behavioural responses of rice weevil/wood lice to dry and humid conditions.

3. Study of geotaxis behaviour in earthworms.

4. Study of the phototaxis behaviour in insects/defensive behaviour in mosquito larvae.

5. Visit to Biodiversity Park/Zoological Park/ any natural habitat to study behavioural activities of animals and prepare a short report.

6. Study and actogram construction of locomotor activity of suitable animal models.

7. Study of circadian functions in humans (daily eating, sleep and temperature patterns).

Text Books:

1. Animal Behaviour: Mechanisms. Ecology. Evolution by Drickamar, Vessey, 5th Ed. Jakob; McGraw Hill.
2. Survival Strategies by Raghavendra Gadagkar, University Press

References:

1. An Introduction to Animal Behaviour by Manning and Dawkins; 5th Ed. Cambridge Univ. Press
2. Measuring Behaviour: An Introductory Guide by Martin and Bateson; 3rd Ed.Cambridge Univ. Press
3. Introduction to Behavioural Ecology by Krebs and Davies; Wiley-Blackwell

Course Outcome

This course deals with both theoretical as experimental protocols of both the sciences. The scope of this course is of immense importance and demands in both industry (animal breeding/rearing) and scientific/pharmaceutical laboratories. A student perusing a career in research of wild life, experimental biology, zoological gardens will benefit from the knowledge and practical exposure from this course.

DS-11: Endocrinology, Histology and Histochemistry (Theory, 3 credits = 45 classes)

Course Objectives

Students are able to learn how the homeostatic model applies to every endocrine system in normal physiology and disease. Also able to learn how every aspect of our physiology and behavior is directly controlled or modified by hormones using reproduction, growth, development, stress, and metabolism as examples. Students are able to learn how biochemical and cellular processes of chemical communication are involved in endocrinology. Learn the various endocrine diseases and prevention. The skill gained through this course in histopathology will introduce students to microscopic features of tissues and organs, giving them the opportunity to compare and contrast the normal with the abnormal in various disease states. Students will use logical and systematic thinking to solve problems with this diagnostic technique and procedure. This course will give students an edge to pursue career in various histopathological laboratories, diagnostic centres or paramedical institutions.

Endocrinology

Unit 1: Introduction to Endocrinology **2 classes**

General idea of Endocrine systems, Classification, Characteristics and Transport of Hormones, Neurosecretions and Neurohormones

Unit 2: Epiphysis, Hypothalamo-hypophysial Axis 8 classes

Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction; Structure of pituitary gland, hormones and their functions, disorders, hypothalamus (neuroendocrine gland) - principal nuclei involved in neuroendocrine control, hypothalamo-hypophysial portal system.

Unit 3: Peripheral Endocrine Glands 8 classes

Thyroid, parathyroid, adrenal, pancreas, ovary and testis: structure, hormones, functions, regulations and disorders

Unit 4: Mechanism of Hormone Action 8 classes

Mechanism of hormone action, signal transduction pathways for steroidal and non steroidal hormones and receptors, bioassays of hormones using RIA & ELISA; estrous cycle in rat and menstrual cycle in human; hormonal regulation of parturition

Histology and Histochemistry

Unit 5: Theory and principles of different staining procedures in Histology. 4 classes

Unit 6: Theory and principles of different staining procedures in Histochemistry; Fixatives & Staining solutions; decalcification of calcified tissue before sectioning. 6 classes

Unit 7: Immunohistochemistry. 3 classes

Unit 8: Study of histology 4 classes

Bone, cartilage, stomach, small intestine, large intestine, liver, spleen, kidney, cardiac muscle, ovary, testis.

Unit 9: Histopathology in cancer tissue 2 classes

Comparing normal and abnormal tissue

Endocrinology and Histology Lab

1. Microtomy: Preparation of permanent H/E stained slide of any five (liver, heart, kidney, adrenal, thyroid, pancreas, Testis, Ovary, lung, salivary gland, stomach, small intestine, large intestine (bird/rat).

2. Study of permanent slides of Mammalian skin, Cartilage, Bone, Liver, Kidney, Heart, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid

3. Dissection and display of Endocrine glands in rat.

4. Estimation of plasma level of any hormone using ELISA

5. Preparation of slide and staining mucopolysaccharides by PAS reaction

6. Preparation of slide and staining proteins by Mercurobromophenol blue/Fast Green

Text Books:

1. Hall JE. 2015. Guyton and Hall Textbook of Medical Physiology. 13th Edition. Saunders

publication.
2. Ross MH, Pawlina W. 2010. Histology: A Text and Atlas. Sixth Edition. Lippincott Williams and Wilkins.
3. Norris DO, Carr JA. 2013. Vertebrate Endocrinology. 5 editions Academic Press.

References:

1. Fox T, Brooks A, Baidya B. 2015. Endocrinology. JP Medical, London.
2. Gardner DG, Shoback D. 2011. Greenspan's Basic and Clinical Endocrinology. 9th Edn. McGraw Hill Lange.
3. Goodman HM. 2000. Basic Medical Endocrinology. 4th Edn. Academic Press.
4. Jameson JL. 2010. Harrison's Endocrinology. 2nd Edn. McGraw Hill.
5. Melmed S, Conn PM. 2005. Endocrinology: Basic and Clinical Principles. 2nd Edn. Humana Press.
6. Melmed S, Polonsky K, Larsen PR, Kronenberg H. 2016. William's Text Book of Endocrinology.13th Edn. Elsevier.
7. Molina PE. 2013. Endocrine Physiology. 4th Edn. McGraw Hill Lange.
8. Neal JM. 2000. Basic Endocrinology; An Interactive Approach. Blackwell Science.
9. Norris DO. 2007. Vertebrate Endocrinology. 4th Edn. Elsevier Academic Press.
10. Strauss JF, Barbieri RL. 2014. Yen & Jaffe's Reproductive Endocrinology. Elsevier Sounders
11. Cormack DH. 2003. PDQ Histology. B.C. Decker Ins., London
12. Gunasegaran JP. 2010. A Text book of Histology and a Practical Guide. Elsevie
13. Junqueria LC, Carneiro J. 2005. Basic histology text and atlas
Randall D, Burggren W. 2001. Eckert Animal Physiology by. 4th edition. W. H. Freeman
14. Eroschenko VP. 2008. diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott & Wilkins

Course Outcome

Endocrine system brings about maturation, reproduction maintenance of homeostasis, in a nutshell understand the functioning of physiology. On the other hand histology is one of the most powerful systems to understand experimental and diagnostic physiology. The tool if harnessed shall enable students to aid in medical diagnostic centers, fields of drug designing, toxicology, pharmaceutical science and clinical experimentations.

