Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Zoology

(Faculty of Science & Technology)

F.Y.B.Sc. Zoology

Choice Based Credit System Syllabus

to be implemented from

Academic Year 2019-2020

Preamble:

Zoology is one of the major subjects of Basic Sciences and deals with all aspects of animal biology. It includes an interesting range of highly diverse topics. A zoology student needs to gain understanding of many areas of the subject to keep pace with advancements in Life Sciences.

This under-graduate degree program has been designed by the Board of Studies in Zoology of Savitribai Phule Pune University with a substantial component of what is needed from zoologists as a skilled career and what zoologists need to pursue for post-graduation and further academic studies. It follows the guidelines laid down by the University Grants Commission, New Delhi. This newly designed curriculum is a perfect blend of the classical aspects in Zoology and the advanced and more specialized areas.

This degree offers Discipline Specific Core Courses **[CC]** in Animal Systematics, Animal Ecology, Animal Cell biology, Applied Zoology, Pest Management, Histology, Biological Chemistry, Genetics, Developmental Biology, Parasitology, Medical & Forensic Zoology, Animal Physiology, Molecular Biology, Entomology, Techniques in Biology and Evolutionary Biology.

In addition to the Core Courses, Ability Enhancement Compulsory Courses **[AECC]** have been added in the second year i.e. Semester III and Semester IV of the undergraduate course. In the third year i.e. Semester V and Semester VI, Discipline specific Elective Courses **[DSEC]** and Skill Enhancement Courses **[SEC**] have been offered. The students, therefore, have an opportunity to take courses in Environment Awareness, Language communication: English/Marathi, Aquarium Management, Poultry Management and Environmental Impact Assessment. In Semester VI the students also have a course dedicated to Project work.

The syllabus has been framed in such a way that the student gains each year, a broader perspective of the subject as he progresses towards completion of the degree program. Field trips, Educational visits and the Project work have been included for the student to experience the applications of the theory learnt in the classroom.

After completion of the program, it is expected that students will understand and appreciate: animal diversity, few applications of Zoology, the structure, functions and life processes at cellular, tissue, organ and system level, significance of evolution, and basic concepts of human health. The students would also gain an insight into laboratory and field work through the practical course, field work and the project.

While presenting this new syllabus to the teachers and students of F.Y.B.Sc. Zoology, I am extremely happy to state that efforts have been made to seek inputs of all the stake holders to make it more relevant.

The new course that will be effective from the academic year 2019- 2020 and will follow the Choice Based Credit System in a Semester mode. It has been primed keeping in view the distinctive requirements of B.Sc. Zoology students. The contents have been drawn-up to accommodate the widening prospects of the discipline of Life Sciences. They reflect the changing prerequisites of the students. This program has been introduced with 132 credits for the subject group while 08 credits to earn from any of the 08 groups offering a range of curricular, cocuricular and extracurricular activities. This pattern has been specially aimed towards the overall development of the students'. The calculation of credits and CGPA will

be as per the guidelines of the University. The B.Sc. Zoology program provides an appropriate blend of classical and applied aspects of the subject. This newly designed curriculum will allow students to acquire the skill in handling scientific instruments planning and performing in the laboratory and exercising critical judgement, independent thinking and problem solving skills. The Syllabus has been revised with the following aims

- To foster curiosity in the students for Zoology
- To create awareness amongst students for the basic and applied areas of Zoology
- To orient students about the importance of abiotic and biotic factors of environment and their conservation.
- To provide an insight to the aspects of animal diversity.
- To inculcate good laboratory practices in students and to train them about proper
- handling of lab instruments.

1. Course Structure:

Course Structure with Credit Distribution of the Undergraduate Science Program in Zoology

Course	Course Code and Name of the Course		Credits
F.Y.B.Sc.	**SEMESTER I**	**SEMESTER II**	
CC	ZO-111 Animal Diversity I	ZO-121 Animal Diversity II	2+2
CC	ZO-112 Animal Ecology	ZO-122 Cell Biology	2+2
CC	ZO-113 Zoology Practical Paper	ZO-123 Zoology Practical Paper	1.5 +1.5
S.Y.B.Sc.	**SEMESTER III**	**SEMESTER IV**	
CC	ZO-231 Animal Diversity III	ZO-241 Animal Diversity IV	2+2
CC	ZO-232 Applied Zoology I	ZO-242 Applied Zoology II	2+2
CC	ZO-233 Zoology Practical Paper	ZO-243 Zoology Practical Paper	2+2
AECC	EVS 231-Environment Awareness	EVA 241-Environment Awareness	2+2
AECC	LA 231-English/Marathi	LA 241- English /Marathi	2+2
T.Y.B.Sc.	**SEMESTER V**	**SEMESTER VI**	
DSEC	ZO-351 Pest Management	ZO-361 Medical & Forensic Zoology	2+2
DSEC	ZO-352 Histology	ZO-362 Animal Physiology	2+2
DSEC	ZO-353 Biological Chemistry	ZO-363 Molecular Biology	2+2
DSEC	ZO-354 Genetics	ZO-364 Entomology	2+2
DSEC	ZO-355 Developmental Biology	ZO-365 Techniques in Biology	2+2
DSEC	ZO-356 Parasitology	ZO-366 Evolutionary Biology	2+2
DSEC	ZO-357 Zoology Practical Paper 1	ZO-367 Zoology Practical Paper 1	2+2
DSEC	ZO-358 Zoology Practical Paper 2	ZO-368 Zoology Practical Paper 2	2+2
DSEC	ZO-359 Zoology Practical Paper 3	ZO-369 Zoology Practical Paper 3	2+2
SEC	ZO-3510 Aquarium Management	ZO-3610 Environmental Impact Assessment	2+2
SEC	ZO- 3511 Poultry Management	ZO-3611 Project	2+2

Detailed Syllabus of F.Y.B.Sc.

Paper	Semester I Course Code & Course	Credits	No of Lectures	Marks (Internal + University)		SemesterII Course Code & Course	Credits	No of Lectures	Marks (Internal + University)
I	ZO-111 Animal Diversity I	02	30	15+ 35= 50		ZO-121 Animal Diversity II	02	30	15+ 35 = 50
II	ZO-112 Animal Ecology	02	30	15+ 35 = 50		ZO-122 Cell Biology	02	30	15+ 35 = 50
III	ZO-113 Zoology Practical Paper	01	15 practical	15+ 35 = 50		ZO-123 Zoology Practical Paper	01	15 Practical	15+ 35 = 50

Course No.	Course Title	Total Number of lectures/practical per Term	Standard of passing		
			Internal marks	**University marks**	**Total marks**
ZO-111 (First term)	Animal Diversity–I	Three lectures/Week (Total 30 lectures per term)	15	35	50
ZO-121 (Second term)	Animal Diversity-II	Three lectures/Week (Total 30 lectures per term)	15	35	50
ZO-112 (First term)	Animal Ecology	Three lectures/Week (Total 30 lectures per term)	15	35	50
ZO-122 (Second Term)	Cell Biology	Three lectures/Week (Total 30 lectures per term)	15	35	50
ZO-113 (First term)	Zoology Practical Paper	Practical session of 3 hours. 15 Practicals	15	35	50
ZO-123 (Second Term)	Zoology Practical Paper	Practical session of 3 hours. 15 Practicals	15	35	50

Animal Diversity I & II

Objectives:

1. To understand the Animal diversity around us.
2. To understand the underlying principles of classification of animals.
3. To understand the terminology needed in classification.
4. To understand the differences and similarities in the various aspects of classification.
5. To classify invertebrates and to be able to understand the possible group of the invertebrate observed in nature.to understand our role as a caretaker and promoter of life.

Learning outcomes for the course:

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

Course Title: Animal Diversity –I

Course Code-ZO-111

Semester I **(2 credits-30 lectures)**

No.	Title & Contents	Number of lectures
1.	**Principles of Classification:**	**(05)**

Taxonomy & Systematics

1.1 Taxonomy: Basic terminology and Introuction

- Alpha, Beta and Gamma levels of taxonomy, Micro-taxonomy
- Macro taxonomy: Phenetics (numerical taxonomy, Cladistics (Phylogenetic systematics), Evolutionary taxonomy (evolutionary systematics)
- Classical taxonomy and experimental or neo taxonomy (biochemical taxonomy and Cytotaxonomy)
- Significance of Taxonomy

1.2 Systematics: definition introduction

1.3 Linnaean system of classification (Six level classification: Phylum, class, order, family, genus, species)

1.4 Concept of Species: Biological & Evolutionary

1.5 Introduction to Binomial Nomenclature.

1.6 Introduction to Five kingdom system.

2. **General Features of kingdom Animalia** **(02)**

2.1 General characters of Kingdom Animalia, Grades of organization

2.2 Symmetry.

3. **Kingdom Protista (Phylum: Protozoa)** **(07)**

3.1 Introduction to Phylum Protozoa

3.2 Salient features of Phylum Protozoa

3.3 Classification of Phylum Protozoa up to classes with two examples of each class (names only).

Class Rhizopoda (e.g :*Entamoeba histolytica, Arcella*),

Class Mastigophora (e.g: *Euglena viridis, Trypanosoma gambiense*),

Class Ciliata (e.g *Paramoecium caudatum, Opalina ranarum*),

Class Sporozoa (e.g *Plasmodium vivax, Toxoplasma gondii*)

3.4 Locomotion in Protozoa: Amoeboid, Ciliary and Flagellar with suitable examples

3.5 Type Study: ***Paramecium caudatum***: Classification, Habit and Habitat, External morphology, Feeding and digestion, Excretion, Reproduction (binary fission and conjugation)

3.6. Economic importance of Protozoa (three harmful and one useful protozoan)

3.6.1-**Harmful Protozoa**:

Plasmodium vivax (malarial parasite),

Entamoeba histolytica (Amoebic dysentery),

Trypanosoma gambiense (Gambian sleeping sickness).

3.6.2- **Useful Protozoa**:

Trichonympha

4. **Origin of Metazoa** **(01)**

4.1 Introduction Origin and importance of Metazoa

5. **Phylum Porifera** **(06)**

5.1. Introduction to Phylum Porifera

5.2 Classification of Phylum Porifera up to classes with two examples of each class (names only, no description of specimens).

Class Calcarea (e.g.: *Leucosolenia, Sycon (Scypha)*

Class Hexactinellida (e.g: *Euplectella* (venus flower basket), *Hyalonema* (glass sponge))

Class Demospongiae (e.g: *Chalina* (Mermaid's gloves, *Spongilla* (fresh water sponge))

5.3 Canal system in sponges: Ascon, Leucon and Rhagon type.

5.4 Skeleton in sponges: Spicules, its types:

Microscleres & Megascleres,

Monoaxon – monactinal, diactinal, Amphidiscs, Triaxon, Polyaxon,

Spongin fibres.

5.5 Regeneration in sponges.

5.6 Economic importance of Phylum Porifera.

6. **Phylum: Cnidaria** **(05)**

6.1 Introduction to Phylum Cnidaria

6.2 Salient features of Phylum Cnidaria

6.3 Classification of Phylum Cnidaria up to class level with given

examples each class (names of examples only)

Class Hydrozoa e.g.: Hydra, *Physalia* (Portuguese man of war)

Class Scyphozoa e.g: *Aurelia* (Jelly fish), *Leucernaria* (trumpet shaped Jellyfish)

Class Anthozoa: e.g; Metridium (Common sea anemone0

6.4 Polymorphism in Hydrozoa: Polyps & Medusa (polyp types: gastrozooids, dactylozooids, gonozooids) and functions

6.5 Economic importance of Cnidarians with reference to Corals and Coral reefs.

7. **Phylum Platyhelminthes** **(04)**

7.1 Introduction to Phylum Platyhelminthes

7.2 Salient features of Phylum Platyhelminthes

7.3 Classification of Phylum Platyhelminthes up to classes with two examples each class (names of examples only).

Class: Turbellaria (e.g: *Dugesia, Bipallium*)

Class: Trematoda (e.g*: Fasciola hepatica, Schistosoma haematobium*)

Class Cestoda: (*Taenia solium* (pork tape worm),*Echinococcus granulosus* (dog tapeworm)

7.4 Parasitic adaptations in Platyhelminthes: structural and physiological.

7.5 Economic importance of Platyhelminthes

Course Title: Animal Ecology

Course Code: ZO 112

Semester I **(2 Credits-30 Lectures)**

Learning outcomes for the course:

- The learners will be able to identify and critically evaluate their own beliefs, values and actions in relation to professional and societal standards of ethics and its impact on ecosystem and biosphere due to the dynamics in population.
- To understand anticipate, analyse and evaluate natural resource issues and act on a lifestyle that conserves nature.
- The Learner understands and appreciates the diversity of ecosystems and applies beyond the syllabi to understand the local lifestyle and problems of the community.
- The learner will be able to link the intricacies of food chains, food webs and link it with human life for its betterment and for non-exploitation of the biotic and abiotic components.
- The working in nature to save environment will help development of leadership skills to promote betterment of environment.

ZO 112: Animal Ecology **(2 Credits-30 Lectures)**

No.	Topic & Content	Number of lectures
1.	**Introduction to Ecology**	**(02)**
	1.1 Concepts of Ecology, Environment, Population, Community, Ecosystem, Biosphere, Autecology and synecology.	
2.	**Ecosystem**	**(08)**
	2.1 Types of ecosystems: Aquatic (Freshwater, estuarine, Marine and terrestrial (Forest, Grassland and Desert)	
	2.2 Structure and Composition of Ecosystem (Abiotic components and biotic components.	
	2.3 Food chain: Detritus and grazing food chains, Food web, Energy flow through the ecosystem, Ecological pyramids: Number, Biomass, and Energy.	
	2.4 concept of Eutrophication in lakes and rivers.	
3	**Population**	**(08)**
	3.1Characteristic of population: Density, Natality, Mortality, Fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion.	
	3.2Exponential and logistic growth,	
	3.3 Population regulation – density-dependent and independent factors.	
	Population interactions, Gause's Principle with laboratory and field interactions,	
	3.4 Quadrate, line and belt transect methods.	
4.	**Community**	**(07)**
	4.1Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Eco tone and edge effect; Ecological succession with one example.	
5.	**Animal interactions**	**(05)**
	5.1Introduction to Animal interactions	
	5.2 Types of Animal interactions with at least to suitable examples of each	
	5.2.1-Competition: Interspecific and intraspecific	

5.2.2- Beneficial Associations:

Commensalism (remora fish on shark, Cattle egrets on livestock),

Mutualism (Termite and *Trichonympha*, bees and flowers, cleaning symbiosis in fish by prawns.

5.3 Antagonistic associations: Parasitism (*Ascaris* and man, lice and humans), Prey predation (Lion and deer).

Course Title: Zoology Practical Paper

Course Code: ZO113

Semester I **(1.5 Credits-45 Hours)**

Animal Diversity –I

1. Museum Study of phylum Protozoa: Euglena, Paramecium, Amoeba, Plasmodium sp.
2. Museum study of Phylum Porifera: *Sycon*, *Euplectella*, *Chalina*, Spongilla.
3. Museum study of phylum Cnidaria: *Hydra*, *Physalia*, *Aurelia*, *Metridium*.
4 Museum Study of phylum Platyhelminthes: *Planeria*, *Faciola hepatica*, *Taenia solium*
5. Study of Paramecium: Culture, External morphology, Conjugation and Binary fission.
6. Study of permanent slides: Spicules and Gemmules in Sponges, T.S. of *Sycon*, T.S. of Hydra, Taeniasolium: Scolex, Gravid proglottid.
7. Identification of any three museum specimen with help of taxonomic identification key.
8. Visit to Zoological survey of India/ Museum/National Park.

Animal Ecology:

1. Estimation of Dissolved oxygen from given water sample.
2. Estimation of Water Alkalinity from given water sample.
3. Study of animal community structure by quadrate method (Field or Simulation).
4. Determination of density, frequency and abundance of species by quadrat method.
5. Study of microscopic fauna of freshwater ecosystem (from pond).
6. Estimation of water holding capacity of given soil sample.
7. Estimation of dissolved and free carbon dioxide from water sample.
8. Study of Eutrophication in lake/river.