Semester VI

DS-12: Biostatistics and Taxonomy (Theory: 3 credits = 45 classes)

Course Objectives:

This course aims to enable students with a basic understanding and hands on experience of biostatistics and taxonomy. Biostatistics is essential for having a quantitative understanding of biology and is an integral part of research. A basic understanding of biostatistics is needed for any higher studies or research in zoology. The course introduces the basic concepts of distributions, sampling, various statistical tests and statistical significance. Taxonomy is an important part of zoology and is used to identify and classify organisms. The course provides a basic knowledge of taxonomy and also introduces techniques of constructing phylogenies. This will enable students to have a good foundation of the principles involved in identification and classification of animals, as well as have an understanding of phylogenetic analysis.

Unit 1: Introduction to Biostatistics **10 classes**

Importance of statistics in biological research. Basic idea of population and sample. Variation– continuous versus discrete. Types of variables. Frequency and frequency distribution. Introduction to some distributions with examples – Gaussian, Poisson and Binomial. Measures of central tendency – mean, median and mode. Measures of dispersion – variance, standard deviation and standard error. Skewness and kurtosis.

Unit 2: Comparing distributions **8 classes**

Concept of significance testing and its purpose. Type I and Type II error. Concept of parametric versus non-parametric tests. One tailed versus two tailed tests. Testing for difference of means – Student's t test. Testing for goodness of fit – Chi square. Analysis of variance (one way).

Unit 3: Finding patterns **4 classes**

Correlation – Pearson's coefficient (r). Linear regression. Basic concept of multiple regression and non-linear regression.

Unit 4: Basic taxonomy **6 classes**

Definition and explanation: taxonomy, identification, systematics, classification. Different levels (alpha, beta and gamma taxonomy, micro and macrotaxonomy). Priory and posteriori weighting, artificial and natural classification. Properties of good classification, upward and downward classification, Biochemical compounds of taxonomic importance (sex pheromones, pigments, Animal toxins, secondary plant metabolites, pyrolysis product). Taxonomic characters and character states.

Unit 5: Special characters **2 classes**

Strong selection pressure, environmental effects, molecular sequence characters, microcharacters, cryptic characters, animal artifacts, behavioural characters, morphological, structure of genitalia, physiological; metabolic; serological; biochemical; secretions and sterility factors; ecological: food, host, season and effects due to parasitism; ethological: territoriality, courtship, mating and such others; geographical: distribution related to geography and its inter-relationship; embryological: information of ancestral, some intermediary features or characters. SEM, TEM, Repetitive DNA, mtDNA and cpDNA, G+C and A+T ratio in taxonomy, transition and transversion.

Unit 6: Species and species concept **4 classes**

Definition: species, taxon, phenon, taxonomic category, subspecies concept and types of subspecies. Polytopic subspecies and superspecies. other infraspecific categories. Species concept: biological species concept and its limitations, evolutionary Species Concept, phylogenetic species

concept.

Unit 7: Type concept and ICZN **4 classes**

Type concept: Typification and Essential features of typification. Categories of type, special kinds of typification. ICZN: Principle of nomenclature, authorship, priority, synonymy and homonymy. Concept of Taxonomic Key (indented, dichotomous and pictorial).

Unit 8: Phylogenetic reconstruction **7 classes**

Basic idea on molecular taxonomy and bar-coding. Basics of phenetics and cladistics. Understanding tree topologies: tree length, parsimony analysis. Construction of phylogenetic trees (distance method, UPGMA, NJ).

Biostatistics and Taxonomy Lab (Practicals: 2 credits = 30 classes)

1. Arranging data and graphical representation of data – bar diagram, histogram, box plot and scatter plot (using MSExcel/LibreOffice/MySTAT or any other suitable freely available software).

2. Calculation of mean, median, mode, variance and standard deviation from a data set (previously arranged and displayed graphically) using MSExcel/LibreOffice/MySTAT/R or any other freely available software.

3. Performing t test on a data set (previously arranged and displayed graphically) using MySTAT/R or any other freely available software.

4. Performing correlation and linear regression on a data set (previously arranged and displayed graphically) using MySTAT/R or any other freely available software.

5. Study of taxonomic characters of agricultural pests, beneficial insects, genera of mosquitoes and whole mount of minute insects and vectors (specimen characters and systematic position). Preparation of dichotomous key based on taxonomic characters.

7. Construction of phylegenetic tree from hypothetical data (distance method and UPGMA).

Textbooks:

1. Zar JH. Biostatistical Analysis. Prentice Hall/Pearson. 2014.
2. Van Emden HF. Statistics for terrified biologists. 2nd edition. Wiley Blackwell. 2019.
3. Dytham C. Choosing and using statistics: a biologist's guide. 3rd edition. Wiley-Blackwell. 2011.
4. Theory And Practice Of Animal Taxonomy, 6th ed, Kapoor V C, Oxford and IBH Publishing, 2008 - 272 pages
5. Principles of Systematic Zoology. Ernst Mayr and Peter D Ashlock, 475 pages, Tabs, figs, Publisher: McGraw Hill
6. Principles and Techniques of Contemporary Taxonomy by Donald L. J. Quicke
Publisher : Kluwer Academic Publishers (1 July 1993), ISBN-10 : 075140019X, ISBN-13 : 978-0751400199

References:

1. Sokal RR & Rohlf J. Biometry. WH Freeman. 1995.
2. Le CT. Introductory Biostatistics. John Wiley & Sons Publication. 2003.

Course Outcomes:

By completing this course, students will have a working knowledge of quantitative data in zoology: how it can be represented and analysed. They will understand the need and purpose of statistical analysis of data, and will also gain hands on skills in displaying, analysing and interpreting data. This will improve their analytical abilities needed for research and will enable them to perform data analysis. By gaining a foundation in the knowledge of taxonomy, students will have a more thorough understanding of how to identify and classify animals. They will also acquire hands on skills in

constructing phylogenies and this will help to provide them with a more thorough understanding of evolutionary biology. It will enable them to take up research or higher studies related to taxonomy in future and will also provide opportunities of being employed as a taxonomist.