Course Title: Animal Diversity –II

Course Code: ZO-121:

Semester II **(2 credits-30 lectures)**

No.	Title & Contents	Number of lectures
1.	**Phylum Aschelminthes**	**(04)**
	1.1 Introduction to phylum Aschelminthes 1.2 Salient features of Phylum Aschelminthes 1.3 Classification of Phylum Aschelminthes (Class Nematoda only with two examples – *Ascaris lumbricoides* (common round worm), *Wuchereria bancrofti* (Elephantiasis)). 1.4 Economic importance of class Nematoda.	
2.	**Phylum Annelida**	**(06)**
	2.1 Introduction to Phylum Annelida 2.2 Salient features of Phylum Annelida. 2.3 Classification of Phylum Annelida up to classes with examples of following classes (names of examples only). Class Polychaeta (e.g: *Nereis pelagica (neries/* sand worm, *Aphrodita aculeata* (=Aphrodite/ seamouse) Class Oligochaeta (e.g.: *Pheritima posthuma* (earthworm), Class Hirudinea (e.g: *Hirudinaria granulosa* common cattle leech) 2.4 Economic importance of Annelida with reference to earthworms as friends of farmers and in their role in vermicomposting.	
3.	**Phylum Arthropoda**	**(06)**
	3.1 Introduction to Phylum Arthropoda 3.2 Salient features of Phylum Arthropoda 3.3 Classification of Phylum Arthropoda with specific classes and mentioned examples (names only) Class:Crustacea*:Palaemon palaemon* (Prawn) *Brachyura* spp. crabs) Class: Chilopoda: *Scolopendra* sp. (centipede) Class: Diplopoda: *Julus* sp. (millipede)	

Class Insecta*: Periplaneta americana* (American Cockroach), *Anopheles stephensii* (mosquito).

Class: Arachnida- Spiders, *Buthus sp (*scorpion)

3.4 mouth parts in insects: Mandibulate (cockroach), Piercing and sucking (female Anopheles mosquito), chewing and lapping type (honey bee)

3.5 Economic importance of Arthropoda

Useful Insects: Honey bee, Lac insect, Silkworm.

Harmful insects: Female Anopheles mosquito, Red cotton bug, Rice weevil

4. **Phylum Mollusca** **(06)**

4.1 Introduction to Phylum Mollusca

4.2 Salient features of Phylum Mollusca

4.3 Classification of Phylum Mollusca with specific classes and mentioned examples (names only)

Class Gastropoda e.g *Pila globosa* (apple snail)

Class Pelecypoda e.g *Lamellidens marginalis*(Bivalve)

Class Polyplacophora e.g *Chiton*

Class: Cephalopodae.g: *Octopus vulgaris* (common octopus), *Sepia officinalis* (common Cuttle fish)

4.4 Economic importance of Mollusca.

5. **Study of Phylum Echinodermata** **(08)**

5.1 Introduction to Phylum Echinodermata

5.2 Salient features of Phylum Echinodermata.

5.3 Classification of Phylum Echinodermata with specific classes and mentioned examples (names only)

Class Asteroidea (*Asterias rubens* sea stars or starfish)

Class: Holothuroidea. *Holothuria sp*. sea cucumbers)

Class: Echinoidea *(Echinus esculentis* common sea urchins)

Class: Crinoidea (sea lilies or feather stars)

5.4 **Type study: *Asteriasrubens* (Sea Star):** Classification, Habit

Habitat, External Morphology, Digestive system, Water vascular

System and autotomy and regeneration

5.5 Pedicillaria in Echinodermata: straight, crossed, valvate, tridactylous, globigerous.

5.6 Economic importance of Echinidermata.

Course Title: Cell biology

Course Code: ZO122:

Semester II (2 credits-30 lectures)

Learning outcomes for Cell Biology

- The learner will understand the importance of cell as a structural and functional unit of life.
- The learner understands and compares between the prokaryotic and eukaryotic system and extrapolates the life to the aspect of development.
- The dynamism of bio membranes indicates the dynamism of life. Its working mechanism and precision are responsible for our performance in life.
- The cellular mechanisms and its functioning depends on endo-membranes and structures. They are best studied with microscopy.

ZO122: Cell biology (2 credits-30 lectures)

No. Title & Contents Number of lectures

1. **Introduction: (04)**

1.1 Introduction cell biology,

1.2 Cell as basic unit of life.

1.3 Importance of Cell Biology and its applications in industry.

Overview of Cells

1.3 Introduction to Prokaryotic and Eukaryotic cells.

1.4 Structure and function of Prokaryotic *(E. coli)*

1.5 Structure and function of Eukaryotic cells (Animal and Plant Cell)

2	**Techniques in Cell Biology:**	**(04)**
	3.1 Introduction 3.2 Microscopy: Basic Principle, Simple, Compound and applications of Electron Microscope. 3.3 Stains and dyes: Types of Stain: Acidic, basic and neutral. Dye (Preparation and chemistry of dyes not expected) 3.4 Micrometry.	
3	**Plasma Membrane:**	**(06)**
	4.1Introduction 4.2 Structure of plasma membrane: Fluid mosaic model. 4.3Transport across membranes: Active and Passive transport, Facilitated transport, exocytosis, endocytosis, phagocytosis – vesicles and their importance in transport. 4.4 Other functions of Cell membrane in brief Protection, cell recognition, shape, storage, cell signalling. 4.5 Cell Junctions: Tight junctions, gap junctions, Desmosomes.	
4	**Nucleus: Structure and function**	**(04)**
	5.1Introduction to Nucleus 5.2 Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleoplasm, Nucleolus 5.3 Chromatin: Eu-chromatin and Hetro-chromatin, nature and differences. 5.4 Functions of nucleus	
5.	**Endomembrane System**	**(04)**
	6.1 Introduction 6.2 Structure, location and Functions: Endoplasmic Reticulum, Golgi apparatus, Lysosomes and vacuoles.	
7.	**Mitochondria and Peroxisomes**	**(03)**
	7.1 Introduction 7.2 Mitochondria: ultrastructure and function of mitochondrion.	

7.3 Peroxisomes

Cell Division **(05)**

7.1 Introduction

7.2 Cell cycle (G1, S, G2, M phases),

7.3 Mitosis.

7.4 Meiosis.

Course Title: Zoology Practical Paper

Course Code: ZO123

Semester II **(1.5 Credits-45 Hours)**

Animal Diversity –II

1. Museum study of Phylum Aschelminthes: *Ascaris lumbricoides*,
2. Museum study of phylum Annelida: *Neries*, Earthworm, Leech.
3. Museum study of phylum Arthropoda: Prawn, Cockroach, Centipede, Millipede, Crab
4. Museum study of phylum Mollusca: *Pila*, *Chiton*, Bivalve, Octopus.
5. Museum study of phylum Echinodermata: Sea Star, Sea urchin, Brittle Star, sea cucumber.
6. Study of permanent slides: Mouthparts of Insects -Mandibulate, Piercing and sucking, Chewing and Lapping.
7. Types of Shells in Mollusca. *Pila*, Bivalve, Chiton, Sepia.
8. Economic importance of honey bees, Lac insects silk worms, red cotton bug, Anopheles mosquito
9. Earthworm: vermicomposting bin preparation and maintenance.
10. Visit to a vermicomposting unit/ field for insect pest collection and its identification

Cell Biology

1. Study of Microscope: Simple and Compound
2. Micrometry: Measurement of microscopic objects
3. Study of cell: Preparation of temporary mount of human buccal epithelial cells.
4. Preparation of blood smears to observe the blood cells
5. Temporary preparation of mitotic cell from onion roots
6. Study of Cell organelles (any three) by using microphotographs

Recommended Reference Books

Animal Diversity – I and II

1. Anderson, D.T (Ed) 1988: Invertebrate Zoology, Oxford University Press.
2. Barnes, R.D. (1982). Invertebrate Zoology, V Edition. Holt Saunders International Edition.
3. 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
4. Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson
5. Boradale, L.A. and Potts, E.A. (1961). Invertebrates: A Manual for the use of Students. Asia Publishing Home.
6. Brusca, R.C andBrusca, G. J (2003): Invertebrate (2^{nd} ed.) Sinauer Associates Inc., Publishers Sunderland.
7. Hadzi, J (1963): The Evolution of Metazoa, Macmillan Newyork.
8. Hyman, L. H (1940): Invertebrates Vol I, Protozoa through ctenophore.
9. Hyman. L. H (1955): The Invertebrates Vol: IV, Echinodermata, the coelomate bilateria, Mcgraw Hill, Newyork.
10. Modern Text-Book of zoology, Vertebrates. By Kotpal, RL., Rastogi and Co., Meerut.
11. Nigam H.C., Zoology of Chordates, Vishal Publication, Jalandhar-144008.
12. Phylum Protozoa to Echinodermata (series) by Kotpal, RL. Rastogi and Co., Meerut
13. Parker T.J and W.A Haswell (1972): A text book of Zoology, Vol –I (7^{th} edition by Marshall and Williams) Mcmillan Press ltd.
14. Jordan, E.L. and P.s.Verma Invertebrate Zoology, S. Chand and Co., Ltd. Ram Nagar, New Delhi.
15. Russel Hunter: - A Biology of higher invertebrates, MacMillon Co. Ltd. London

Animal Ecology

1. Colinvaux, P. A. (1993). Introduction to Ecology. II Edition. Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001). Ecology: The Experimental Analysis of Distribution and Abundance, 6th Edition, ©2009, Pearson
3. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
4. Robert Leo Smith Ecology and field biology Harper and Row publisher
5. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press
6. Sharma P.D. (2002) Ecology and Environment, Himalaya Publication

Cell Biology

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI EditionJohn Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIIEdition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition.ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
5. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London
6. Inside the Cell (2005); US Department of Health Sciences, National Institute of Health, Natinal institute of General Medicine Sciences.
7. Lodish, H., D. Baltimore, A. Berk, L. Zipursky, M. Matsudaira and J. Darnell. (2010).
8. Molecular Cell Biology, Eds. 3, Scientific American & W. H. Freeman. New York.
9. Powar C B.: Cell Biology, Himalaya Publication, Meerut

Note: Latest editions of the recommended books may be referred.

SavitribaiPhule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Zoology

(Faculty of Science & Technology)

S.Y.B.Sc. Zoology

(w.e.f. June 2020)

As per

Choice Based Credit System

Syllabusimplemented from

Academic Year 2020-2021

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In addition to the Core Courses, Ability Enhancement Compulsory Courses **[AECC]** have been added in the second year i.e. Semester III and Semester IV of the undergraduate course. In the third year i.e. Semester V and Semester VI, Discipline specific Elective Courses **[DSEC]** and Skill Enhancement Courses **[SEC]** have been offered. The students, therefore, have an opportunity to take courses in Environment Awareness, Language communication: English/Marathi, Aquarium Management, Poultry Management and Environmental Impact Assessment. In Semester VI the students also have a course dedicated to Project work.

The syllabus has been framed in such a way that the student gains each year, a broader perspective of the subject as he progresses towards completion of the degree program. Field trips, Educational visits and the Project work have been included for the student to experience the applications of the theory learnt in the classroom.

After completion of the program, it is expected that students will understand and appreciate: animal diversity, few applications of Zoology, the structure, functions and life processes at cellular, tissue, organ and system level, significance of evolution, and basic concepts of human health. The students would also gain an insight into laboratory and field work through the practical course, field work and the project.

While presenting this new syllabus to the teachers and students of F. Y. B. Sc. Zoology, I am extremely happy to state that efforts have been made to seek inputs of all the stake holders to make it more relevant.

The new course that will be effective from the academic year 2019- 2020 and will follow the Choice Based Credit System in a Semester mode. It has been primed keeping in view the distinctive requirements of B. Sc. Zoology students. The contents have been drawn-up to accommodate the widening prospects of the discipline of Life Sciences. They reflect the changing prerequisites of the students. This program has been introduced with 132 credits for the subject group while 08 credits to earn from any of the 08 groups offering a range of curricular, cocuricular and extracurricular activities. This pattern has been specially aimed towards the overall development of the students'. The calculation of credits and CGPA will be as per the guidelines of the University. The B. Sc. Zoology program provides an appropriate blend of classical and applied aspects of the subject. This newly designed curriculum will allow students to acquire the skill in handling scientific instruments planning and performing in the laboratory and exercising critical judgement, independent thinking and problem solving skills.

The Syllabus has been revised with the following aims

- To foster curiosity in the students for Zoology
- To create awareness amongst students for the basic and applied areas of Zoology
- To orient students about the importance of abiotic and biotic factors of environment and their conservation.
- To provide an insight to the aspects of animal diversity.
- To inculcate good laboratory practices in students and to train them about proper • handling of lab instruments.

Course Structure:

Course Structure with Credit Distribution of the Undergraduate Science Program in Zoology

Course	Course Code and Name of the Course		Credits
F. Y. B. Sc.	**SEMESTER I**	**SEMESTER II**	
CC	ZO - 111 Animal Diversity I	ZO-121 Animal Diversity II	2 + 2
CC	ZO - 112 Animal Ecology	ZO-122 Cell Biology	2 + 2
CC	ZO - 113 Zoology Practical Paper	ZO-123 Zoology Practical Paper	1.5 +1.5
S. Y. B. Sc.	**SEMESTER III**	**SEMESTER IV**	
CC	ZO - 231 Animal Diversity III	ZO - 241 Animal Diversity IV	2 + 2
CC	ZO - 232 Applied Zoology I	ZO - 242 Applied Zoology II	2 + 2
CC	ZO - 233 Zoology Practical Paper	ZO - 243 Zoology Practical Paper	2 + 2
AECC	EVS 231- Environment Awareness	EVA 241- Environment Awareness	2 + 2
AECC	LA 231 - English/Marathi	LA 241 - English /Marathi	2 + 2
T. Y. B. Sc.	**SEMESTER V**	**SEMESTER VI**	
DSEC	ZO - 351 Pest Management	ZO - 361 Medical & Forensic Zoology	2 + 2
DSEC	ZO - 352 Histology	ZO - 362 Animal Physiology	2 + 2
DSEC	ZO - 353 Biological Chemistry	ZO - 363 Molecular Biology	2 + 2
DSEC	ZO - 354 Genetics	ZO - 364 Entomology	2 + 2
DSEC	ZO - 355 Developmental Biology	ZO - 365 Techniques in Biology	2 + 2
DSEC	ZO - 356 Parasitology	ZO - 366 Evolutionary Biology	2 + 2
DSEC	ZO- 357 Zoology Practical Paper 1	ZO - 367 Zoology Practical Paper 1	2 + 2
DSEC	ZO- 358 Zoology Practical Paper 2	ZO - 368 Zoology Practical Paper 2	2 + 2
DSEC	ZO- 359 Zoology Practical Paper 3	ZO - 369 Zoology Practical Paper 3	2 + 2
SEC	ZO - 3510 Aquarium Management	ZO- 3610 Environmental Impact Assessment	2 + 2
SEC	ZO - 3511 Poultry Management	ZO - 3611 Project	2 + 2

Detailed Syllabus of S. Y. B. Sc.

Paper	Semester III Course Code & Course	Credits	No of Hours	Marks (Internal + University)		Semester IV Course Code & Course	Credits	No of Hours	Marks (Internal + University)
I	ZO - 231 Animal Diversity III	02	30	15+ 35= 50		ZO - 241 Animal Diversity IV	02	30	15+ 35 = 50
II	ZO - 232 Applied Zoology I	02	30	15+ 35 = 50		ZO - 242 Applied Zoology II	02	30	15+ 35 = 50
III	ZO - 233 Zoology Practical Paper	02	14 Practicals	15+ 35 = 50		ZO - 243 Zoology Practical Paper	02	14 Practicals	15+ 35 = 50
AECC	EVS 231- Environment Awareness	02	30	15+ 35 = 50		EVA 241- Environment Awareness	02	30	15+ 35 = 50
AECC	LA 231- English/ Marathi	02	30	15+ 35 = 50		LA 241- English/ Marathi	02	30	15+ 35 = 50

Animal Diversity III & IV

Objectives –

1. To understand the origin and advancement of higher vertebrates (tetrapoda).
2. To understandgeneral characters of different groups of higher vertebrates.
3. To classify vertebrates and to become able to understand the possible group of vertebrates observed in nature.
4. To understand different behaviours and adaptations in higher vertebrates
5. To understand affinities among different groups of higher vertebrates.

Learning Outcomes for the course -

1. The students will be able to understand, classify and identify the diversity of higher vertebrates.
2. The students will able to understand the complexity of higher vertebrates
3. The students will be able to understand different life functions of higher vertebrates.
4. The students will be able to understand the linkage among different groups of higher vertebrates.
5. The student will become aware regarding his role and responsibility towards nature as a protector, to understand his role as a trustee and conservator of life which he has achieved by learning, observing and understanding life.

Course Title: Animal Diversity - III

Course Code: ZO – 231,

Semester - III (2 credits – 30 Hours)

No. Title & Contents **Number of Lectures**

1. Introduction to Phylum Chordata – (03)

1.1 Origin & Ancestry of Chordates.

1.2 Comparative account of fundamental characters of Chordates with Non Chordates.

1.3 Salient features of Phylum Chordata.

1.4 Classification of Phylum Chordata upto classes – Pisces, Amphibia, Reptilia, Aves, Mammalia.

2. Introduction to Group – Protochordata. (03)

2.1 Salient features of Protochordata.

2.2 Salient features of subphylumswith two example each - Names only.

Hemichordata – *Balanoglossus*and*Rhabdopleura*, Urochordata - *Herdmania*and*Salpa*, Cephalochordata –*Branchiostoma*(Amphioxus) and*Asymmetron*.