DS-13: Developmental Biology (Theory, 3credits= 45 classes):

Course Objectives:

The journey from a single cell (fertilized egg/ zygote) to its ultimate multi-cellular form is best delineated in the course of Developmental Biology. The course deals with the morphological, cellular, molecular and biochemical processes/events involved in this transformation. Cellular changes depicting its potential versatility to its specialized cellular characters that makes it the functional unit in the specific tissue of the organism is dealt with in details. The course ends with a unit dedicated to the use of this science in various fields.

Unit 1: Introduction **3 classes**

Basic concepts: Phases of Development; morphogenetic movements, Cell-cell interaction, Differentiation and growth; Differential gene expression

Unit 2: Early Embryonic Development **14 classes**

Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; (Amphibia and Fish) Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula.Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers

Unit 3: Late Embryonic Development **6 classes**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta)

Unit 4: Post Embryonic Development **10 classes**

Development of brain and eye in Vertebrate Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each)

Unit 5: Development in murine model **8 classes**

Early Mammalian Development; Cleavage in Mammals; Escape from the Zona Pellucida; Gastrulation in Mammals; Mammalian Anterior-Posterior Axis Formation; The Dorsal-Ventral and Left-Right Axes in Mammals

Unit 6: Implications of Developmental Biology **4 classes**

Teratogenesis: Teratogenic agents and their effects on embryonic development; In vitro fertilization, Stem cell (ESC), Amniocentesis

Developmental Biology Lab (Practicals, 2 credits= 30 classes):

1. 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)

2. Study of different sections of placenta (microphotographs/ slides)

3. Project report on Drosophila culture/chick embryo development

4. Zebrafish embryo as a model to study developmental biology

Text Books:

1. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece, Published by Pearson Copyright © 2017.
2. Developmental Biology by Gilbert, S. F. (2010), IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA

References:

1. Principles of Development by Wolpert and Beddington; OUP Oxford, 2nd Ed., 2001
2. Essential Developmental Biology by Slack JMW; 3rd Ed., Wiley

Course Outcome:

A student shall learn how to understand, analyze, access and compare various physical/chemical/climatic influence on development and homeostasis in animals. The knowledge shall help the student interpret experimental results (in the specific field) and conclusions in a scientific manner. The knowledge also helps understand the various diseases where such development is not found as in cancer and or birth defects/abnormalities. This science finds huge application in bio-tech companies, toxicological studies, medical therapeutics, diagnosis and research in general.

DS-14: Evolutionary Biology (Theory, 3 credits= 45 classes):

Course Objectives:

It has been said that "Nothing in biology makes sense except in the light of evolution. Evolutionary biology is the basic framework on which rests the proper understanding of all biology. Understanding how the genotypes and phenotypes of populations change over time, and thereby species evolve and become extinct is crucial for understanding biological diversity. Hence it is important to develop clear concepts about the mechanisms of evolution. This course introduces how the concepts of evolutionary biology developed, and provides a foundation for understanding the mechanisms of evolution through fossil studies, population genetics and phylogeny. This course provides training in developing evolutionary thinkingwithout which knowledge and understanding about zoology would remain poor and largely incomplete.

Unit 1: Origin of earliest life **4 classes**

Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes, three domains of life with special reference to LUCA hypothesis

Unit 2: Historical review of evolutionary concept **5 classes**

Pre-Darwinian Concepts and theories including Lamarckism, Wallace and Darwin's Theory
Neo-Darwinian Synthesis

Unit 3: Evidences in favor of Evolution **4 classes**

Fossil records: types of fossils, geological time scale, transitional forms: examples of fossils depicting the evolutionary stages of the modern horses
Molecular (universality of genetic code and protein synthesis machinery) evidences

Unit 4: Sources of variations **3 classes**

Heritable variations present in natural populations (classical study of Lewontin and Hubby, 1966 in Drosophila, as example)

Unit 5: Evolutionary genetics: **12 classes**

Concept of Populations and calculation of allele frequencies in a population

Gene pool and calculation of allele frequencies in a population; Hardy-Weinberg Law and equilibrium (derivations, applications of law to find gene and genotype frequencies in human Populations)

Evolutionary forces disrupting H-W equilibrium-

Natural selection: Definition as the differential rate of reproductions and survivals of competing alleles, concept of fitness, selection coefficient, Types of natural selection with examples- Disrupting, Stabilizing, Directional.

Genetic Drift- outline of its mechanism, basic concepts and examples of founder's effect, bottleneck phenomenon;

Role of Gene flow and Mutation rates in changing allele frequencies in a population (No mathematical models)

Unit 6: Products of evolution **6 classes**

Inter-population variations: modes of speciation (just outlines of Allopatric, Sympatric and Parapatric speciation models with examples), Isolating mechanisms Adaptive radiations/ macroevolution as exemplified by Galapagos finches

Unit 7: Geological time scale **2 classes**

Macro-evolution through Geological time scale; K-T extinction.

Unit 8: Origin and evolution of man **4 classes**

Unique hominin characteristics contrasted with primate characteristics (including social and cultural ones), Primate phylogeny with reference to origin of man; Molecular evidences of human origin and migrations (brief outline)

Unit 8: Molecular Phylogeny **5 classes**

The basic concept of molecular phylogeny, Neutral theory of molecular evolution, molecular clock (brief introduction), Example of evolution in vertebrate globin genes.

Evolutionary Biology Lab (Practicals, 2 credits= 30 classes):

1. Study of fossils from models/ photographs; Archaeopteryx, horses.
2. Study of homology and analogy from suitable specimens (from Photographs/models)
3. Verification of Hardy-Weinberg equilibrium in a population by chi square analysis
4. Collection of a sample of height, weight, age, sex data from at least 100 individuals and applying of different statistical analyses (frequency distribution, mean, mode, standard deviations, correlations, etc) and graphical representations.

Text Books:

1. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece , Published by Pearson Copyright © 2017.
2. Evolution by Ridley,M. 3rd Ed.(2004) Blackwell publishing Or
3. Evolutionary Biology Douglas, J. Futuyma (1997); Sinauer Associates

References:

1. Evolution by Barton et al, 1st Ed. 2007 Cold Spring Harbor Lab Press
2. Why Evolution is True by Jerry Coyne; 2010, Penguin India

3. Strickberger's Evolution by Hall and Halgrimmson; 5th Revised Ed., 2013, Jones and Bartlett

Course Outcomes:

At the end of this course, students will possess a broad knowledge about various aspects of evolution, and will know about the morphological, population genetic and molecular approaches towards understanding evolution. Students will achieve skills in developing evolutionary thinking, and be able to analyse, compare and explain evolutionary trends. They will learn to apply intelligence to understand evolutionary changes in a population genetic framework and have knowledge about various approaches used to study evolution.