3. Introduction to subphylum – Vertebrata (02)

3.1 Salient features of Vertebrata.

3.2 Introduction and General characters of sections with two examples - Names only.

Agnatha–*Petromyzon&Myxine*&Gnathostomata–Frog&*Labeo*.

4. Introduction to Class – Pisces (04)

4.1 Salient features of Class – Pisces.

4.2 Introductaionand Salient features of sections with two examples - Names only.

Class – Chondrichthyes–*Scoliodon*and *Chimaera*&Osteichthyes – *Labeo*and*Catla*

4.3 Types of Scales in Fishes.

4.4 Types of Fins in Fishes.

5. Introduction to Class – Amphibia (03)

5.1 Salient features of Class – Amphibia.

5.2 Introduction to order – Apoda–*Ichthyophis*,Urodela–*Salamandra*(Salamander) and& Annura - *Rana*.

5.3 Parental care in Amphibia.

6. Study of *Scoliodon* (15)

Scoliodon – 6.1 - Systematic position, Geographical distribution, Habit, Habitat 01

6.2 - External characters 01

6.3 - Digestive System, Food and feeding mechanism. 02

6.4 - Respiratory System – Structure of Holobranch only. 02

6.5- External & Internal Structure of heart, Working of heart. 02

6.6 - Nervous System – Brain only. 03

6.7 - Male urinogenital system & Female reproductive System. 03

6.8- Yolk sac placenta. 01

Applied Zoology I and II

Objectives :

1. To understand the basic life cycle of the honeybees, beekeeping tools and equipments.
2. To learnfor managing beehives for honey production and pollination.
3. To understand the basic information about fishery, cultural and harvesting methods of fishes.
4. To understand fish preservation techniques.
5. To understand the biology, varieties of silkworms and the basic techniques of silk production and harvesting of cocoons.
6. To learn the different silkworm species and their host plants.
7. To study types of agricultural pests and Major insect pests of agricultural importance.
8. To study Pest control practices.

Learning Outcomes of the course:

1. The learner understands the basics about beekeeping tools, equipment, and managing beehives.
2. The learner understands the basic information about fishery, cultural and harvesting methods of fishes and fish preservation techniques.
3. The learner understands the biology, varieties of silkworms and the basic techniques of silk production.
4. The learner understands the types of agricultural pests, Major insect pests of agricultural importance and Pest control practices.

Course Title - Applied Zoology I

Course Code - ZO - 232

Semester III **2 Credits - 30 lectures**

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1) Sericulture: **16**

1.1 An introduction to Sericulture, Study of different types of silk moths, their distribution, Taxonomic position and varieties of silk produced in India : Mulberry, Tassar, Eri and Muga silk moths. 02

1.2 ExternalMorphology and life cycle of *Bombyxmori*. 02

1.3 Cultivation of mulberry :

a) Varieties for cultivation,

b) Rain fed and irrigated mulberry cultivation- Fertilizer schedule, Pruning methods and leaf yield. 02

1.4 Harvesting of mulberry : **a)** Leaf plucking, **b)** Branch cutting, **c)** Whole shoot cutting. 01

1.5 Silk worm rearing :

a) Varieties for rearing,

b) Rearing house,

c) Rearing techniques,

d) Important diseases and pests. 03

1.6 Preparation of cocoons for marketing. 01

1.7 Post harvest processing of cocoons :

a) Stiffling, sorting, storage, deflossing and riddling,

b) Cocoon cooking, reeling equipment and rereeling, washing and polishing. 03

1.8 Biotechnological and biomedical applications of silk. 02

2) Agricultural Pests and their control: **14**

2.1 An introduction to Agricultural Pests, types of pests (agricultural, store grain, veterinary). 01

2.1 Major insect pests of agricultural importance (Marks of identification, life cycle, nature of damage and control measures). 06

a) Jowar stem borer,

b) Red cotton bug,

c) Brinjal fruit borer,

d) Mango stem borer,

e) Blister beetle,

f) Rice weevil,

g) Pulse beetle,

h) Tick.

2.3 Non insect pests: Rats, Crabs, Snails, and Squirrels 01

2.4 Pest control practices in brief: Cultural control, Physical control, Mechanical control, Chemical control, Biological control, Pheromonal control, Autocidal control and Concept of IPM in brief. 04

2.5 Plant protection appliances: Shoulder type Rotary duster, Knapsack sprayer, Cynogas Pump. 02

Course Title: Zoology Practical Paper

Course Code: ZO – 233

Semester - III **(2 credits – 60 Hours)**

Animal Diversity - III

1. Museum study of Group Protochordata : *Balanoglossus*, *Herdmania*, *Petromyzon*. (D)
2. Museum study of Class Pisces: Labeo, *Scoliodon*, *Hippocampus.* (D)
3. Museum study of Class Amphibia :*Salamandra*, *Rana*, *Ichthyophis*. (D)
4. Study of types of scales in fishes: Placoid scale, Cycloid scale, Ctenoid scale & Ganoid scale. (D)
5. Study of types of tail fins in fishes: Homocercal, Heterocercal &Diphycercal. (D)
6. Study of external characters & digestive system of locally available fish. (E) - Compulsory
7. Study of brain of locally available fish. (D)
8. Temporary preparation of scales & its identification from locally available fish. - (E) Compulsory
9. Compulsory field visit to study pond ecosystem with reference to Pisces and amphibians, report writing and submission. (**2 P**)

Sericulture –

1. Study of external morphology and life-cycle of *Bombyx mori.* (D)
2. Study of five equipments in Sericulture. (E) - Compulsory
3. Preparation of a map showing distribution of silk moth and rearing/ sericulture practices in India. (E)
4. Compulsory submission of Photographs/ sketches of Mulberry, Tassar, Eri and Muga silkmoths. (E)

Agricultural Pests and their control -

1. Study of following insect pests with respect to marks of identification, nature of damage, economic importance and control measures. (D)
   a) Jowar stem borer,
   b) Red cotton bug,
   c) Brinjal fruit borer,
   d) Mango stem borer.
2. Study of following pests with respect to marks of identification, nature of damage, economic importance and control measures. (D)
   a) Blister beetle,

b) Rice weevil,

c) Pulse beetle,

d) Tick.

3. Study of any two non insect pests corresponding to theory course. (D)
4. Compulsory submission of at least five Insect Pests/ Photographs/ Sketches. (E)
5. Study of pest control appliances (as per theory course). (D)
6. Compulsory field visit to Sericulture farm/ Agricultural farm, report writing and submission. **(2 P).**

Minimum 14 practicals must be conducted with at least Seven practicals from each paper.

Course Title: Animal Diversity - IV

Course Code: ZO – 241

Semester - IV (2 credits – 30 Hours)

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1. Introduction to class –Reptilia (04)

1.1 Salient features of class Reptilia with one example (name only) – *Chelone*, *Calotes*.

1.2 Venomous and Non-venomous snakes – Cobra, Russell's viper, Rat snake, Grass snake.

1.3 Snake venom, symptoms, effect and cure of snake bite, first aid treatment of snakebite.

1.4 Desert adaptations in reptiles in brief.

2. Introduction to class –Aves (05)

2.1 Salient features of class Aves with two examples (names only) – Sparrow, Parrot.

2.2 Flight adaptations in birds.

2.3 Types of Beaks and feet in birds.

2.4 Migration in birds – Altitudinal, Latitudinal.

3. Introduction to class - Mammalia. (04)

3.1 Salient features of class Mammalia with two examples (names only) – Rat, Rabbit.

3.2 Egg laying mammals.

3.3 Aquatic adaptations in mammals.

3.4 Flying adaptations in mammals.

3.5 Cursorial and fossorial adaptation in mammals

4. Study of Rat (17)

4.1 Systematic position, habit and habitat.	01
4.2 External characters.	01
4.3 Digestive system, food and feeding.	02
4.4 Respiratory system.	02
4.5 Blood vascular system – Structure of Heart.	02
4.6 Nervous system – Central Nervous system only.	03
4.7 Sense organs – Structure and functions of Eye & Ear.	03
4.8 Reproductive system.	03

Course Title - Applied Zoology II

Course Code - ZO-242

Semester IV **2 Credits- 30 lectures**

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1. Apiculture: **16**

1.1 An introduction to Apiculture, Systematic position, Study of habit, habitat and nesting behaviour of *Apisdorsata*, *Apisindica*, *Apis florae* and *Apismellifera*. 02

1.2 Life cycle, Colony organization and Division of labour. 02

1.3 Bee behaviour and communication (Round Dance and Wag-Tail Dance) . 02

1.4 Bee keeping equipments :

a) Bee box (Langstroth type),

b) Honey extractor,

c) Smoker,

d) Bee-veil,

e) Gloves,

f) Hive tool,

g) Bee Brush,

h) Queen excluder. 02

1.5 Bee keeping and seasonal management. 02

1.6 Bee products (composition and uses) :

a) Honey,

b) Wax,

c) Bee Venom,

d) Propolis,

e) Royal jelly,

f) Pollen. 02

1.7 Diseases and enemies of Bees :

a) Bee diseases - Protozoan (Nosema), Bacterial (American foul brood), Viral (Sac brood), Fungal (Chalk brood).

b) Bee pests - Wax moth (Greater and Lesser), Wax beetle.

c) Bee predators - GreenBee eater, King crow, Wasp, Lizard. 02

1.8 Bee pollination and management of bee colonies for pollination. 02

2. Fisheries : **14**

2.2 An introduction to fisheries and its types (in brief) : Freshwater fisheries, Marine fisheries, Brackish water fisheries. 02

2.3 Habit, habitat and culture methods of following freshwater forms : 03

a) Rohu (*Labeo rohita*) ,

b) Catla (*Catla catla*) ,

c) Mrigal (*Cirrhinus mrigala*).

2.3 Harvesting methods of following marine forms: 03

a) *Harpodon*,

b) Mackerel,

c) Pearl oyster.

2.4 Crafts and Gears in Indian Fishery: 02

a) Crafts – Catamaran, Machwa, Dinghi.

b) Gears – Gill net, Dol net, Rampani net, Cast net.

2.5 Fishery byproducts: 02

a) Fish meal,

b) Fish flour,

c) Fish Liver oil,

d) Fish manure,

e) Fish fin soup.

2.6Fish preservation technique: 02

a) Chilling,

b) Freezing,

c) Salting,

d) Drying,

e) Canning.

Course Title: Zoology Practical Paper

Course Code: ZO – 243

Semester - IV **(2 credits – 60 Hours)**

Animal Diversity - IV

1. Museum study of Class Reptilia: Venomous & Non-venomous snake – Two each. (D)
2. Identification of Venomous & Non-venomous snakes with the help of pictorial taxonomic keys. – (D) -Compulsory
3. Museum study of Class Aves: Crow, *Kingfisher*& Duck. (D)
4. Study of types of beaks &feets in birds – Any two each. (D)
5. Museum study of Class Mammalia: Rat, Shrew & Bat. (D)
6. Study of external characters & digestive system of Rat. (D)
7. Study of Heart of Rat. - (D) -Compulsory
8. Study of brain of Rat. (D)
9. Study of reptilian / avian diversity in and around the campus (**2 P**) - (E) -Compulsory
10. Compulsory visit to Zoo / Wildlife sanctuary / Bird sanctuary, report writing and submission. (**2 P**)

Apiculture –

1. Study of external morphology, life cycle and polymorphism in Honey Bee. (D)
2. Temporary mountingof mouth parts, legs, wings and sting apparatus of worker bee. (E)
3. Study of Bee keeping Equipment: Bee box, Honey extractor, Smoker**,** Bee-veil, queen excluder. (D)- Compulsory
4. Study of Bee products: Honey, Wax, Venom, Royal jelly, Pollen. (D)
5. Estimation of carbohydrates from Honey in different samples. (D)- Compulsory
6. Study of Bee enemies: Wax moth, Bee eater, ant. (D)

Fisheries –

1. Identification, Classification and study of habit, habitat and economic importance of **a)** Rohu (*Labeo rohita*), **b)** Catla (*Catla catla*), **c)** Mrigal (*Cirrhinus mrigala*). (D)
2. Identification, Classification and study of habit, habitat and economic importance of **a)** Prawn, **b)** Crab, **c)** Lobster, **d)** Pearl Oyster. (D)
3. Study and maintenance of Aquarium. (D) - Compulsory

4. Study of crafts: **a)** Catamaran, **b)** Machwa, **c)** Dinghi (Photographs/models/line drawings). (D)

5. Study of gears in fishing: **a)** Gill net, **b)** Dol net, **c)** Rampani net, **d)** Cast net. (Photographs/models/line drawings). (D)

7. Study of nutritional value of fish: Biochemical estimation of fish muscle proteins by using Biuret method. (E) - Compulsory

7. Compulsory study tour/field visit to Apiculture institute / Fish farm/ Aquarium. (E) **(2 P)**.

Minimun 14 practicals must be conducted with at least Seven practicals from each paper.

Recommended Reference Books

Animal Diversity – III & IV

1. Text Books of Zoology, Invertebrates Vol- II, 1992, T.J.Parker and W.A. Haswel, Edited by Marshall and Williams,CBS publications and distribution, New Delhi.
2. Integrated Principles of Zoology, Eleventh Edition, Hickman CP, Roberts LS & Larson A. International Edition ISBN 0–07–118077–X, The McGraw-Hill Companies, Inc.,
3. Modern Text Book of Zoology, Vertebrates. R. L. Kotpal, 3rd edn. Rastogi Publications, Meerut.
4. Chordate Zoology, 1982, P.S.Dhami and J.K.Dhami, R. Chand and Co., New Delhi.
5. Biology, Campbell nand Reece. 7th Edn. Pearson Education in South Asia, Delhi.
6. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
7. Pough H. Vertebrate life, VIII Edition, Pearson International.
8. Integrated Principles of Zoology, Eleventh Edition, Hickman C. P., Roberts L. S.& Larson A. International Edition ISBN 0–07–118077–X, The McGraw-Hill Companies, Inc.,
9. Arora M.P. Chordates I. Himalya Publications.
10. Organic Evolution. R.S. Lull. Light & Life Publishers.
11. Jordan E. L.&Verma P. S. 2003. Chordates Zoology. S. Chand & Company Ltd. New Delhi.
12. Biology, Campbell Nand Reece. 7th Edn. Pearson Education in South Asia, Delhi.

Applied Zoology I & II

1. Principal of Sericulture, 1994. HisaoArguo, Oxford & Co.
2. An Introduction of Sericulture, 1995. G.Ganga, J. Sulochana, Oxford & IBH Publication Co. Bambay.
3. FAQ Manual of Sericulture. Vol I - Mulberry Cultivation, Vol II - Silkworm Rearing. Central Silk Board, Bangalore.
4. Mane, P.C., Chaudhari R. D. et al. Highly sensitive label-free bio-interfacial colorimetric sensor based on silk fibroin-gold nanocomposite for facile detection of chlorpyrifos pesticide. Scientific Reports2020,10, 4198. https://doi.org/10.1038/s41598-020-61130-y
5. Entomology & Pest Management. Pedigo L. P. Prentice Hall, India 1996.
6. General & Applied Entomology, Nayar K. K. & T. N. Ananthkrishnan& B. V. Davis, Tata McGraw Hill Publication, New Delhi.
7. Insects. M. S. Mani, National Book Trust, India, 2006.
8. Insects & Mites of Crops in India. M. R. G. K. Nair – by ICAR, New Delhi.
9. The Science of Entomology. W. S. Romosor and J. G. Stoffolano, McGraw Hill Publication, 1988.

10. Agricultural Insect Pests of India and their Control, Dennis S. Hill, Cambridge University Press.
11. Applied Entomology. Vol. I & II. K. P. Srivastava. Kalyani Publication, Ludhiana, New Delhi.
12. Principles of Insect Pest Management. G. S. Dhaliwal and Ramesh Arora, Kalyani Publications, Ludhiana.
13. Pest Management and Pesticides: Indian Scenario. Editor- B. Vasantaraj David, Namrutha Publications, Madras (Chennai).
14. Concepts of Insect Control. Ghosh M. R. Wiley Eastern Ltd. New Delhi.
15. Destructive and useful Insects, their habit and Control, 1973. C.L. Metcalf and W. P. Flint, Tata McGraw Hill Publications, New Delhi.
16. A Text Book of Entomology, 1974. V. K. Mathur and K. D. Upadhayay, Goel Printing Press, Barani.
17. Imm's general Text Book of Entomology, Vol I & II, Richard and Davis Owen.
18. Biology of Insects, 1992. S. C. Saxena. Oxford and IBH Publishing Co., New Delhi, Bombay, Calcutta.
19. Bee and Bee Keeping, 1978, Roger A. Morse, Conell University Press, London.
20. The Behaviour& Social Life of Honey Bees, C. R. Ribbandas, Dover Publication inc. New York.
21. Fishes. Mary Chandy. National Book Trust India, 2005.
22. Economic Zoology, Shukla Upadhyay, Rastogi Publication, Meerut, India, 1998.
23. Fisheries Developments, K. K. Trivedi, Oxford and IBH Pub. Co.
24. Marine Fishes in India, 1990, D.V. Bal & K. Virabhdra, Tata McGraw Hill Publication.
25. Fishery Management, 1990, S. C. Agarwal, Avinash Publication House, New Delhi.

Note – Use latest editions of the books.

Savitribai Phule Pune University
(Formerly University of Pune)

Three Year B. Sc. Degree Program in Zoology
(Faculty of Science & Technology)

T. Y. B. Sc. Zoology

Choice Based Credit System Syllabus

To be implemented from
Academic Year 2021 - 2022

Preamble:

Zoology is one of the major subjects of Basic Sciences and deals with all aspects of animal biology. It includes an interesting range of highly diverse topics. A zoology student needs to gain understanding of many areas of the subject to keep pace with advancements in Life Sciences.
This under-graduate degree program has been designed by the Board of Studies in Zoology of Savitribai Phule Pune University with a substantial component of what is needed from a zoologist as a skilled career and what zoologists needs to pursue for post-graduation and further academic studies. It follows the guidelines laid down by the University Grants Commission, New Delhi. This newly designed curriculum is a perfect blend of the classical aspects in Zoology with the advanced and more specialized areas.

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- To orient students about the importance of abiotic and biotic factors of environment and their conservation,
- To provide an insight to the aspects of animal diversity,
- To inculcate good laboratory practices in students and to train them about proper handling of lab instruments.

Board of Studies in Zoology
Savitribai Phule Pune University

1. Course Structure:

Course Structure with Credit Distribution of the Undergraduate Science Program in Zoology

Course	Course Code and Name of the Course		Credits
F. Y. B. Sc.	**SEMESTER I**	**SEMESTER II**	
CC	ZO-111 Animal Diversity I	ZO-121 Animal Diversity II	2+2
CC	ZO-112 Animal Ecology	ZO-122 Cell Biology	2+2
CC	ZO-113 Zoology Practical Paper	ZO-123 Zoology Practical Paper	1.5+1.5
S. Y. B. Sc.	**SEMESTER III**	**SEMESTER IV**	
CC	ZO-231 Animal Diversity III	ZO-241 Animal Diversity IV	2+2
CC	ZO-232 Applied Zoology I	ZO-242 Applied Zoology II	2+2
CC	ZO-233 Zoology Practical Paper	ZO-243 Zoology Practical Paper	2+2
AECC	EVS 231-Environment Awareness	EVA 241-Environment Awareness	2+2
AECC	LA 231-English / Marathi	LA 241- English / Marathi	2+2
T. Y. B. Sc.	**SEMESTER V**	**SEMESTER VI**	
DSEC	ZO-351 - Pest Management	ZO-361 - Medical & Forensic Zoology	2+2
DSEC	ZO-352 - Histology	ZO-362 - Animal Physiology	2+2
DSEC	ZO-353 - Biological Chemistry	ZO-363 - Molecular Biology	2+2
DSEC	ZO-354 - Genetics	ZO-364 - Entomology	2+2
DSEC	ZO-355 - Developmental Biology	ZO-365 - Techniques in Biology	2+2
DSEC	ZO-356 - Parasitology	ZO-366 - Evolutionary Biology	2+2
DSEC	ZO-357 - Zoology Practical Paper 1	ZO-367 - Zoology Practical Paper 1	2+2
DSEC	ZO-358 - Zoology Practical Paper 2	ZO-368 - Zoology Practical Paper 2	2+2
DSEC	ZO-359 - Zoology Practical Paper 3	ZO-369 - Zoology Practical Paper 3	2+2
SEC	ZO-3510 - Aquarium Management	ZO-3610 - Environmental Impact Assessment	2+2
SEC	ZO- 3511 - Poultry Management	ZO-3611 - Project	2+2

2. Detailed Syllabus of T. Y. B. Sc.

Following is the syllabus of each course along with the course outcomes:

SR.NO.	SEMESTER	COURSE NUMBER AND NAME	CREDITS
1	V	ZO 351 - Pest Management	2
2	V	ZO 352 - Histology	2
3	V	ZO 353 - Biological chemistry	2
4	V	ZO 354 - Genetics	2
5	V	ZO 355 - Developmental Biology	2
6	V	ZO 356 - Parasitology	2
7	V	ZO 357 - Zoology Practical Paper 1	2
8	V	ZO 358 - Zoology Practical Paper 2	2
9	V	ZO 359 - Zoology Practical Paper 3	2
10	V	ZO 3510 - Aquarium Management	2
11	V	ZO 3511 - Poultry Management	2
12	VI	ZO 361 - Medical & Forensic Zoology	2
13	VI	ZO 362 - Animal Physiology	2
14	VI	ZO 363 - Molecular Biology	2
15	VI	ZO 364 - Entomology	2
16	VI	ZO 365 - Techniques in Biology	2
17	VI	ZO 366 - Evolutionary Biology	2
18	VI	ZO 367 - Zoology Practical Paper 1	2
19	VI	ZO 368 - Zoology Practical Paper 2	2
20	VI	ZO 369 - Zoology Practical Paper 3	2
21	VI	ZO 3610 - Environmental Impact Assessment	2
22	VI	ZO 3611 - Project	2

SEMESTER - V

Course Title: Pest Management
Course Code: ZO 351
Credits - 02

ZO 351 - Pest Management

Course Objectives:

After you complete your study of this unit, you should be able to:

- Explain why identification of the pest is the first step in developing an effective pest control strategy.
- Explain the differences between continuous pests, sporadic pests, and potential pests.
- Explain what is meant by prevention, suppression, and eradication of pests.
- Describe "thresholds" and why they are an important consideration in developing a pest control strategy.
- Describe "monitoring" as it relates to pest control and explain why it is important to pest control strategy.

Course Outcomes:

1. Define pest management.
2. Describe the economic, ecological, and sociological benefits of IPM.
3. Distinguish positive and negative impacts of pesticide use.
4. Understand problems resulting from misuse, overuse, and abuse of chemical pesticides.
5. Define and describe pesticide resistance and how it develops.
6. Identify ecological and biological characteristics important in development of pest populations.
7. Identify 10 tactics commonly used in IPM and be able to distinguish them.
8. Understand society's role in IPM decisions.
9. Describe different groups of pests and compare them to weeds and plant pathogens.
10. Analyse and compare management tactics to determine the best approach to reducing pest populations, weeds, and disease presence.
11. Locate appropriate, scientifically valid sources of information on specific tactics to manage insect pests, weeds, and diseases.
12. Know and how to develop an IPM program.

Title & Contents	**Number of lectures**
1. Pest:	**2 L**
1.1. Definition.	
1.2. Types of pests.	
1.3. Types of damages caused by the pest.	
2. Pest management using Regulatory control:	**4 L**
2.1. Quarantine.	
2.2. Eradication.	

2.3. Control districts.
2.4. "Crop-free" periods.

3. Pest management using Cultural control: 4 L

3.1. Sanitation.
3.2. Tillage.
3.3. Crop rotation.
3.4. Cropping systems.

4. Pest management using Biological control: 4 L

4.1. Ecological considerations.
4.2. Biological control of insects.
4.3. Biological control of plant disease.
4.4. Biological control of weeds.

5. Biotechnology approaches in pest management: 4 L

5.1. Introduction.
5.2. Recent advance in use of fungi and viruses.
5.3. Methodology in Biotechnology.
5.4. Somaclonal variability.
5.5. Concept of Genetic engineering and Transgenic plants.

6. Integrated pest management (IPM): 5 L

6.1. Principles and its components.
6.2. Advantages and disadvantages.
6.3. Biological control -
Predators, Parasitoids, Entomopathogens, Weed killers and their mass production.

7. Insecticides: 4 L

7.1. Classification of insecticides based on mode of entry.
7.2. Action and chemical nature.
7.3. Insecticides formulations and their uses.
7.4. Safe handling of insecticides.

8. Insecticide residue: 3 L

8.1. Methods of residue detection – Organochlorine, Organophosphates, Synthetic Pyrithroides, Systemic.
8.2. Problems in fruits, vegetables, medicinal plants.
8.3. Maximum permissible residue limits (MRLs).

Reference Books -

1. Handbook of Pest Management in Agriculture by Pimentel.
2. Principles of Insect Pest Management by Dhaliewal and Arora.
3. Agricultural Pest of India & South East Asia by A. Satwal.
4. Pathological Problems of Economics Crop Plants & their Management by Paul Khurana, S. M., 1998.

5. Integrated Diseases Management and Plant Health by Gupta V. K. & Sharma R. C.
6. Diseases of Millets by Ramkrishnan T. S., I. C. A. R. Publ. New Delhi.
7. Fungal diseases of Rice in India by Padmanabhan S. Y., I. C. A. R. Publ., New Delhi.
8. Analysis of Pesticides Residues by H. A. Moye (JW)
9. Advance in Pest Control Research by R. L. Methcalf (JW)
10. Chemistry of pesticides by K. H. Buchel (JW).
11. Progress in Pesticides Biochemistry and Toxicology Vol. I, II & III by D. H. Hutsonand T. R. Robert.
12. Evaluation of Pesticides in Ground Water by W. Y. Garnett, R. C. Honeycatt and others.
13. Chemistry of Pesticides by Edward
14. Insecticide Biochemistry and Physiology by C. F. Wilkinson.

Course Title: Histology
Course Code: ZO 352
Credits: 02

ZO 352 - Histology

Objectives –

1. To understand the histological aspects of mammalian organs.
2. To study the important features of different types of tissues in organ system.
3. To understand the classification of various types of basic tissues.
4. To study structure & functions of various tissues in organ system.
5. To understand histological structure of various glands and its functions.

Learning Outcomes for the course –

1. The students will be able to understand, classify and identify the different types of tissue.
2. The students will understand the complexity of various tissues in an organ.
3. The students will be able to learn structure & functions of various tissues.
4. The students will understand the various diseases related to organs.
5. The student will be able to know the role of glands in mammals.

Title & Contents	Number of lectures
1. Introduction: Definition and Scope of Histology.	**1 L**
2. Definitions and Review of Types of Tissues: 2.1 Epithelial tissue. 2.2 Connective tissue. 2.3 Nervous tissue. 2.4 Muscular tissue.	**3 L**
3. Histological study of following mammalian organs: 3.1 Skin (V. S.). 3.2 Tooth (V. S.).	**5 L**

3.3 Tongue (C. S.) with reference to mucosa papillae and taste buds.

4. Histological study of Alimentary canal and Liver: 6 L

4.1 Oesophagus (T. S.).
4.2 Stomach (T. S.).
4.3 Duodenum (T. S.).
4.4 Rectum (T. S.).
4.5 Liver (C. S.).

5. Histological study of Respiratory organs: 2 L

5.1 Trachea (T. S.).
5.2 Lung (C. S.).

6. Histological study of Excretory organs: 3 L

6.1 Kidney (L. S.).
6.2 Juxtaglomerular complex.

7. Histological study of Reproductive organs: 4 L

7.1 Testis (T. S.) with reference to Seminiferous Tubules and Cells of Leydig.
7.2 Ovary (C. S.).

8. Histology of Endocrine glands: 6 L

8.1 Pituitary gland.
8.2 Thyroid gland.
8.3 Adrenal gland.
8.4 Pancreas (C. S.) including both exocrine and endocrine components.

Reference Books: -

1. A Text Book of Histology, 2014, 5th Edn. Krishna Garg, Indira Bahl & Mohini Kaul CBS Publication & Distributors, Delhi.
2. Histology, 1987, 9th Edn., Arthur W. Ham, David H. Cormack, J. B. Lippincott Co. Philadelphia.
3. Histology, 1977, 4th Edn., R. O. Greep and L. Weiss, McGraw Hill Int. Book Co., New York.
4. Hand Book of Histo-pathogical & Histo-chemical Techniques, 1983, 3rd Edn. reprint, Butterworth & Co. (Publishers) Ltd, UK.

Course Title: Biological Chemistry
Course code: ZO 353
Credits: 02

ZO 353 - Biological Chemistry

Objectives –

1. To understand the basic concepts and significance of biochemistry.
2. To understand the basic concepts pH and Buffers
3. To understand the chemical structures of carbohydrate, and their biological and clinical significance.
4. To understand the structure and importance of proteins and lipids
5. To understand the variations in enzyme activity and kinetics.

Learning Outcomes for the course -

1. Learners shall be able to understand basic concepts and significance of biochemistry
2. The students will learn about the pH and Buffers.
3. The students will learn about the chemical structures of carbohydrate, and their biological and clinical significance.
4. The students will be able to understand, interpret structure and importance of proteins, carbohydrates and lipids
5. Learners will be able to comprehend variations in enzyme activity and kinetics.

Title & Contents	**Number of lectures**
1. Introduction of Biochemistry: Importance of Biochemistry in Life Sciences.	**1 L**
2. p^H and Buffers: 2.1 Concept of p^H. 2.2 Concept of p^H scale, biological significance of p^H 2.3 Concept of acid and base, Ionization of acids and bases. 2.4 Derivation of Henderson-Hassel Balch equation & its applications. 2.5 Buffer - Definition, Concept, Functions, Types of buffer and Buffering Capacity.	**3 L**
3. Carbohydrates: 3.1 Definition, Classification & Biological importance of Carbohydrates. 3.2 Isomerism in carbohydrates - Structural and Stereoisomerism. 3.4 Significance of Gluconeogenesis, Glycogenolysis and Glycogenesis. 3.3 Clinical Significance - Hypoglycemia and Hyperglycemia.	**7 L**
4. Amino acids and Proteins: 4.1 General Structure of amino acids and Peptide bond. 4.2 Essential and non-essential amino acids. 4.3 Types of proteins, protein structures (primary, secondary, tertiary and quaternary structures with suitable example), Forces responsible for their stability. 4.5 Biological importance of proteins – Biocatalysts, Carrier proteins Contractile proteins, Hormonal role of proteins.	**6 L**
5. Enzymes: 5.1Nomenclature, Types and properties of enzymes. 5.2 Regulatory and non-regulatory enzymes. 5.3 Enzyme inhibition. 5.4 Factors influencing enzyme activity (pH, temperature, substrate concentration). 5.5 Introduction of isoenzymes and cofactor. 5.6 Clinical significance of enzymes - PKU and AKU.	**10 L**
6. Lipids:	**3 L**

6.1 Introduction.
6.2. Fatty acids - Types and nomenclature (saturated and unsaturated).
6.3 Clinical significance (obesity, atherosclerosis, myocardial infarction).
6.4 Biological importance of lipids.

Reference books

1. Principles of Biochemistry, 1993, Lehninger A. L. Nelson D. L. & Cox M. M. W. H. Freeman Company, USA.
2. Biochemistry, 1995 5th Edn. Zuby G. W, C. Brown Communications USA.
3. Harpers Biochemistry, 1996 26th Edn. p Murray R. K., Granner D. K., Mayes P. A. & Rodwell V. W. Prentice Hall international USA.
4. Outline of Biochemistry, 1995 5th Edn, Conn E. E., Stumph P. K. Bruening G & Doi R. H. John Wiley & Sons, USA.
5. Principals of Biochemistry, 1993, 1st Edn., Pattabhiraman T. N. Gajanan Book publishers and distributors Bangalore.
6. Clinical Biochemistry, 1994, B. P. Godkar, Bhalini Publishing House, Mumbai.
7. Biochemistry, 1995 5th Edn., Stryer San Francisco, W. H. Freeman & Co.
8. Biochemistry, 1990, 8th Edn., D. Voet & J. Voet, John Willey, New York
9. David T. Plummer: An Introduction to Practical Biochemistry, IIIrd edition (1988)

Course Title: Genetics
Course code: ZO 354
Credits: 02

ZO 354 - Genetics

Title & Contents	**Number of lectures**
1. Introduction to genetics:	**3 L**
1.1 Classical and Modern concept of Gene, Cistron, Muton, Recon.	
1.2 Mendel's laws of Inheritance.	
2 Exceptions to Mendelian Inheritance:	**6 L**
2.1 Incomplete dominance.	
2.2 Co-dominance.	
2.3 Multiple alleles: Concept, characteristics and importance of multiple. alleles, ABO & Rh - blood group system and its medico legal importance.	
2.4 Lethal alleles.	
3. Gene Mutation:	**6 L**
3.1 Definition.	
3.2 Types of mutations: spontaneous, induced, somatic, gametic, forward, reverse. Types of point mutation - deletion, insertion, substitution, transversion, transition.	
3.3 Mutagenic agents	
a) UV radiation and ionising radiation.	
b) Base analogs, alkylating and intercalating agents.	