DS-15: Immunology (Theory, 3 credits = 45 classes):

Course Objectives:

This course is designed to delineate the cellular and functional aspects of the immune system. The course shall deal with both innate and adaptive wing of the immune system. The student shall learn in detail the cellular components and their function at the molecular level. Apart from this the learner shall earn in details of T Cell (development and differentiation). The student shall also learn about the structure and functions of different classes immunoglobulins, bonds associated with antigen antibody binding, immune-techniques, vaccines, monoclonal antibody and its production. The role of immune system in chronic and acute (infection) disease will be discussed.

Unit 1: Overview of Immune System **6 classes**

Historical perspective of Immunology, Organs (Primary & Secondary lymphoid organs and its importance) and Cells of the Immune system,
Concept of Haematopoiesis and development of progenitor cells of the Immune system (Brief idea)

Unit 2: Innate and Adaptive Immunity **6 classes**

Principle of Innate .

- Components of innate immunity
- Epithelial barriers (skin and mucosal membranes [concept])
- Cellular mechanisms (phagocytes, NK cells, mast cells, eosinophils, inflammation [concept])
- Humoral mechanisms (complement, cytokines, chemokines etc. [concept])

Adaptive Immunity

- Components of adaptive immunity
- Cellular mechanisms (Cell-Mediated Immune System (CMIS) or T- Cell Immunity [concept])
- Humoral mechanisms (Formation of Plasma B cells and Memory B cells [concept])

Unit 3: Antigen, Antigen presentation & MHC **8 classes**

Concept of Antigen, Immunogen, Allergen & Pathogen.
Adjuvants and haptens, Factors influencing immunogenicity, Epitope. Types of Antigen Presenting Cells (APC),
Structure of Major Histocompatibility Complex (MHC) molecules.
Mechanism of antigen presentation and involvement of MHC molecules (both MHC-I & MHC-II) in details.
Co-stimulatory molecules on APC.

Unit 4: T Cell development and differentiation **6 classes**

Structure of T cell receptors, Co-stimulatory molecules on T cells
Concept of synapse between APC & T cells (between MHC≈TCR & between Co- stimulatory molecules) in details.

Central differentiation of T cells; T cell selection in thymus Peripheral differentiation of T cells; Th1 & Th2

Unit 5: Immunoglobulins **6 classes**

Structure and functions of different classes of immunoglobulins, Antigen- antibody interactions, Immunoassays (ELISA and RIA), Hybridoma technology, Monoclonal antibody production

Unit 6: Complement System **2 classes**

Components and pathways of complement activation.

Unit 7: Hypersensitivity **2 classes**

Gell and Coombs' classification and brief description of various types of hypersensitivities.

Unit 8: Immunology of diseases **6 classes**

Malaria, Visceral Leishmaniasis, Filariasis, Dengue and Tuberculosis

Unit 9: Vaccines **3 classes**

Various types of vaccines. Active & passive immunization (artificial and natural).

Immunology Lab (Practicals, 2 credits= 30 classes):

1. Demonstration of lymphoid organs.

2. Histological study of spleen, thymus and lymph nodes through slides/ photographs

3.Macrophage isolation

(The experiments can be performed on white rats).

Text Books:

1. Campbell's Biology, 11th Edition by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece , Published by Pearson Copyright © 2017.
2. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication

References:

1. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
2. Abbas, K. Abul and Lechtman H. Andrew (2003.) Basic Immunology E-Book: Functions and Disorders of the Immune System; 2012 Saunders Publication

Course Outcome:

The student shall learn how to understand, analyze, access and compare various of the various aspects of immune function/dysfunction, immune response to infection and general molecular understanding of immune function. The course shall also equip the learner of uses to immune system in modern day treatment and analysis. This course shall be useful for students wanting to do research both as of the basic and clinical aspects of immune system. This science finds huge application in bio-tech companies, pharmaceutical research, medical therapeutics, diagnosis and research in general.

Semester VII

DS-16: Entomology and Vector Biology (Theory, 3 Credits = 45 classes)

Course Objectives:

This course has three distinct parts, the first dealing with the biology and classification of Insects, the second part is dedicated in understanding the uses of insect in commerce and also their control and finally the third part about vector biology and forensic entomology. The huge family of insects has been interacting with human in numerous ways and its relationship is very complex yet important. They may serve as pollinators as well as vectors. Disease like dengue, malaria, Leishmaniasis. Is very predominant in our country. At the same time bees and silk worm has been the source of lively hood for numerous families of India. Insects thus have become probably the most important group of animals for humans.

Unit 1: General Entomology **17 classes**

Classifications of Insects with salient identifying characters (till Order level)
Important insect structures and functions (flight, vision, reproductive structures and systems, digestive systems)
Insect metamorphosis with special reference to role of hormones.

Unit 2: Applied Entomology **18 classes**

Economically Beneficial Insects and their cultures: Honey bees, Lac insect and Mulberry Silk Moths.
Insect Pests: Agricultural Pests (Rice, wheat, vegetable crops)
Insecticides: Chemical and Biological Controls, Insecticide resistance and mechanism of resistance, IPM (Integrated Pest Management)

Unit 3: Medical Entomology **10 classes**

Vector Biology of *Plasmodium* sp, Japanese Encephalitis, Dengue, Leishmaniasis. Brief concept of Ticks and Mites and their role in disease propagation and allergy.
Methods of Vector Control
Forensic entomology

Entomology and Vector Biology Lab/Field (Practicals, 2 Credits = 30 classes)

1. Identification: honey bees, mosquitoes, sandfly, lac insect, silkworms
2. Collection and preservation of common invertebrates: soil microarthropods, insects from litter, garden, agricultural filed and household pests; whole mount slide preparation, insect set-pinning, dry and wet preservation.
3. Identification of pollen grains from corbicular pollen
4. Study of any crop pest- ecology, behaviour, life history strategies and control
5. Identification of different stages of Lac-insects and their host plants
6. Methods of insecticide application
7. Determination of LC50 and LD50
8. Study of the ecology, behaviours and life history strategies of major vector mosquitoes/sand flies

Suggested Readings:

1. Insects by R.F. Chapman
2. Agricultural pests of South-East Asia and their management – A.S Atwal &G.S. Dhallwal
3. An Introduction to Sericulture- by J Ganga; SulachanaChetty
4. Bees & Beekeeping in India by D.P. Abrol
5. Lac-culture in India- N. Ghorai, International Books and periodical supply service, New Delhi
6. Medical Entomology – A.K. Hati
7. Medical Entomology- Bruce F. Eldridge, John D. Edman, Kluwer Academic Publishers

Course Outcome

Insect biology is of great interest and importance in our country. Entomologist are being recruited in rural areas to conduct both survey and awareness programs to control vector borne diseases. Sericulture as a livelihood in West Bengal is also present. Human insect interaction and vector biology has gained much importance in forensic laboratories, ZSI, agriculture sector, defense wing etc. This course finds its importance both in the basic level as well as applied sectors.