4. Sex-determination: **4 L**

4.1 Introduction.

4.2 Types of sex determination: -XX-XY, ZZ-ZW, XX-XO and Parthenogenesis, Hypodiploidy.

4.3 Gynandromorphism.

5. Population Genetics: **3 L**

5.1 Basic Concepts in population genetics: Mendelian population, gene pool, gene / allele, Frequency, chance mating (Panmictic mating).

5.2 Hardy Weinberg law and its equilibrium.

6. Human Population Genetics: **4 L**

6.1 Karyotype.

6.2 Genetic disorders, Structural & numerical alterations of chromosomes (chromosomal aneuploidy - Down, Patau, Edward, Turner and Klinefelter syndromes).

7. Sex linked inheritance in human: **2 L**

7.1 Colour – blindness.

7.2 Haemophilia.

7.3 Hypertrichosis.

8. Application of genetics: **2 L**

8.1 Genetic counselling.

8.2 Diagnostics & breeding technology.

Reference Books -

1. Principles of Genetics, 1997, P. D. Snustad, M. L. Simmons J. B. Jenkins, John Wiley & Sons, USA
2. Genetics, 2014, 9th Edn., Verma P. S. and Agarwal V. K., S. Chand and Co., New Delhi.
3. Genetics, 2014, 4th Edn. Gupta P. K., Rastogi Publications, Meerut.
4. Principles of Genetics, Gardner, E. J. *et al.* (2006), John Wiley and Sons Inc.
5. Genetics: A Molecular Approach, 3rd Edn, Russell, P. J., Benjamin Cummings.
6. Principles of Genetics 8th Edition, Gardner, E. J., Simmons, M. J., Snustad, D. P. (2008). John Wiley and Sons Inc.
7. Principles of Genetics. 5th Edn. Snustad, D. P. and Simmons, M. J. (2009). John Wiley and Sons Inc.
8. Concepts of Genetics, 10th Edn. Benjamin Cummings. Klug, W. S., Cummings, M. R. and Spencer, C. A. (2012).
9. An Introduction to Genetic Analysis, 11th Edn. Carroll S. B.; Doebley J., Griffiths, A. J. F. and Wessler, S. R. (2018) W. H. Freeman and Co. Ltd.

Course Title: Developmental Biology
Course code: ZO 355
Credits: 02

ZO 355 - Developmental Biology

Title & Contents	Number of lectures
1. Fundamentals of Developmental Biology: 1.1 Definition and scope. 1.2 Concepts in Developmental Biology: Growth, Differentiation, Dedifferentiation, Cell determination, Cell communication, Morphogenesis, Induction and Regeneration.	**3 L**
2. Theories of Developmental Biology: 2.1 Preformation. 2.2 Pangenesis. 2.3 Epigenesis. 2.4 Axial gradient. 2.5 Germplasm.	**3 L**
3. Gametogenesis: 3.1 Spermatogenesis & Structure of sperm with respect to human. 3.2 Oogenesis & Structure of ovum with respect to human. 3.3 Types of eggs.	**5 L**
4.Fertilization: 4.1 Concept and types. 4.2 Chemotaxis. 4.3 Sperm penetration: Acrosome reaction, Capacitation & Decapacitation. 4.4 Activation of ovum: Fertilization cone. 4.5 Prevention of polyspermy: Fast block & Slow block. 4.6 Significance of fertilization.	**6 L**
5. Cleavage and Blastula: 5.1 Planes and symmetry of cleavage. 5.2 Types of cleavage. 5.3 Significance of cleavage. 5.4 Definition and types of Blastula.	**5 L**
6. Gastrulation: 6.1 Definition and Concept. 6.2 Basic cell movements in gastrulation: Epiboly, Emboly, Convergence, Invagination, Ingression & Involution with reference to frog. 6.3 Concept of Organizer : Primary, Secondary and Tertiary.	**3 L**
7. Chick Embryology: 7.1 Structure of Hen's egg.	**6 L**

7.2 Fertilization and cleavage in Chick.
7.3 Formation of primitive endoderm.
7.4 Primitive streak development.
7.5 Head process and regression of Primitive streak.

References:

1. An Introduction to Embryology (2012), 5th Edition., Balinsky B. L., Fabian B. C. Brooks Cole Pub. Co., USA
2. Developmental Biology (2013), 10th Edn. Gilbert S. F., Sinauer Associates Inc.
3. Developmental Biology: Patterns**,** Principle and Problems (1982), Saunders J. W., Prentice Hall Coll Div.
4. Principles of Development (2007), 3rd edition, Lewis Wolpert, Oxford University Press Publisher

Course Title: Parasitology
Course code: ZO 356
Credits: 02

ZO 356 - Parasitology

Objectives:

1. To understand the basic terminologies in parasitology.
2. To understand the concepts of animal association with examples.
3. To understand the morphology and life cycle of common parasites (Protists and Platyhelminthes).
4. To understand the phenomenon of Host-parasite relationship.
5. Explain the importance of arthropod vectors with examples.

Learning outcomes:

1. The students will be able to learn about basics and scope of parasitology.
2. The students will be able to learn the types of host and parasite with examples.
3. The students will be able to learn about the morphology, life cycle, pathogenicity and treatment of common parasites (Protists and Platyhelminthes).
4. The students will be able to learn about host -parasite relationships and their effects on host body.
5. The students will be able to learn about the arthropod parasites and their role as vector.

Title & Contents	**Number of lectures**
1. Introduction, Scope and Branches of Parasitology: 1.1. Definition: host, parasite, vector, commensalisms, mutualism and parasitism. 1.2. Branches of parasitology.	**2 L**
2. Types of Parasites and Hosts: 2.1 Ectoparasites.	**3 L**

2.2 Endoparasites and its subtypes.
2.3 Types of hosts - Intermediate, definitive, paratenic and reservoir.

3. **Host - Parasite relationship:** **3 L**
3.1 Host specificity.
3.2 Types of host specificity: structural specificity, physiological specificity and ecological specificity.
3.3 Effects of parasite on host.

4. Study of Parasitic Protists: **9 L**
4.1 *Entamoeba histolytica* - Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment.
4.2 *Plasmodium vivax* - Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment.

5. Study of Parasitic worms: **9 L**
5.1 *Ascaris lumbricoides* - Study of Morphology, Life Cycle, Prevalence.
5.2 Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment.
5.3 *Taenia solium* (Tapeworm) - Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment.

6. Study of Parasitic Arthropoda: **4 L**
Morphology, pathogenicity and control measures of –
6.1 Soft tick.
6.2 Head louse.
6.3 Rat flea.
6.4 Bed bug.

Reference Books:

1. Parasitology: K. D. Chatterjee.
2. Parasites: ecology, diseases, and management (2013).
3. Parasitic Helminths: Targets, Screens, Drugs, and Vaccines, 201.
4. Parasitism: The Diversity and Ecology of Animal Parasites (2014) Tim Goater, Timothy M. Goater, Cameron P. and Esch, Gerald W. Cambridge University Press.
5. Principles of Veterinary Parasitology (2016), 1st Edn, Dennis E. Jacobs, Mark Fox, Lynda M. Gibbons, Carols Hermosilla, John Wiley & Sons.
6. Veterinary Parasitology (2013), Hany M. Elsheikha, Jon S. Patterson, CRC Press Taylor & Francis Group
7. Textbook of medical parasitology – C. K. Jayaram Panikar.
8. Textbook of medical parasitology – Arora & Arora.
9. Textbook of medical parasitology – S. C. Parija.
10. Veterinary Parasitology, 2013 - (Taylor, M. A.).
11. Encyclopedia of parasitology, 2008.
12. The Biogeography of Host-Parasite Interactions by Serge Morand, Boris R. Kransov, Oxford University Press.
13. Textbook of medical microbiology – Rajesh Bhatia & Itchpujani.

14. Textbook of medical microbiology – Arora & Arora.
15. Biological Control of Parasites, 2012.
16. Biology of Malaria Parasites, 2012.
17. Sherris medical microbiology: Ryan.
18. Medical microbiology: Jawetz Melnick & Adelbergs.
19. Current concepts in parasitology, 2012.
20. Textbook of Parasitology, Ashok Kumar, Discovery Publishing.
21. Introduction to parasitology: With special reference to the parasites of man, A.C. Chandler- John Wiley & Sons.
22. A text book of Parasitology – D. P. Karyakarte & A. S. Damle.

For Practical papers of both V and VI semester, minimum 6 practicals should be conducted from each section, thus a minimum of 12 practicals should be conducted per practical paper. (C) stands for compulsory.

Course Title: Zoology Practical Paper I
Course code: ZO 357
Credits: 02

Course Title : Zoology Practical Paper - I

Section I: Practicals in Pest Management

1.	To study the plant protection appliances.	D
2.	Studies on beneficial insects. (C)	D
3.	Study of pests and diseases of honeybees. (C)	D
4.	Applications of IPM components in various crops.	D
5.	Separation of the pesticides or plant products by TLC and Column chromatography. - 2 P(C)	E
6.	Detection of pesticides residues in food stuffs. (C)	E
7.	Rearing of pest species (Any 2 species). (C)	D
8.	Study of life cycle of Red cotton bug and Lemon butterfly.	D
9.	Study of the detection of damage caused by pests.	D
10.	Plant disease, its intensity & calculation of VI (Virulence Index) of at least two diseases.	D

Section II: Practicals in Histology

1.	Study of the different types of tissues with the help of permanent slides – Epithelial tissue, Connective tissue, Muscular tissue and Nervous tissue.	D
2.	Study of permanent histological slides of T. S. of skin, V. S. of tooth and C. S. of tongue.	D
3.	Study of permanent histological slides of digestive parts – T. S. of Stomach, T. S. of Duodenum, T. S. of Rectum, C. S. of Liver.	D

4. Study of permanent histological slides of glands - T. S. of Pituitary gland, T. S. of Thyroid gland, T. S. of Adrenal gland, C. S. of Pancreas. D
5. Study of permanent histological slides of reproductive organs- T. S. of Testis, C. S. of Ovary. D
6. Study of human blood smear to observe different types of blood cells. (C) E
7. Temporary mounting of tissues of any mammal (freshly dissected or preserved) - Striated Muscle Fibre. (C) E
8. Temporary mounting of tissues of any mammal (freshly dissected or preserved) - Smooth Muscle Fibre. (C) E

Course Title: Zoology Practical Paper - II
Course code: ZO 358
Credits: 02

ZO 358 - Zoology Practical Paper - II

Section I: Practicals in Biological Chemistry

1. To determine the enzyme activity - salivary amylase/ urease/ invertase. E
2. To determine specific activity of an enzyme. E
3. Detection of carbohydrates (monosaccharides, disaccharides and polysaccharides) with the help of suitable tests. (C) E
4. Isolation of starch from potato and digestion of starch by salivary amylase. (C) E
5. Preparation of buffer of desired pH and molarity. (C) E
6. Protein estimation by Lowry *et al*. method. (C) E
7. Isolation of Caesin from milk by adjusting iso-electric point. (C) E
8. Preparation of Acid, Alkali & it's standardisation. E
9. Principle, Working & Measurement of pH of any three samples. E

Section II: Practicals in Genetics

1. Study of monohybrid ratio by providing hypothetical data and deducing applicability of Mendelian laws (Two examples). (C) D
2. Study of Dihybrid ratio by providing hypothetical data and deducing applicability of Mendelian laws (Two examples). (C) D
3. Study of genetic traits in human beings (tongue rolling, widow's peak, ear lobes, colour-blindness and PTC tasters/ non-tasters). D

4. Study of blood groups in human (ABO and Rh). (C) D
5. Study of Hardy - Weinberg law with suitable recording of genetic traits. D
6. Study of human karyotypes and numerical alterations (simulated & theoretical sample data) (Down syndrome, Klinefelter syndrome and Turner syndrome). D
7. Temporary preparation of polytene chromosomes from suitable material. (C) E
8. Study of structural chromosome aberrations (dicentric, ring chromosomes and inversions in polytene chromosomes) from prepared slides / photographs. D
9. Study of external characters, life cycle and Rearing of *Drosophila.* (C) D
10. Study of *Drosophila* mutants. D

Course Title: Zoology Practical Paper III
Course code: ZO 359
Credits: 02

ZO 359 - Zoology Practical Paper - III

Section I: Practicals in Developmental Biology

1. Study of ultrastructure of Sperm and Ovum of Mammal. D
2. Study of eggs with the help of slide / Photograph / chart / Model (Insect, *Amphioxus*, Frog and Hen). (C) D
3. Study of cleavage and its types with the help of Slide / Photograph / Chart / Model. D
4. Study of blastulae (*Amphioxus*, Frog and Hen). D
5. Study of gastrulae (*Amphioxus*, Frog and Hen). D
6. Study of whole mount slides of chick embryology – 24 hrs, 33 hrs and 48 hrs. (C) D
7. Study of T. S. and V. S. of chick embryo of Brain & Heart with the help of slide / Photograph / chart / Model – 24 hrs & 33 hrs. D
8. Temporary preparation of chick embryo. (C) E
9. Ex-ovo culture of chick embryo. D

Section II : Practicals in Parasitology

1. Study of parasitic association with their example - D
   a) Commensalism.
   b) Parasitism.
2. To study the life cycle, pathogenecity, diagnosis and treatment of *Entamoeba histolytica* and *Plasmodium vivax* through permanent slides or microphotographs. D
3. To study the life cycle, pathogenecity, diagnosis and treatment of *Ascaris lumbricoides* and *Taenia solium* through specimen, permanent slides or microphotographs. (C) D

4. Study of following parasites with its role as vector - Soft tick, *Pediculus humanus*, *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides or photographs. (C)	D
5. Study of effects of parasites on host body.	D
6. Study of the pathogenecity and control measures of - Tick (soft tick and hard tick) and Mite *(Sarcoptes scabiei*).	D
7. Study of parasites from the gut of cockroach. (C)	E
8. Collection & submission of various parasites. (C)	E

Course Title: Aquarium Management
Course Code: ZO 3510
Credits: 02

ZO 3510: Aquarium Management

Title & Contents	**Number of lectures**
1. Introduction to Aquarium Fish Keeping: 1.1 The potential scope of Aquarium Fish Industry as a Cottage Industry. 1.2 Exotic and Endemic species of Aquarium Fishes. 1.3 Nutritional value of fish.	**4 L**
2. Biology of Aquarium Fishes: 2.1 Common characters and sexual dimorphism of Aquarium fishes - Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish, Butterfly fish and Fighter fish.	**6 L**
3. Food and feeding of Aquarium Fishes: 3.1 Use of live fish feed organisms. 3.2 Preparation and composition of formulated fish feeds. 3.3 Overview on types of fish food.	**4 L**
4. Fish Transportation: 4.1 Live fish transport: a) Fish handling. b) Fish packing. c) Fish forwarding techniques. 4.2 Causes of mortality in transport.	**4 L**
5. Maintenance of Aquarium: 5.1 General Aquarium Maintenance - budget for setting up an Aquarium. 5.2 Fish Farm as a Cottage Industry, Rules & regulations of fish rearing. 5.3 Common diseases of Aquarium fish.	**3 L**
6. Physico-chemical parameters of water for fish culture: 6.1 Acidity, Alkalinity, Calcium, Nitrate, Ammonia, Total hardness.	**4 L**
7. Fish preservation: 7.1 Fish preservation and processing.	**2 L**

7.2 Fish preservation techniques.

8. Fish breeding: **3 L**

8.1 Types of fish breeding -

a) Natural fish breeding.

b) Induced fish breeding.

Course Title: Poultry Management

Course Code: ZO 3511

Credits: 02

ZO – 3511 Poultry Management

Objectives:

1. To understand the basics of Poultry Farming and its important.
2. To understand breeding management of broilers and layers of chickens.
3. To understand housing management and equipment of Poultry farming.
4. To understand food, feeding and digestion mechanism of chickens.
5. To understand the poultry diseases and their control.
6. To understand the economic importance of poultry products.

Expected Outcome:

1. The students will be able to understand the Poultry farming practices.
2. The students will able to understand the poultry breeding techniques.
3. The students will be able to understand poultry rearing techniques.
4. The students will be able to understand feeding requirement and food ingredients.
5. The students will be able to understand the poultry disease and their pathogens.
6. The students will be able to understand market value of poultry products.

Title & Contents	**Number of lectures**
1. Introduction to Poultry Farming: 1.1 Definition of Poultry, Importance of Poultry Farming and Poultry Development in India. 1.2 Present and future prospects.	**2 L**
2 Breeding Management: 2.1 Male and female reproductive system of chicken. 2.2 Breeds and strains of broilers and layers of chicken. 2.3 General aspects of breeding for better egg production and body weight gain. 2.4 Selection and culling. 2.5 Artificial insemination.	**5 L**

3 Housing Management: **5 L**

3.1 Establishment of poultry farm.
3.2 Housing and equipment.
3.3 Incubation and hatching of eggs.
3.4 Broiler and layer management.
3.5 Lighting schedule for poultry.
3.6 Transport strategy of Poultry birds.

4 Feeding Management: **6 L**

4.1 Digestive system and Digestion Mechanism of chicken.
4.2 Feed ingredients.
4.3 Feed processing.
4.4 Formulation of feed *viz*., Starter, Grower, Layer, Finisher and Breeder ration, Feed conversion ratio (FCR), Nutritional deficiency conditions.

5 Health Management: **5 L**

5.1 Vaccination schedule for poultry birds.
5.2 Common poultry diseases, i. e. Ranikhet, Marek, Chicken pox, Gumboro, Infectious bronchitis and Chronic Respiratory Disease (CRD).
5.3 Control of internal and external parasites.

6 Poultry Products: **4 L**

6.1 Preservation and storage of eggs.
6.2 Grading of eggs and AGMARK standard of egg.
6.3 Egg powder.
6.4 Slaughtering and processing of chicken.
6.5 Poultry By Products – Feathers and Poultry Manure.

Reference Books

1. Commercial Chicken Meat and Egg Production (2007), 5th Edn,Bell D. Donald and Weaver D. William Jr., Springer India Pvt. Ltd., Noida.
2. Poultry Science (2015) 3rd Edn, Ensmiger. M. E., International Book Distribution Co., Lucknow, India.
3. Modern Poultry Farming (2003), 1st Edn, Hurd M. Louis, International Book Distributing Company, Lucknow.
4. Handbook of Poultry Production and Management (2007), 2nd Edn., Jadhav N. V., and Siddique M. F., Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.
5. Successful Poultry Management (2007), 2ndEdn, Jull A. Morley, Biotech Books, New Delhi.
6. Poultry Husbandry (2008) 2nd Edn, Jull A. Morley, J. V. Publishing House, Jodhpur, Rajasthan.
7. Broiler Breeder Production (2001), 1stEdn, Leeson. S., and Summers J. D. International Book Distributing Company, Lucknow.
8. Poultry and Ratite Nutrition (2013), 1stEdn, Pathak N. N., Narendra Publishing House, New Delhi, India.
9. Simply Poultry Science (2011) 1st Edn, Rajini Asha R., Alfa Publications, New Delhi.

10. Poultry Production (2011) 3rd Edn, Singh, R. A., Kalyani Publishers, New Delhi.
11. Textbook of Poultry Science (2015) 1stEdn, Sreenivasaiah., P. V. Write & Print Publications, New Delhi.
12. Encyclopedia of Broiler Breeder Production: Production, Feeding and Management Techniques (2013) Vol. 1, 2 & 3, Youn Michael, Anmol Publications Pvt. Ltd., New Delhi

Note: Latest editions of the recommended books may be referred.

SEMESTER - VI

Course Title: Medical & Forensic Zoology
Course Code: ZO 361
Credits: 02

ZO 361 - Medical & Forensic Zoology

Objectives:

1. To understand the scope, need and History of Forensic Science.
2. To understand the role of different institutes & allied institutes of Forensic Science.
3. To understand the various branches of Forensic Sciences from Life Sciences.
4. To understand human physiology, post mortal investigations.
5. To understand knowledge of handling different types of evidences and their examinations.

Expected Outcome

1. The students will be able to understand the basics principles of Medical and Forensic Zoology.
2. The students will able to understand scientific methods in crime detection.
3. The students will be able to understand the advancements in the field of Medical and Forensic Zoology.
4. The students will be able to understand modern tools, techniques and skills in forensic investigations.
5. The students will be able to describe the fundamental principles and functions of forensic science and its significance to human society.

Title & Contents	**Number of lectures**
1. Introduction to medical zoology and its importance :	**2 L**
2. Medico-legal Autopsy: 2.1 Death and its Causes- External examination of deceased body – Internal Examination - Determination of time since death and cause of death. 2.2 Injuries – Classification - Medico-legal aspects of injuries. 2.3 Post-mortem changes - collection of post-mortem samples and Preservation.	**6 L**
3. Urine Analysis: 3.1 Physical characteristics, abnormal constituents, renal failure, renal calculi, dialysis.	**3 L**

4. Non infectious Diseases: **2 L**

4.1 Causes, Types, Symptoms, Complications, Diagnosis and Prevention of Diabetes (Type I and II), Hypertension, Hypotension, Obesity, Atherosclerosis, Myocardial Infraction.

5. Infectious Diseases: **2 L**

5.1 Causes, Types, Symptoms, Complications, Diagnosis and Prevention of Tuberculosis and Hepatitis.

6. Introduction to Forensic Zoology: **3 L**

6.1 Definition, Scope and Application of Forensic Zoology.
6.2 Forensic Laboratories in India.
6.3 Basic Principles of Forensic Science with Examples.

7. Forensic Medicine: **3 L**

7.1 Introduction to Forensic Medicine: Definitions of Forensic Medicine.
7.2 Medical Jurisprudence.
7.3 Medical evidence documentations.

8. Forensic Analysis: **9 L**

8.1 Examination of Biological Materials: Examination of Hair, Fibres, Diatoms, plants materials, human tissues.
8.2 Examination of Body Fluid: Blood, Semen and Saliva.
8.3 Forensic Importance of Insects: Insects of forensic importance - indicators of time of death stages of insect development & comparative decomposition of human body - colonization - Evidence collection of insects – Territorial & Aquatic Insects.
8.4 DNA Fingerprint Technique and Examination of Biological Traces: Liquid blood, blood stains, & swabs, semen, Seminal stains, tissues, Bones, Hairs, Teeth, Saliva, Skeletal remains.
8.5 Toxicological Investigations: Poisons – Definition, Forms of Poison – Physical, Chemical & Mechanical state. Introduction with examples of – Neurotoxic Poisons – Cerebral & Spinal, Cardiovascular Poisons, Asphyxiants, Miscellaneous poisons – Pesticides, Pharmaceutical drugs, Petroleum poisons, Food poisons, Radioactive poisons.

Reference Books

1. Godkar P. B and Godkar D. P, Textbook of Medical Laboratory Technology, II Edition, Bhalani Publications
2. Textbook of Microbiology: R. Ananthanarayan, C. K. Jayaram Panikar, University Press.
3. A textbook of Microbiology: P. Chakraborty
4. Text book of pathology: Robbins & Cotran, Vol. 1 & 2, Tenth Edition, Elsevier Publication.
5. Pathologic basis of disease: M. K. Singh & Vinay Kumar, Vol. 1 & 2, 10th edition, Elsevier.
6. Text book of General pathology: Bhende & Deodhare Part I & II.
7. Pathologic basis of Disease: Robbins & Cotran, Vol. 1 & 2, 10th edition, Elsevier publications.
8. Essentials of medical pharmacology: K. D. Tripathi, 8th edition, Jaypee brothers publishers.
9. Review of pharmacology: K. D. Tripathi, Jaypee brothers publishers.

10. Essentials of medical microbiology: Apurba S. Sastry & Sandhya Bhat, Jaypee brothers.
11. W. G. Eckert and S. H. James, Interpretation of Bloodstain Evidence at Crime Scenes, CRC Press, Boca Raton (1989).
12. The essentials of forensic medicine & toxicology: K. S. Narayan Reddy.
13. A textbook of Clinical pharmacology: Roger H. J., Spector R. G., Trounce J. R., Hodder & Stoughton publishers.
14. Pharmacology & Pharmacotherapeutics : Satoskar R. S., Bhandarkar S. D., Popular Prakashan, Mumbai.
15. The synopsis of forensic medicine & toxicology: K. S. Narayan Reddy.
16. Textbook of pathology: Harsh Mohan.
17. G. T. Duncan and M. I. Tracey, Serology and DNA typing in, Introduction to Forensic Sciences, 2nd Edition, W. G. Eckert (Ed.), CRC Press, Boca Raton (1997).
18. T. Bevel and R. M. Gardner, Blood stain Pattern Analysis, 3rd Edition, CRC Press, Boca Raton (2008).
19. Arti Nigam and Archana Ayyagari, Lab manual in Biochemistry, immunology and biotechnology, Mc Graw Hill Publishing Company ltd.
20. Fundamentals of Forensic Science, Second Edition, Max M. Houck and Jay A Siegel, Academic Press.
21. Forensic Science, Third Edition, Stuart H James and Jon. J. Nordby.
22. Forensic Science in India and the World, Deepak Ratna and Mohd. Zaidi, Alia Law Agency, Allahabad.
23. Forensic Science in India - A Vision for 21st Century, B. B. Nanda and Dr. R. K. Tewari, Select Publishers.
24. Cell Biology, Sixth Edition International Students Edition, Gerald Karp, Wiley Publications, 2010.
25. Human Physiology: From Cells to Systems, Lauralee Sherwood, Cengage Learning, 2008.
26. Forensic Biology, Richard Li, CRC Press.
27. Human Anatomy Vol. 1,2,3,4, Chaurasia B. D.
28. Text Book of Medical Jurisprudence, Forensic Medicine and Toxicology by Parikh C. K.
29. Forensic Science: An introduction to Scientific and Investigative Techniques by S. H James, J. J. Nordby.
30. Parikh C. K., Medical Jurisprudence.

Course Title: Animal Physiology
Course Code: ZO 362
Credits: 02

ZO 362 - Animal Physiology

Course Objectives:

1. To acquaint students with the principles and basic facts of Animal Physiology and with some of the laboratory techniques and equipment used in the attainment of physiological data. The importance will be on mammalian.
2. The course will focus on organ-system physiology,
3. Furthermore, emphasis will be placed on nutritive, circulatory, respiratory, excretory, muscular, nervous, reproductive and endocrine physiology. Where appropriate, basic chemical and physical laws will be reviewed in order to enhance and to promote student understanding.

4. The laboratory module of the course is designed to support the topics discussed in theory lecture, as well as to acquaint students with some of the laboratory techniques and equipment used in the gaining of physiological facts**.**

Learning Outcomes:

Upon successful completion of this course, the students will be able to describe, identify, and/or explain:

1. The various physiological organ-systems and their importance to the integrative functions of the human body.
2. Understand Concept of energy requirements
3. Various aspects of Digestive physiology.
4. Circulatory system with medical conditions
5. Understand Respiratory mechanism and gases transport.
6. Eliminations of waste materials from the body.
7. Develop understanding in Structure and functions of muscles
8. Understand formation of gametes and function of endocrine glands.

Title & Contents	**Number of lectures**
1**. Nutrition and digestion:** 1.1 Nutritional requirement & balanced diet. 1.2 Digestion and absorption of carbohydrates, proteins and lipids. 1.3 Vitamins - outline of fat soluble and water-soluble vitamins; Sources, deficiency and diseases.	**5 L**
2. Respiration: 2.1 Mechanism of respiration: Regulation of ventilation in lungs, exchange of gases at respiratory surface. 2.2 Respiratory pigments in animals: Haemoglobin, Hemocyanin, Hemerythrin, Chlorocruorin. 2.3 Transport of gases : O_2 and CO_2 transport.	**5 L**
3. Circulation: 3.1 Blood: Definition and its constituents, functions of blood. 3.2 Heart: Structure of human heart, Pace maker, Cardiac Cycle. 3.3 Origin and conduction of heart beat.	**5 L**
4. Excretion: 4.1 Structure of Uriniferous tubule. 4.2 Mechanism of urine formation. 4.3 Normal and abnormal constituents of urine, Elementary idea of dialysis.	**5 L**
5. Muscles: 5.1 Structure of smooth, skeletal and cardiac muscles. 5.2 Mechanism of muscle contraction by Sliding filament theory.	**3 L**
6. Reproduction and Endocrine Glands: 6.1 Physiology of male reproduction, hormonal control of spermatogenesis. 6.2 Physiology of female reproduction, hormonal control of menstrual cycle.	**7 L**

6.3 Structure and functions of pituitary, thyroid, parathyroid, pancreas and adrenal glands.

Reference Books

1. Textbook of Medical Physiology, Guyton A. C. & Hall J. E., 2006, 11th Edition, Hercourt Asia Pvt. Ltd. / W. B. Saunders Company
2. Principles of Anatomy & Physiology, 2006, 11th Edition, Tortora G. J. & Grabowski S., John Wiley & sons, Inc.
3. Haematology: De Gruchi.
4. Human physiology, Vol. I & II, 1980, 12th Edn. Dr. C. C. Chatterjee, Medical Applied Agency, Kolkata
5. Text book of Animal Physiology, 2008, 2nd Edn. Nagabhushanam, S. V. S. Rana, S. Kalavathy, Oxford University Press, India.
6. Animal Physiology: Adaptation and Environment, 1997, Schmidt-Nielsen, Knut, Cambridge University Press.
7. General and Comparative Physiology, 1983, 3rd Edn., Hoar W. S., Prentice Hall, UK.7.
8. Medical Physiology, 2006, Asis Das, Books and Allied Pvt. Ltd., Kolkata.
9. Endocrinology, 2005, Lohar P. S., M J P Publishers, Chennai.
10. Vander, Sherman, Luciano's Human Physiology: The Mechanisms of Body Function, 2003, 9th Edn., Eric P. Widmaier, Hershel Raff, Kevin T. Strang, Mc Graw H.
11. Tortora, G. J. and Derrickson, B. H. (2009) Principles of Anatomy and Physiology (12th edition) John Wiley and Sons, Inc.
12. Widmaier, E. P., Raff, H. and Strang, K. T. (2008) Vander's Human Physiology (9th edition) McGraw Hill.
13. Human Anatomy and Physiology, (1998) Marieb, E. (4th edition) Addison-Wesley.
14. Experimental Physiology, (2007) Kesar, S. and Vashisht, N., Heritage Publishers.

Course Title: Molecular Biology
Course Code: ZO 363
Credits: 02

ZO 363 - Molecular Biology

Objectives:

1. The course aims to provide students with an introduction of the underlying molecular mechanisms of various biological processes in cells and organisms.
2. To understand the Structure of DNA and RNA, DNA and RNA as genetic material
3. To understand the Central Dogma of Molecular Biology
4. To understand the concept of gene regulation
5. To understand the DNA Damage and Repair
6. The course aims to develop basic understanding of structure-function relationships of nucleic acids and proteins.

Learning outcomes:

1. Learner shall get an insight into molecular mechanisms of various biological processes in cells and organisms
2. Learner shall get an insight into the Structure of DNA and RNA, DNA and RNA as genetic material
3. The course shall prepare learner to get insight into the Central Dogma of Molecular Biology

4. Learner shall also understand the concept of gene regulation
5. Learner shall get an insight into the DNA Damage and Repair

Title & Contents	**Number of lectures**
1. Nucleic Acids and Chromatin: 1.1 Structure of RNA & DNA. 1.2 Types of RNA. 1.3 DNA as genetic material - evidences (Griffith's, Avery *et al*., Hershey and Chase experiment), RNA as genetic material - TMV 4. 1.4 Structure of Chromatin, packaging of DNA, Heterochromatin, Euchromatin.	**7 L**
2. Central Dogma of Molecular Biology: 2.1 **DNA Replication -** Semiconservative (Messelson and Stahl experiment), Basic mechanism of replication in prokaryotes and eukaryotes. 2.2 **Transcription -** 2.2.1 Basic mechanism of transcription in prokaryotes and eukaryotes, RNA polymerase enzyme in prokaryotes. 2.2.2 RNA modifications and processing (splicing - mRNA, modifications at 3'and 5' end). 2.3 **Translation -** Genetic code, properties of genetic code, Basic mechanism of Translation in *E. coli* and eukaryotic cells.	**15 L**
3. Lac operon:	**1 L**
4. DNA repair mechanism: Photo repair, dark repair, base excision repair.	**3 L**
5. Recombinant DNA Technology: Introduction, restriction enzymes, cloning vector, PCR (polymerase chain reaction), DNA finger printing.	**4 L**

Reference Book:

1. Molecular biology of cell, 3rd and 4th edition, Albert's B. D. Lewis J. Raff M. Roberts K. and Watson.
2. Gene, Vol. V, VI, VII, VIII and IX, Lewin B., Oxford University Press, Oxford.
3. Molecular biology of the Gene, 1993, Watson J. Hopkins, Roberts Steitz & Weiner, Benjamin Cummings.
4. Text Book of Molecular Biology, 1994, K. Sivrama Sastry G. Padmanabhan and C. Subramanyam : MacMillan, India.
5. Cell and Molecular biology, 1996, G. Karp, John Willey & Sons, U.S.A.

6. Principles of Genetics, 1997, P. D. Snustad, M. L. Smmons, J. B. & Jenkins, John Willey & Sons, U.S.A.
7. Cell and Molecular biology, De Robertis and De Robertis, 8th & 9th Edition, Saunders Publications.