DS-17: Biodiversity and Wildlife Conservation (Theory, 3 Credits = 45 classes)

Course Objectives:

Students will know how to assess biodiversity with different methodologies and they will be able to conduct a critical analysis of measures to manage biodiversity. Studies on biodiversity and wildlife conservation would serve as an insurance policy for the future. The course on biological diversity and the conservation of wildlife would lead to the understanding of essential ecological diversity to preserve the continuity of natural food webs. Students would be able to appreciate that biodiversity provides immediate benefits to society in different ways. The course would focus on how the genetic diversity of wildlife is preserved. Students will understand what ensures the sustainable utilisation of life support systems on Earth. The course would help the students to appreciate how a reservoir of wildlife is preserved, thus enabling them to be introduced, if need be, to the surrounding areas.

Unit-1: Introduction to Biodiversity and Wildlife **5 classes**

Definition, levels, patterns/scales and values of Biodiversity; Concept of Biodiversity Hotspots; Causes of depletion of biodiversity in India. Definition and endangered animals of West Bengal.

Unit 2: Evaluation and management of biodiversity **4 classes**

An overview of Climatic Zones and Biodiversity; Background and current rates of extinction; Extinction vortices; Red Data Book and its significance; Significance of gene banks and germplasm conservation

Unit 3: Management of Forest Habitats **10 classes**

Major forest types of India and West Bengal; Forest cover estimation: remote sensing and GIS; Management of Successional wild habitats; Forest fire; Fragmentation and corridors; Restoration of degraded wild habitats (the above topics should be learnt mostly in reference to the protected areas in West Bengal); Joint forest management.

Unit 4: Population estimation **3 classes**

Populations and population density estimations: different methods in practice; Sex Ratio computation and Fertility status

Unit 5: Wildlife conservation practices in India **3 classes**

Traditional Conservation ethics and practices in India; Conservation strategies and Practices: Wildlife ProtectionActs, IUCN, CITES, TRAFFIC.Wildlife Conservation (in-situ and ex-situ conservation).

Management strategies for tiger conservation.

Unit 6: Management planning of wildlife in protected areas **5 classes**

Estimation of carrying capacity; Concept of climax persistence; Ecology of perturbance; Major wildlife diseases and their control; Single Large Or Several Small (SLOSS) Debate

Unit 7: Man and Wildlife **5 classes**

Urban biodiversity; strays and feral populations; causes and consequences of human-wildlife conflicts and mitigation; traditional practices to overcome conflict, wildlife/Ecotourism advantages and disadvantages, concept of PBR.

Unit 8: Protected areas **10 classes**

Wildlife Reserves, Biosphere Reserves, etc.; major wildlife areas in India (Sanctuaries, National Parks in view of conservation of Tiger and other Wildlife); Community reserve: concepts and examples; Management challenges in Tiger reserve

Biodiversity and Wildlife Conservation Lab/Field (Practical, 2 Credits = 30 classes)

1. Identification of common local flora, mammalian fauna, avian fauna, herpeto-fauna

2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Range Finders, Global Positioning System, Various types of Cameras and lenses)

3. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers, etc.

4. Demonstration of different habitat-specific flora and fauna

5. Quadrat and other methods for ground cover assessment, Height-Girth relationships in trees, Canopy cover assessment in a patch of vegetations.

6. Trail / transect monitoring for abundance and diversity estimation of butterflies, mammals and birds; field recording of direct and indirect evidences)

Text Books:

1. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management.Blackwell Science.
2. Conservation Biology: A Primer for South Asia by Kamaljit S. Bawa, Meera Anna Oommen, and Richard B. Primack, Atree and University Press

References:

1. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Coexistence?Cambridge University.
2. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5 th edition. The Wildlife Society, Allen Press.
3. Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
4. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

Course Outcome:

Upon successful completion, students will have the knowledge and skills to articulate why society strives to conserve biodiversity. They will be able to identify key threats to biodiversity. The course will help them to evaluate which management options are likely to be effective for conserving

biodiversity in different settings. In this course, students will explore options for conserving biodiversity. Learning tools and techniques relevant to monitoring biological diversity would prepare students for future employment in this field. The course would enhance the student's ability to design a field-based project with rationale and appropriate methodology.

Semester VIII

DS-18: Research Methodology & Scientific Writing (Theory, 3 credits = 45 classes):

Course Objectives:

Research methodology is the fundamental basis of how scientific research is conducted. All practicing researchers and students of science should have a good understanding of research methodology. The course is designed to help students through all steps of research – asking a good research question, literature review, study design, data collection, data analysis and interpretation. The course also introduces the basics of research ethics. Scientific writing is of paramount importance for research as this is the way by which researchers communicate their findings to others. It is of utmost importance to know the fundamental conventions followed in scientific writing and also to learn about how to communicate scientific results to scientists as well as to the general populace. Hands on exposure to study design and various other aspects of research, as well as scientific writing are being provided in this course.

Unit 1: Foundations of research **8 classes**

Origins of the scientific method. Meaning and objectives of research. Summary of steps involved in research. Case studies of at least 2 major scientific discoveries. Types of research: analytical versus descriptive, qualitative versus quantitative, basic versus applied.

Unit 2: Process of research **12 classes**

Problem identification. Observation and facts. Prediction and explanation. Identifying variables. Constructing a hypothesis. Hypothesis testing. Study design, determining experimental and sampling designs. Literature review. Developing a research plan with timeline.

Unit 3: Data collection and analysis **8 classes**

Selecting a data collection method. Sampling and sampling methods. Processing and displaying collected data. Overview of data analysis. Interpreting analysed data.

Unit 4: Scientific writing **12 classes**

Standard practices followed in writing a research paper and review article. Covering letter and responding to referee's comments. Publishing in reputed journals and avoiding predatory journals. Writing a research proposal. Oral presentation, poster presentation. Writing a popular science article.