Course Title: Entomology
Course Code: ZO 364
Credits: 02

ZO 364 - Entomology

Objectives:

1. To understand the scope of Entomology and general characters of Insects.
2. To study the morphology and anatomy of Insects.
3. To learn the concept of social organization in Insects.
4. To understand metamorphosis in Insects.
5. To study the economically important insects and Pest management of harmful insects.

Course outcomes:

At the end of this course, Students will -

1. Understand basic concepts in Entomology and its scope.
2. Learn morphology and anatomy of Insects.
3. Understand the concept of social organization in Insects.
4. Understand the development process of Insects.
5. Identify disease causing insect vectors.
6. Will be able to design and implement pest controlling methods against pests.

Title & Contents	Number of lectures
1. Fundamentals of Entomology: 1.1 Definition and scope of Entomology. 1.2 General Classification of Insects. 1.3 General Characters of Insects.	**2 L**
2. Insect Morphology: 2.1 Insect Integument and its derivatives. 2.2 Insect Head, Head Orientations, Head articulations, Insect antennae and Mouth parts. 2.3 Insect Thorax, Insect Wing and modifications, Insect Leg and Modifications – a) Cursorial – Cockroach, b) Fossorial – Mole cricket, c) Saltorial – Grasshopper, d) Raptorial – Praying mantis, e) Pollen basket – Honey bee. 2.4 Insect Abdomen, Genital and Pre – genital appendages of Grasshopper.	**7 L**

3. Insect Anatomy (Grasshopper): 4 L

3.1 Digestive System.
3.2 Circulatory System.
3.3 Nervous System.
3.4 Respiratory System.
3.5 Reproductive System.

4. Insect Ecology: 3 L

4.1 Definition of Insect Ecology.
4.2 Abiotic Factors (Photoperiod, Temperature and Humidity) and Biotic Factors (Food, Foraging and Nesting).
4.3 Mimicry in insects with suitable examples.

5. Insect Metamorphosis: 2 L

5.1 Definition.
5.2 Types and examples of Metamorphosis.

6. Insects as social groups: 6 L

6.1 Definition & significance of Eusociality, Intraspecific and Interspecific relationships among insects.
6.2 Social organization in Wasps and Termites.

7. Economic Importance of Insects: 3 L

7.1 Insects in Research.
7.2 Insects in Medicines and Cosmetics.
7.3 Insects as Vectors.
7.4 Insects as food.

References

1. Social Insects: Their Origin and Evolution, 2006, W. M. Wheeler, Discovery Publishing House, Delhi.
2. Lives of Social Insects, 1968, P. P. Larson, M. W. Larson, World Pub. Co.
3. Modern Entomology, 2nd edition - By D. B. Tembhare, Himalaya Publication House, Bombay.
4. Principles of Insect Morphology - By R. E. Snodgrass, Tata Mc-Graw Hill Bombay.
5. The Insect: Structure & Function - By R. F. Chapman, E. L. B. S., & E. U. P. London.
6. General Entomology, 2nd edition - By M. S. Mani Oxford & IBH Publishing Company, New Delhi.
7. A Text book of Entomology - By H. H. Ross, John Wiley and Sons, Ins. New York.
8. An Introduction to Entomology - By J. H. Comstock, Ithaca, New York.
9. General & Applied Entomology - By K. K. Nayar, T. N. Anathakrishnan & B.V. David, Tata McGraw-Hill, New Delhi.

Course Title: Techniques in Biology
Course Code: ZO 365
Credits: 02

ZO 365 - Techniques in Biology

Title & Contents	Number of lectures
1. Microscopy:	**3 L**
1.1 Definitions - Resolving Power, Limit of Resolution and Magnification, Numerical Aperture.	
1.2 Basic principle of microscopes - Light, Fluorescence, Phase Contrast, Stereo Microscope, SEM and TEM.	
2. Microtomy: Tissue fixation and Processing	**8 L**
2.1 Methods of tissue fixation: Chemical fixation and physical fixation.	
2.2 Procurement of tissue and importance of fixation of tissues.	
2.3 Dehydration, clearing, impregnation, embedding and block making.	
2.4 Types of microtomes.	
2.5 Section cutting: steps and precautions**,** common faults in section cutting, reasons & remedies.	
2.6 Mounting and spreading of ribbons.	
2.7 General procedure for staining of sections.	
2.8 Demonstration of Nucleic acid (Feulgen Reaction).	
3. Haematological Techniques:	**2 L**
3.1 Total count of RBCs, WBCs and Differential count of WBCs and their significance.	
3.2 Bleeding time, clotting time and their significance.	
4. Immunological Techniques:	**3 L**
4.1 Antigen-Antibody Interactions – Immunodiffusion.	
4.2 Principle & Working of ELISA.	
4.3 Raising Monoclonal Antibodies.	
4.4 Application of Immunological techniques in disease diagnosis.	
5. Types of PCR & DNA Barcoding :	**2 L**
6. Methods in Biodiversity:	**4 L**
6.1 Introduction to sampling and sample size.	
6.2 Biodiversity Indices - Species richness, Simpson Diversity Index, Shannon Diversity Index.	
6.3 Measuring Biodiversity- Quadrat sampling, Transect sampling, Insect survey - Active (sweep netting, aquatic nets) and Passive methodology (Pit fall traps, Light traps).	
7. Instruments in Field Biology:	**3 L**
7.1 Binoculars, GPS, Basic digital camera techniques: Camera lens - prime	

and kit lens, Aperture mode, Shutter mode, Megapixels, Telephoto lens, macro lens.

7.2 Adapters for camera and microscopes, Mobile's camera.

8. Laboratory techniques: 3 L

8.1 Microphotographic techniques - CCD and CMOS camera, digital camera.

8.2 Software for image analysis - Image J and GIMP.

References:

1. *Welch*, P. S. 1948. *Limnological* Methods. Blakiston Philadelphia. 381 pp.
2. Wetzel, R. G. 1983. *Limnology*. 2nd Ed. Saunders ColI. Philadelphia.
3. Wilson, E. O. (1992). *The Diversity of Life*. Cambridge, Mass, Belknap Press of Harvard University Press.
4. Krebs C. J., 2009. Ecology. Benjamin-Cummings Publishing Company or Pearson International Edition
5. Eugene P. Odum and Gary W. Barrett. Fundamentals of Ecology Brooks / Cole; 5th Revised edition.
6. Suzanne Bell, Keith Morris. An Introduction to Microscopy. CRC press.
7. *Kato*, M. The Biology of Biodiversity. Springer.
8. Robert Smith and Thomas M. Smith Ecology and Field Biology.
9. Bikram Grewal *et al*., A Photographic Field Guide to the Birds of India, Pakistan, Nepal, Bhutan, Sri Lanka, and Bangladesh. Princeton University Press.

Course Title: Evolutionary Biology
Course Code: ZO 366
Credits: 02

ZO 366 - Evolutionary Biology

Objectives:

1. To provide comprehensive overview of Concept of Evolution.
2. To explain Origin of Life especially Prokaryotes as well as Eukaryotes in detail.
3. To explore salient features of various theories of evolution comprising of Lamarckism, Darwinism and Neo-Darwinism.
4. To impart detailed understanding of Analogy, Homology, Paleontological Evidences, Embryological Evidences and Molecular Phylogeny.
5. To provide adequate information about Geological Time Scale and Neutral Theory of Molecular Evolution.
6. To develop comprehensive knowledge regarding various Sources of Variations and their role in evolution.
7. To give detailed explanation of key concepts of Population Genetics in terms of Hardy-Weinberg Law, Genetic Drift and Types of Natural Selection.
8. To provide adequate knowledge about Micro-evolutionary changes, Speciation and Adaptive Radiation.
9. To give detailed outline of Extinctions and its types.
10. To impart descriptive knowledge regarding Origin and Evolution of Man.

11. To provide glimpse of Phylogenetic Trees and highlight their construction along with interpretation.

Learning outcomes

After completing the course, the student should be able to

1. Students will be able to learn most of the essential aspects of Evolutionary Biology in detail which will help them in acquiring better understanding regarding the subject.
2. Explain important processes, principles and concepts and critically evaluate theories and empirical research within evolutionary biology
3. Apply evolutionary theory and concepts to address empirical and theoretical questions in evolutionary biology.
4. Independently investigate evolutionary questions using literature and analyses of empirical data.
5. Communicate the principles, theories, problems and research results associated with questions that lie within the evolutionary framework to students

Title & Contents	**Number of lectures**
1. Introduction: 1.1 Concept of Evolution. 1.2 Origin of life. 1.3 Origin of eukaryotic cell (Origin of mitochondria, plastids & symbionts).	**4 L**
2. Evidences of Evolution: 2.1 Analogy and Homology. 2.2 Embryological Evidences of Evolution. 2.3 Evolutionary & Paleontological Evidences.	**5 L**
3. Historical Review of Evolutionary Concept: 3.1 Theories of Evolution. 3.2 Lamarckism. 3.3 Darwinism and Neo Darwinism. 3.4 Mutation Theory. 3.5 Modern Synthetic theory.	**3 L**
4. Sources of Variations: 4.1 Variation and Mutations.	**4 L**
5. Isolation	**5 L**
6. Speciation: 6.1 Types of speciation (Allopatric & Sympatric). 6.2 Mechanism of speciation. 6.3 Patterns of speciation. 6.4 Factors influencing speciation.	**4 L**

7 Population Genetics: **2 L**

7.1 Hardy-Weinberg Law & Genetic Drift.

7.2 Types of Natural Selection.

8 Origin of Man: **4 L**

8.1 Evolution of Man (Evolution of anthropoids including man) - Kenyapithecus to *Homo sapiens*.

9 Zoogeographical Realms With reference to fauna: **2 L**

10 Extinctions: **2 L**

10.1 Extinction - An Overview.

Reference Books

1. Mark Ridley. Evolution. 3rd Edition. Blackwell Publishing. (2004).
2. Mathur, Tomar, Singh. Evolution and Behaviour. Rastogi Publication, Merrut.
3. Mohan P. Arora. Evolutionary Biology, Himalaya Publishing House, Bombay.
4. P. S. Vermin and V. K. Agarwal. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, Revised Edition. S. Chand Publication (2004).
5. Strickberger. Evolution. Prentic Hall. (2002).
6. Theodore H., Jr Eaton. Evolution. 1st Edition. W. W. Norton Publication. (1970).
7. Organic Evolution, Richard Swann Lull, Light & Life Publishers.
8. Introductions to Evolution, Paul Amos Moody, Kalyani Publishers, New Delhi.
9. Organic Evolution, 1991 T.S. Gopal krishanan, Itta Sambashivarab Publ. House.
10. Evolutionary Biology, 1990, Mohan P. Arora, Himalaya Publi. House, Delhi.
11. Evolution, 1968, E. O. Dodson, Reinhold Publ. Crop., New York.
12. The major features of evolution, 1953, Simpson G. G. Columbia, New York.
13. The origin of species, 1959, Charles Darwin, New American Library, New York.

Course Title: Environmental Impact Assessment
Course Code: ZO 3610
Credits: 02

ZO 3610 - Environmental Impact Assessment

Title & Contents	Number of lectures
1. Environment:	**2 L**
1.1 Definition.	
1.2 Divisions.	
1.3 Importance.	
2. Pollution:	**3 L**
2.1 Definition and types.	
2.2 Impact on wildlife, natural resources, development.	
3. Sustainable development:	**2 L**

3.1 Definition and need.
3.2 Exploitation of natural resources.
3.3 Concept of carrying capacity.
3.4 Three pillars of Sustainability.
3.5 UN 17 Sustainable Development Goals (SDGs).

4. Overview of Environmental Protection acts: 5 L

4.1 The Air (Prevention and Control of Pollution) Act 1981.
4.2 The Water (Prevention and Control of Pollution) Act 1974.
4.3 The Environment Protection Act 1986.
4.4 The National Green Tribunal Act 2010.
4.5 Biological Diversity Act 2002.

5. Environmental Impact Assessment (EIA): 5 L

5.1 Definition, need and importance of EIA.
5.2 EIA notification 2006 - key elements, History and Evolution of EIA.
5.3 Categories of Industries / establishments requiring EIA, Types of EIA - strategic EIA, regional EIA, sectoral EIA, project level EIA and life cycle assessment.
5.4 Rapid and comprehensive EIA.

6. EIA Process: 5 L

6.1 Screening, Scoping and consideration of alternatives.
6.2 Baseline data collection, Impact analysis, Mitigation, Reporting, Public hearing.
6.3 Review of EIA.
6.4 Decision-making, monitoring clearance conditions.

7. Stakeholders in EIA process: 3 L

7.1 Project proponent, Environmental consultant.
7.2 CPCB / MPCB.
7.3 Public, EIA agency (IAA).

8. Overview of Scheme for Accreditation of EIA Consultant Organizations (NABET / QCI): 5 L

8.1 Eligibility and benefits.
8.2 EIA coordinator (EC), Functional area experts (FAEs).
8.3 Functional area associate (FAA) and team members: Role, educational qualification, experience and functions.

References:

1. Glasson, J., Therivel, R. (2019) Introduction to Environmental Impact Assessment. Routledge. London.
2. Judith, P. 1999. Handbook of Environmental Impact Assessment. Blackwell Science.
3. Marriott, B. 1997. Environmental Impact Assessment: A Practical Guide. McGraw-Hill, New York, USA.

Course Title: Project
Course Code: ZO 3611
Credits: 02

ZO 3611 - Project

Students have to complete the research project in the stipulated time and present the dissertation at the time of the examination in a proper format. Students should be encouraged to take up laboratory work, hands-on practical investigation and design experimental setup. Field work to be carried out under proper supervision and permissions from the concerned authorities.

Possible key aspects of the project work -

1. Planning the project
2. Selecting a suitable title
3. Significance of the work
4. Hypothesis, Objectives
5. Reviewing the available literature
6. Methodology to be used
7. Outcomes of the Project work
8. Conclusion and Discussion
9. Future plans

Students should be made aware of plagiarism and research ethics.

Course Title: Zoology Practical Paper - I
Course Code: ZO 367
Credits: 02

ZO 367 - Zoology Practical Paper - I

Section I: Practicals in Medical & Forensic Zoology

1. To carry out routine analysis of given urine sample for - 2 (E)
   i. Physical Properties: Volume, Colour, pH, Turbidity, Specific gravity.
   ii. Chemical Properties: Sugars, Protein, Bile salts & bile pigments, Ketone bodies, Blood. (C)
2. Determination of serum urea. E
3. Determination of serum uric acid. E
4. Determination of serum Calcium. (C) E
5. To examine human hair for cortex and medulla. (C) E
6. To examine hair morphology and determine the species to which the hair belongs. E
7. To prepare slides of scale pattern of human hair. (C) E
8. To Visit a Forensic Laboratory and submission of the report. E
9. To Identify and differentiate various types of Finger prints. (C) E

10. To prepare a case report on forensic entomology with respect to insect's succession and its relationship to determine time since death. E

Section II: Practicals in Animal Physiology

1. Haemoglobin estimation using Sahli's haemoglobinometer. (C) E
2. Preparation of haemin and haemochromogen crystals. (C) E
3. To estimate the blood glucose level from given sample. (C) E
4. Estimation of bleeding and clotting time. (C) E
5. Study of disorders caused by endocrine glands with the help of photographs. D
6. Detection of blood groups in human being. E
7. Differential count of blood. E
8. Estimation of haemoglobin percentage with the help of haemometer. E
9. Qualitative detection of nitrogenous waste products (Ammonia, urea, uric acid) in given sample. (C) E
10. Demonstration of kymograph unit, Respirometer through available resources. D
11. Measurement of lung capacity. E

Course Title: Zoology Practical Paper - II
Course Code: ZO 368
Credits: 02

ZO 368 - Zoology Practical Paper - II

Section I: Practicals in Molecular Biology

1. Lab safety techniques & sterilisation. D
2. Preparation of DNA paper model and study its characteristics. E
3. Staining of DNA and RNA by methyl green – pyronin. (C) E
4. Estimation of DNA by Diphenylamine method. (C) E
5. Estimation of RNA by Bial's Orcinol method. E
6. Isolation of DNA from Bacteria / liver / Onion. (C) – 2 P E
7. Absorption spectra of DNA isolated from Bacteria / Liver / Onion. (C) E
8. Principle & application of Spectrophotometer & PCR. D

Section II - Practicals in Entomology

1. Study of external characters of any Insect (Grasshopper / Cockroach / Plant bug). E
2. Study of Insect Head, its articulations and types of mouthparts and their modifications. D
3. Study of Insect Legs, wing and their modifications. D
4. Study of Digestive system of any locally available insect pest. (C) E

5. Study of Reproductive system of any locally available insect pest. (C) E
6. Study of Social organization in Termites and Honey Bees. D
7. Study of Insect egg, larva, pupa and their types. D
8. Study of Insect vectors - Mosquito, House fly, Cockroaches, Bugs. D
9. Temporary mountings of Mouthparts, Antennae, E
   Legs and Wings of any locally available insect pest. (C)
10. Study of Preservation of Insect pest by using spreading techniques & submission
    of any five insect pests / vectors. (C) E
11. Compulsory field visit to a Wildlife Sanctuary / National Park / Tiger Reserve / E
    to study the Insect diversity – 2P.