Unit 5: Research ethics **5 classes**

Ethical issues in study design and data collection from human subjects and animal experimentation/sampling (Animal Ethics Committee, Human Ethics Committee, Biosafety Committee). Plagiarism and infringement of intellectual property. Collaboration agreement and authorship agreement. Bias underlying scientific thinking.

Research Methodology & Scientific Writing Lab (Practicals, 2 credits = 30 classes)

1. Performing literature review using Google Scholar, Google and Researchgate with emphasis on combination of search key words.

2. Reference management using any standard reference management and citation software like Mendeley, EndNote, etc.

3. Exercise on designing a study –how to proceed to find the answer to a given research question (students can be divided into groups and a separate question given to each group).

4. Learning about plagiarism checking, language correction using any freely available software.

5. Project on writing a review article or writing a research proposal or giving an oral presentation.

Textbooks:

1. Research Methodology: A Step By Step Guide For Beginners by Ranjit Kumar, 5thedition, 2019. Sage Publications.
2. Research Methodology: From Philosophy Of Science To Research Design, by Alexander M. Novikov and Dmitry A. Novikov. 2013. CRC Press.
3. Managing Science: Methodology And Organization Of Research, by Frederick Betz. 2010. Springer.
4. Mastering Scientific And Medical Writing – A Self Help Guide, by Silvia M. Rogers. 2007. Springer.
5. A Scientific Approach to Scientific Writing, by John Blackwell and Jan Martin. 2011. Springer.

References:

Students are encouraged to explore authentic websites (e.g. Wikipedia, different university websites and OCWs) at internet for reading materials on a particular topic if they do not find enough in the text books or otherwise.

Course Outcomes:

By completing this course students will possess knowledge about the steps involved in research. They will have theoretical understanding of the basic skills needed in research, and should be able to design experiments and explain and interpret the results of experiments. Students will know how to communicate research findings and will have a hands-on knowledge about study design, literature review, reference management, plagiarism check, scientific writing, language editing and oral presentation. This course will provide the foundation for those students who will undertake research work in the next semester or in future for higher studies.

DS-19: Toxicology & Cancer Biology (Theory, 3 Credits = 45 classes)

Course Objectives

The course intends to equip students with the knowledge of effects of toxic substances on molecular and cellular levels and on public health. The principal aim of the course is to make the students familiar with essential toxicological concepts based on toxicodynamics and toxicokinetics to develop an understanding about drug/toxicant disposition, side-effects of drugs and awareness regarding environmental exposures to toxic substances including carcinogens. On the other side, the impact of cancer on all our lives emphasizes the need to continue training individuals to pursue research into its cure and prevention. The goal of this course is to provide students with education and training that enables them to make significant contributions to tackle this ever- increasing burden of cancer.The aim of the course is to provide an in-depth understanding of the molecular mechanisms underlying the development of cancer. The course will provide students with the knowledge and training needed to approach and formulate scientific questions relevant to the cancer biology. The course will also survey the frontiers of cancer research and aims to make the students acquainted with to the applied advanced methods, technologies and state-of-the-art web-tools used in cancer research.

Unit 1: Basics of Toxicology **22 classes**

General principles of Toxicology: Dose-Response relationships, characteristics of exposure to toxic agents
The absorption, distribution, metabolism and excretion of Xenobiotics: Toxicokinetics (Introductory level)

Interaction of toxicants with their target site: Toxicodynamics (Introductory level)
A brief introduction to various toxic agents and their health effects such as heavy metals, pesticides, pollutants.

Unit 2: Cancer Biology **23 classes**

Cytology of Cancer cells. Fundamental concepts in the molecular biology of cancer, including oncogenes, tumor suppressor genes, cell cycle and cell cycle check points, cell proliferation and apoptosis
Nature of Cancer: Multistage carcinogenesis, classification of cancer.
Introducing key cellular mechanisms and processes that underlie cancer development, growth and spread: Basic knowledge of tumor angiogenesis, cell migration, invasion and metastasis.

Toxicology & Cancer Biology Lab (Practicals, 2 Credits = 30 classes)

1. Measurement of serum biochemical markers of hepatotoxicity (ALT, AST, ALP) in murine/piscine models.

2. Measurement of oxidative stress: Assessment of Lipid peroxidation in different organs of murine/piscine system.

3. Identifying the differences between normal and cancer cells (from slides)

4. Identification of nuclear anomalies in piscine peripheral blood smear in response to toxicant exposure

Text and Reference Books:

1. Casarett & Doull's Toxicology: The Basic Science of Poisons, 9th Edition, McGraw Hill
2. The Biology of Cancer, Author: Robert Allan Weinberg, Edition 2, Garland Science, 2014

Course Outcome:

Students also learn about the current state of the epidemiology, clinical diagnosis, treatment, and prevention of human cancers. Given this huge investment in cancer research, the job market for individuals with doctoral degrees in cancer biology is very large and growing. This course will provide students an edge to pursue a career in the field of cancer biology. Life style factor affecting the incidence of cancer is also being dealt with as it will help the students in acquiring knowledge of preventive strategies against cancer incidence. The course will provide practical training in toxicological methods, to introduce the students to the study of cytotoxicity, genotoxicity, oxidative stress markers in various experimental setup as well as familiarize students with the basic differences between normal and cancer cells

DS-20: Fish and Fishery (Theory 3 Credits = 45 classes):

Course Objectives

The students will gain an overview of the fishery and aquaculture industry. Within fishery topics students will learn overview of species, morphology & physiology; nutrient chains; fishing seasons; fishing crafts and gears; initial fish processing, on shore or at sea; by catch/by product handling; regulations, structural changes in the fish industry and sustainable fishery & aquaculture.

Unit 1: Introduction and Classification **4 classes**

General description of fish
Feeding habit, habitat and manner of reproduction with special reference to Indian species
Classification of Indian fishes (up to Subclasses) with important examples

Unit 2: Morphology and Physiology **10 classes**

Types of fins and their modifications; Locomotion in fish; Hydrodynamics; Types of Scales, Use of scales in Classification and determination of age of fish; Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy; Osmoregulation in Elasmobranchs; Electric organ, Bioluminescence

Unit 3: Fisheries **6 classes**

Inland Fisheries; Marine Fisheries; Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal; Fishing crafts and gears; Depletion of fishery resources; Application of remote sensing and GIS in fisheries; Fisheries laws and regulations

Unit 4: Aquaculture **10 classes**

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish; Management of fin fish hatcheries; Preparation and maintenance of fish aquarium; Ornamental fish. Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products.

Unit 5: Fish in research **5 classes**

Transgenic fish, Zebra fish as a model organism in research

Fish and Fishery Lab (Practical, 2 Credits = 30 classes):

1. Morphometric and meristic characters of fishes in relation to identifications of species (with locally cultured non-indigenous fishes)

2. Study of external salient features in *Pristis, Chimaera, Exocoetus, Hippocampus, Gambusia, Labeo, Heteropneustes, Anabas* (all from photographs)

3. Study of different types of scales (through permanent slides/ photographs).

4. Study of crafts and gears used in Fisheries

5. Water quality criteria for Aquaculture: assessment of pH, conductivity, total solids, total dissolved solids

6. Study of air breathing organs in *Channa, Heteropneustes, Anabas and Clarias*

7. Project Report on a visit to any fish farm/ pisciculture unit/Zebra fish rearing Lab.

Text Book:

1. Q. Bone and R. Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.

References:

1. D. H. Evans and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press,
2. von der Emde, R.J. Mogdans and B.G. Kapoor. The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
3. C.B.L. Srivastava, Fish Biology, Narendra Publishing House
4. J.R. Norman, A history of Fishes, Hill and Wang Publishers
5. S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing

House
6. Chaudhuri, S. (2017), Economic Zoology. New Central Book Agency

Course Outcome

This course shall help the student in learning and establishing fish and fishery both as commercial as well as scientific disciple. The scope of fishery is of immense importance and demands in both industry and scientific laboratories. Students can use this knowledge to get employment or sustain themselves by self employment. Zebrafish and aquaculture are both find their application in experimental laboratories and commercial sectors.

DS-21: Parasitology (Theory, 3 Credits = 45 classes):

Course Objectives:

The course aims to introduce the student to Parasite,parasitism, Parasitoid and Vectors (mechanical and biological vector), host parasite relationship, zoonosis and other forms of animal associations. Furthermore expanding on the information on the study of morphology, life cycle, prevalence, epidemiology, pathogenicity, diagnosis and prophylaxis of parasitic Protists, Platyhelminthes, Nematodes, Arthropoda and Vertebrates. Parasitology find great importance in both zoology and biomedical science.

Unit 1: Introduction to Parasitology **4 classes**

Brief introduction of Parasitism and other animal associations, Parasite, Parasitoid and Vectors (mechanical and biological vector) Host parasite relationship and zoonosis

Unit 2: Parasitic Protists **12 classes**

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis and Prophylaxis of *Trypanosoma gambiense, Plasmodum falciparum, Leishmania donovani and Toxoplasma gondii*

Unit 3: Parasitic Platyhelminthes **12 classes**

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis and Prophylaxis of *Paragonimus westermani, Schistosoma haematobium, Echinococcus granulosus and Hymenolepis nana*

Unit 4: Parasitic Nematodes **12 classes**

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis and Prophylaxis of *Ancylostoma duodenale* and *Trichinella spiralis*. Study of structure, life cycle and importance of *Meloidogyne* (root knot nematode), *Pratylencus* (lesion nematode)

Unit 4: Parasitic Arthropoda **3 classes**

Mosquitoes and flies as vectors of human pathogen biology, importance and control of myiasis causing Diptera. Biology, importance and control of ticks, mites, *Pediculus humanus* (head and body louse), *Xenopsylla cheopis* and *Cimex lectularius*.

Unit 6: Parasitic Vertebrates **2 classes**

A brief account of parasitic vertebrates; Cookiecutter Shark, Candiru, Hood Mockingbird and Vampire bat

Parasitology Lab (Practicals, 2 Credits = 30 classes):

1. Study of *Entamoeba histolytica, Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani* and *Plasmodium vivax* through permanent slides/micro photographs

2. Study of *Fasciola hepatica, Schistosoma haematobium, Taenia solium* and *Hymenolepis nana* through permanent slides/micro photographs

3. Study of *Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti* and *Trichinella spiralis* through permanent slides/micro photographs.

4. Study of plant parasitic root knot nematode, *Meloidogyne* from the soil sample through permanent slides/ photographs

5. Study of Pediculus humanus (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs

6. Study of *Monogenea* from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry]

7. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a byproduct]

Text Book:

1. Chatterjee K.D. (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd

References:

1. Bose, M.(2017). Parasitoses and Zoonoses. New Central Book Agency(P) Ltd
2. Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors
3. Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers
4. Noble, E.R. and Noble G.A. (1982) Parasitology: The biology of animal parasites. V Edition, Lea & Febiger
5. Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi
6. Rattan Lal, Ichhpujani and Rajesh Bhatia. Medical Parasitology, III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi

Course Outcome

Parasitology finds great importance in both zoology, biomedical science research and in community awareness. The importance stems form association of these organisms with human and its life stocks. This branch of inter- disciplinary science finds its application in basic and clinical research. It expands the understanding of biological experiments especially molecular deciphering of disease conditions arising from such association. This course finds it application in understanding basic science, health physiology, drug action/discovery, pharmaceutical science, medical science, evolutionary science, diagnosis, find huge application in bio-tech companies but to name a few.

Skill Enhancement Courses

Credit of each course: 3
Total Number of Courses: 3
Skill Enhancement Course (SEC)

SECZOO1: Aquarium Fish Keeping Class (Theory and Practical 3 Credits = 45 classes)

Course Objectives

The course intends to equip students with the knowledge to learn the basic principles, themes and steps needed to set-up and maintain an aquarium. The principal aim of the course is to make the students familiar with essential information of aquarium maintenance in terms of types of fishes, fish biology, fish feed and finally transportation of these sellable commodities. The course will provide students with the knowledge and training needed to approach and formulate aquarium keeping both in business and research .

Unit 1: Introduction to Aquarium Fish Keeping 12 classes

The potential scope of Aquarium Fish Industry as a Cottage Industry, Exotic and Endemic species of Aquarium Fishes , problems of releasing aquarium fishes into natural habitats.

Unit 2: Biology of Aquarium Fishes 11 classes

Common characters and sexual dimorphism of Fresh water and Marine Aquarium fishes such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish

Unit 3: Food and feeding of Aquarium fishes 10 classes

Use of live fish feed organisms. Preparation and composition of formulated fish feeds, Aquarium fish as larval predator

Unit 4: Fish Transportation 6 classes

Live fish transport - Fish handling, packing and forwarding techniques.

Unit 5: Maintenance of Aquarium 6 classes

General Aquarium maintenance – budget for setting up an Aquarium Fish Farm as a Cottage Industry

Reference books:

1. Aquarium : Fish Keeping C B L Srivastava Published by Kitab Mahal
2. Marine Aquarium (Fish: Keeping and Breeding Them in Captivity) Boruchowitz, Davie. Published by Chelsea House Publications (1998)
3. Aquarium Setting Up (Fish: Keeping and Breeding Them in Captivity) Axelrod, Herbert R. Published by Chelsea House Publications (1998)
4. The Tropical Freshwater Aquarium Problem Solver: Practical and Expert Advice on Keeping Fish and Plants Sand ford, Gina Published by Voyageur Press (MN) (1998)
5. Aquariums: The Complete Guide to Freshwater and Saltwater Aquariums, Jan 2009 by Thierry Maitre-alain (Author), Chrisitan Piednoir (Author)

Course Outcome:

Fish has been a very common pet for human household. Ornamental fish, their propagation and keeping provides as very profitable means of livelihood as these animals provide both aesthetic beauties coupled with emotional attachment and pleasure. The financial possibilities and outcome has made aquarium breeding of ornamental fish a very profitable cottage industry with scopes of growth and diversification. This technique also aids in research where fish is used as a biological model.

SEC ZOO2: Poultry Farming (Theory and Practical 3 Credits = 45 classes)

Course Objective:

This course shall familiarize a student about the various aspects of poultry farming feasible in India. The course also talks about both large and small scale poutry farming coupled with the various varieties of poultry framings. This deals with both academic and application aspects of this industry.

Unit 1: Indian Poultry Industry **6 classes**

Overview
Importance and Trends
Poultry Farming in India
Poultry Development Programmes in India

Unit 2: Types of Poultry Farms **6 classes**

Various Types of Poultry Farms
Rural Backyard Poultry Farming

Unit 3: Small Scale and Commercial Broiler Farming for meat **3 classes**

Unit 4: Small Scale and Commercial Layer Farming for eggs **6 classes**

Unit 5: Duck and Quail Farming **6 classes**

Duck Farming for Eggs and Meat
Quail Farming for Eggs and Meat

Unit 6: Poultry Breeds and Breeding **6 classes**

Breeds, Varieties and Strains of Poultry
Systems of Poultry Breeding

Unit 7: Culling and Judging of Poultry **6 classes**

Culling of Birds for Profitable Poultry Farming
Judging of Poultry for Better Performance

Unit 8: Poultry diseases and their management **6 classes**

Symptoms, treatment, prevention and control of: Ranikhet disease, avian influenza, fowl cholera, fowl typhoid, Pullorum disease, chronic respiratory disease, gangrenous dermatitis. Significance of deworming and controlling ectoparasites.

Text Books and references:

1. The Beginner's Guide to Raising Chickens: How to Raise a Happy Backyard Flock by Anne Kuo; Rockridge Press (7 September 2021)

2. The Chicken Health Handbook, 2nd Edition: A Complete Guide to Maximizing Flock Health and Dealing with Disease by Gail Damerow
3. The Small-Scale Poultry Flock: An All-Natural Approach to Raising Chickens and Other Fowl for Home and Market Growers by Harvey Ussery
4. Storey's Guide to Raising Poultry, 4th Edition: Chickens, Turkeys, Ducks, Geese, Guineas, Game Birds by Glenn Drowns
5. https://egyankosh.ac.in/bitstream/123456789/59739/1/Poultry%20development%20programmes%20in%20india.pdf
6. https://www.dahd.nic.in/related-links/central-poultry-development-organization
7. https://egyankosh.ac.in/bitstream/123456789/59745/1/Various%20types%20of%20poultry%20farms.pdf

Course outcome:

Students can go for self employment as an entrepreneur. The course also talks about Government schemes for the said industry. The various aspects of breeds, types and various are intregrities dealt in the course will enable the student to access the real life situation

SEC ZOO 3: Apiculture (Theory and Practical 3 Credits = 45 classes)

Course objectives:

This course shall familiarize a student about the significance of apiculture as an economically viable enterprise in India. It will help them to understand about different species of honey bees, their biology and role in pollination. They will learn about techniques of honey bee rearing, and will understand the significance of apiculture in diversification of agriculture for rural communities to increase their income, create employment opportunities and develop skills for self-employment as a bee keeper.

Unit 1: Biology of Bees **8 classes**

Historical background of apiculture.
Classification and biology of honey bees.
Social organization of the bee colony, behavioral patterns: bee dance, swarming.

Unit 2: Rearing of Bees **11 classes**

Artificial bee rearing in apiary, beehives – Newton and Langstroth, beekeeping equipment, bee pasturage, identification of queen cells, drone cells, brood cells, pollen cells and honey cells.
Selection of bee species for apiculture – *Apis cerana, Apis mellifera*.
Methods of extraction and processing of honey (indigenous and modern).
Apiary management - honey flow period and lean period, effect of pollutants on bees.

Unit 3: Diseases and Enemies **9 classes**

Diseases of honey bees: protozoan, bacterial and viral (one each) – symptoms, nature of damage and control, mite infestation and its control.
Enemies of bees and their control: predatory insects and non-insects.

Unit 4: Bee Economy **9 classes**

Products of apiculture – honey, bees wax, propolis, royal jelly, pollen and their uses.
Modern methods in using artificial bee hives for cross pollination in horticulture and agriculture – stationary and migratory beekeeping.

Unit 5: Entrepreneurship in Apiculture **8 classes**

Bee keeping industry – recent advancements, employment opportunities.
Economics of small and large scale beekeeping, scope of women entrepreneurs in bee keeping sector.

Development programs and organizations involved in bee keeping in India.

Text Books:

1. Jaiswal AG (2019) Practical handbook of apiculture. Laxmi Book Publication.
2. Conrad R (2007) Natural beekeeping – organic approaches to modern apiculture. Chelsea Geeen Publishing.
3. Singh S (1962). Beekeeping in India. Indian Council of Agricultural Research, New Delhi.
4. Mishra RC (1995) Honey bees and their management in India. Indian Council of Agricultural Research, New Delhi.
5. Prost PJ (1962) Apiculture. Oxford & IBH, New Delhi.
6. Rahman A (2017) Beekeeping in India. Indian Council of Agricultural Research, New Delhi.
7. Gupta JK (2016) Apiculture. Indian Council of Agricultural Research, New Delhi.

Course outcome:

Students can go for self-employment as an entrepreneur. The various aspects of species of honey bees, their biology and behavior, techniques involved in bee keeping, and making various products from beekeeping dealt in the course will enable a student to develop skills necessary for starting beekeeping as a livelihood.