Course Title: Zoology Practical Paper – III
Course Code: ZO 369
Credits: 02

ZO 369 - Zoology Practical Paper III

Section I: Practicals of Techniques in Biology

1. Compound and Stereo microscope: Components, usage and maintenance. D
2. To observe different kind of cells under compound microscope and its measurement E
   using micrometer scale or by image analysis software (Ex. Image J). (C)
3. Tissue collection, fixation & Block preparation. (C) E
4. Sectioning, staining & mounting. Submission of any three permanent E
   slides from three different organs. (C)
5. To study population density and percentage frequency of different animal / D
   insect species of a given area.
6. Calculating the different alpha and beta biodiversity indices of different D
   animal /insect species of a given area.
7. Survey for insects using pit fall trap and light traps in your college E
   campus / agriculture field.
8. Use of photography (Mobile camera / DSLR) in scientific documentation D
   of at least 5 species of insects / birds/ mammals.
9. Visit to a water body / forest to study faunal biodiversity using field equipment – (C) 2P E
10. Study of Principle & working of PCR & DNA Barcoding – 2 P E

Section II - Practicals in Evolutionary Biology

1. Study of morphological similarities and differences between man and ape (C) D
2. Study of types of fossils with the help of specimens/ charts/ photos (C) D
3. Study of animal adaptations in: Turtle, Draco, Exocoetus, Bat and Parrot (C) D
4. Study of evidences of evolution- embryological, paleontological, connecting links, morphology and comparative anatomy. (C) E
5. Study of successive stages of evolution of man : a) Australopithecus b) *Homo erectus* c) *Homo neanderthalis* d) Cro-Magnon man e) *Homo sapiens.* (C) D
6. To record Zoogeographical distribution of animals to respective zoogeographical Realms on the world map (Lung fishes, marsupials, flightless birds, Camel, Elephant, Ostrich etc.). (C) E

Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Degree Program in Zoology

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Zoology) Part-I

(for Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Title of the Course: M.Sc. (Zoology)

Preamble

Zoology is a major subject of Basic Sciences which deals with all aspects of animal biology. It includes an interesting range of highly diverse topics. The advancements in biological Sciences demands, a zoology student to be a master of many areas in the subject. This Postgraduate degree program has been designed by the Board of Studies in Zoology of SavitribaiPhule Pune University with a tangible understanding of what is needed from zoologists and what zoologists need to pursue as a skilled career. It emulates closely the Benchmark Statement for Biosciences and the guidelines laid down by the University Grants Commission, New Delhi. This Newly designed Curriculum is an appropriate blend of the classical aspects in Zoology which has been the "backbone" knowledge required for all zoologists and the recent and specialized areas. The flexibility in the Curriculum allows the students to choose their areas of interest leading to enhanced employability. Students will be provided sufficient number of hours for their skill development through the Lab Courses and the Project component. The lab courses have differing flavours and priorities to make a good zoologist. This degree offers specialization in areas like Genetics, Animal Physiology and Entomology along with a range of core courses like Biochemistry, Molecular Biology, Comparative Animal Physiology, Developmental Biology, Environmental Biology etc. Various cross cutting issues relating to Environmental biology have been aptly included to develop the students' sense towards human wellbeing. The field trip/surveys and study tours are included to gives the student an enticing taste of what life is specially outside the walls of the classroom. On successful completion of the programme, the students are expected to understand the key life processes of human and other animal groups, the functioning of molecules, cells, tissues, organs and systems. Also the students will gain increased confidence to use initiative and judgement to make decisions in complex and changeable situations and reflect critically and analytically on personal experience and make informed decisions about further study, training and employment opportunities.

The Master of Science (M.Sc.) in Zoology is a Postgraduate program under the Faculty of Science and Technology of SavitribaiPhule Pune University Pune. The curriculum designed

encompasses subjects like Physiology, Entomology, Genetics, Cell Biology, Developmental Biology, Endocrinology, Biochemistry, Molecular Biology, Freshwater Zoology, Environmental Biology etc. Both classical and applied subjects of Zoology have been rightly blended to offer holistic understanding of the subject.

The Choice Based Credit System (CBCS) will be implemented through this curriculum. This curriculum would certainly felicitate students to develop a strong base of the fundamentals and specialize in the desired area of their fondness and abilities. The students pursuing this program would get a privilege to select optional subjects of their choice. A total of 210 hours for theory lectures and 180 hours for laboratory work have been prescribed in each semester including a research project to inculcate the research culture amongst students. This newly designed curriculum will allow students to acquire the skill in handling scientific instruments planning and performing in the laboratory and exercising critical judgement, independent thinking and problem solving skills.

M.Sc. Zoology - Course structure & Distribution of Credits

M.Sc. Zoology, Part –I, Semester-I

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)	Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	**ZOUT 111** Biochemistry and Biochemical Techniques	-			-	4
2	**ZOUT 112** Cell Biology and Developmental Biology	-			-	4
3	**ZOUT 113** Genetics andEnglish in Scientific Communication.	-			-	4
4	-	**ZODT 114** Theory.	Biostatistics/ Freshwater Zoology	2	-	4
		ZODP 114 Practical	Zoology Practical Paper-1	2		
5	-	-			**ZOUP 115** Basic Zoology Lab-I	4
	Total Credit of Semester 1					**20**

M.Sc. Zoology, Part-I, Semester-II

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)	Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	**ZOUT 121** Molecular Biology and Bioinformatics	-			-	4
2	**ZOUT 122** Endocrinology and Parasitology	-			-	4
3	**ZOUT 123** Comparative Animal Physiology and Environmental Biology.	-			-	4
4	-	**ZODT 124** Theory. ---------- **ZODP 124** Practical	Metabolic pathways / Ichthyology	2	-	4
			Zoology Practical Paper-2	2		
5	-	-			**ZOUP 125** Basic Zoology Lab-II	4
		Total Credit of Semester 2				**20**

M.Sc. Zoology, Part-II, Semester - III

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)		Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	ZOUT 231 Special Paper (any one) Animal Physiology-I/ Entomology-I/ Genetics-I	-				-	4
2	ZOUT 232 Fundamentals of Systematics and Economic Zoology	-				-	4
3	ZOUT 233 Research Methodology and Insect Physiology and Biochemistry	-				-	4
4	-	ZODT 234 Theory --------- ZODP 234 Practical	Immunology/ Genetic Toxicology/ Zoology Practical Paper-3		2 2	-	4
5	-	-				ZOUP 235 Special Lab I	4

M.Sc. Zoology, Part II, Semester – IV

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)	Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	ZOUT 241 Special Paper-Any One- Animal Physiology-II/ Entomology-II/ Genetics-II	-			-	4
2	ZOUT 242 Mammalian Reproductive Physiology and Aquaculture				-	4
3	-	ZODT 243 Theory. ---------- ZODP 243 Practical	Histology and Histochemistry/ Pest Control Zoology Practical Paper-4	2 2	-	4
4	-	ZODT 244 Theory. ---------- ZODP 244 Practical	Pollution Biology. / Apiculture Zoology Practical Paper-5	2 2	-	4
5	-	-			ZOUP 245 (Project)	4
	Total Credit of Semester 4					**20**

Equivalence of Previous Syllabus:

Old Course (2013 Pattern)	New Course (2019 Pattern)
ZY101T: Biochemistry-I	ZOUT 111 Biochemistry and Biochemical Techniques
ZY102T: Cell Biology	ZOUT 112 Cell Biology and Developmental Biology
ZY103T: Genetics	ZOUT 113- Genetics andEnglish in Scientific Communication.
ZY104T: Biostatistics	ZODT 114 Biostatistics
ZY105T: Skills in scientific communication and Writing	ZOUT 113 Genetics and English in Scientific Communication.
ZY106T: Freshwater Zoology	ZODT 114 Freshwater Zoology
ZY101P:Practicals in Biochemistry	ZOUP 115 Basic Zoology Lab-I
ZY102P: Practicals in Cell Biology	
ZY103P: Practicals in Genetics	
ZY105P: Practicals in Skills in scientific communication and writing	
ZY106P: Practicals in Fresh water zoology	ZODP 114 Zoology Practical-1
ZY104P: Practicals in Biostatistics	

Semester-II

Old Course (2013 Pattern)	New Course (2019 Pattern)
ZY201T: Biochemistry-II	ZODT 124Metabolic pathways
ZY202T: Molecular Biology	ZOUT 121 Molecular Biology and Bioinformatics
ZY203T: Developmental Biology	ZOUT 112 Cell Biology and Developmental Biology
ZY204T: Endocrinology	ZOUT 122 Endocrinology and Parasitology

ZY205T: Comparative Animal Physiology	ZOUT 123 Comparative Animal Physiology & Environmental Biology
ZY206T: Biochemical Techniques/Ichthyology	ZOUT 111 Biochemistry & Biochemical Techniques ZODT 124 Ichthyology
ZY201P:Practicals in Biochemistry-II	ZOUP 125 Basic Zoology Lab-II
ZY202P: Practicals in Molecular Biology	
ZY203P: Practicals in Developmental Biology	
ZY204P: Practicals in Endocrinology	
ZY205P: Practicals in Comparative Animal Physiology	
ZY206P: Practicals in Biochemical Techniques/ Ichthyology	ZODP 124 Zoology Practical-2

Detailed Syllabus with Recommended Books:

Program outcomes (POs): After successfully completing the M.Sc. Zoology program students will be able to:

PO1. Zoology knowledge: Apply the knowledge of Zoology, Life Sciences and allied subjects to the understanding of complex life processes and phenomena.

PO2. Problem analysis: Identify, review research literature, and analyse complex situations of living forms.

PO3. Design/development of solutions: Design processes/strategies that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in real situations.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and ICT tools for understanding of the subject.

PO6. The Postgraduate and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the natural and anthropogenic activities in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. Identify a range of invertebrates and vertebrates and justify their conservation.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the work/research practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex life activities with the scientific community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of Zoology and management principles and apply these to one's own work, as a member and leader in a team.

PO12**. Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Following is the syllabus of each course along with the course outcomes:

Course Code and Course Name:

ZOUT 111 Biochemistry and Biochemical Techniques. (4 Credits: 60 Lectures)

Semester I

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

CO1: Define basic terms in biochemistry and biochemical techniques.

CO2: Explain the applications of the various biochemical techniques.

CO3: Explain the structure and functions of various biomolecules.

CO4: Explain the importance of tools and techniques in biology.

CO5: Illustrate the importance of pH, buffer and water in living systems.

CO6: Illustrate the principle, working and applications of basic techniques used in biology.

CO7:Draw the structures of various carbohydrates and amino acids.

CO8: Classify enzymes with examples.

Biochemical techniques:

CO1: Explain the importance and applications of techniques in biochemistry.

CO2: Explain theprinciple and applications of various chromatographic techniques with examples.

CO3: Explain the principle, working, materials used and applications of electrophoresis.

CO4: Describe the concept of light, electromagnetic spectrum and its application in absorption spectroscopy.

CO5: Illustrate the importance of radioactive compounds and radioactivity in biology.

CO6: Demonstrate the principle and working of Warburg's apparatus.

CO7: Demonstrate the principle, working, applications of centrifugation.

CO8: Justify the applications of radioactivity compounds in biology.

CO9: Compare the various separation techniques.

Sr. No.	Name of the topic	Lectures allotted
	Biochemistry:	
1.	**Basics of chemistry-** Structure of atoms, molecules and chemical bonds, Normality, molarity, molality	**(02L)**
2.	**Chemistry of Water :** Structure of water and physicochemical properties of water, water as universal solvent, pH and Buffers, Biological Buffer System	**(04L)**
3.	**Carbohydrates:** Classification, basic Structures and functions, Biological Significance.	**(03L)**
4.	**Lipids:** Classification, structure and function and biological significance.	**(03L)**
5.	**Vitamins:** Classification- water-soluble and fat-soluble vitamins, Biological significance**.**	**(02L)**
6.	**Amino acids:** Classification, properties (Physical properties- Optical Isomerization, Absorption in UV light, Ionization; Chemical properties- Reactions with carboxyl group and amino group)	**(02L)**
7.	**Proteins:** **a.** Peptide bond formation, Ramachandran plot. b. Protein structure:-Primary structure, Secondary structure, Tertiary structure and Quaternary structures with examples, Biological significance of proteins.	**(05L)**
8.	**Enzymes:** a. Classification, nomenclature and properties b. Enzyme kinetics -one substrate reaction (Michaelis-Menten Equation) c. Factors affecting enzyme activity d. Enzyme inhibition e. Allosteric Enzymes. f. Isozymes (LDH) and coenzymes g. Clinical and industrial significance- Any 3	**(09L)**
	Biochemical Techniques:	
1.	**Chromatography:** Principle, working and applications of: Adsorption chromatography Partition chromatography, Ion-exchange chromatography, Molecular exclusion chromatography, Affinity chromatography,Gas chromatography, High Performance Liquid Chromatography.	**(8L)**

2. **Electrophoresis:** Moving boundary electrophoresis, zone electrophoresis, different supports used for electrophoresis, electrophoresis of proteins, electrophoresis of Nucleic acids, isoelectric focussing. **(5L)**

3. **Absorption spectroscopy:** Concepts of light & electromagnetic spectrum, Ultraviolet and Visible spectrophotometry, atomic absorption spectrometry and applications. **(5L)**

4. **Radioactivity:** Properties of radioisotopes, commonly used isotopes, structure & working of G.M, counter, isotopic dilution analysis, use of isotopes in biology, radiation hazards. **(3L)**

6. **Manometry:** Respiratory quotient determination, Principle of Warburg's apparatus, working and applications. **(2L)**

7. **Methods for protein sequencing.** **(4L)**

N-terminal sequencing

C-terminal sequencing.

Methods for DNA sequencing.

Maxam- Gilbert Sequencing

Chain termination method

Dye terminator sequencing

8. **Centrifugation:** Principle, Types of centrifugation- Preparative and Analytical.applications of centrifugation. **(3L)**

REFERENCE BOOKS:

1.Biochemistry, 3rd Ed. (2005), Voet Donald and Voet Judith G. John, Publisher: Wiley & sons, New York.

2.Biochemistry 6th Ed, (2007) Berg Jeremy, Tymoczko John, StryerLubert, Publisher: W. H. Freeman, New York.

3.Lehninger's Principles of Biochemistry, 4th edition, (2005) Nelson D. L. and Cox M. M. W. H. Freeman & Co. NY.

4.Biochemical Calculations, 2nd Ed., (1997) Segel Irvin H., Publisher: John Wiley and Sons, New York.

5.Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.

6.Biochemistry, Geoffrey Zubay, William C Brown Pub; 4th edition (June 1999)

7.Principles and Techniques of Biochemistry and Molecular Biology, 6th edition (2008), Keith Wilson and John Walker, Publisher–Cambridge University Press.

8.Light Microscopy in Biology: A Practical Approach, 2nd edition (1999), Alan J. Lacey, Publisher–Oxford University Press.

9.Electron Microscopy: Principles and Techniques for Biologists, (1992), Lonnie D. Russell, Publisher-Jones & Bartlett

Course Code and Course Name:

ZOUT 112 Cell Biology and Developmental Biology(4 Credit: 60 Lecture)

Semester I

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

Cell Biology:

CO1: Label the various cell parts

CO2: Sketch and label various types of cells and cell organelles.

CO3: Explain carbon as backbone of biomolecules.

CO4: Explain the ultrastructure and functions of various cell organelles.

CO5: Explain the concepts of cell signalling.

CO6: Illustrate the chemistry and organization of cytoskeleton.

CO7: Illustrate the types, development and causes of tumor.

CO8: Diagrammatically represent the cell cycle phases and its regulation.

Developmental Biology:

CO1: Define the terms in developmental biology

CO2: Explain the significance of model organism for developmental studies.

CO3: Explain the types of eggs, concept of fertilization and cleavage pattern.

CO4: Explain the concept of mesoderm induction and pattern formation with examples.

CO5: Describe neural competence and induction.

CO6: Explain the concept of growth and differentiation.

CO7: Illustrate postembryonic development.

CO8: Compare and contrast spermatogenesis and oogenesis.

Sr. No.	Name of the topic	Lectures allotted
1.	Cell theory, general organisation of cell and characteristics of living systems**.**	**(02L)**
2.	Overview of chemical nature of the cell and importance of carbon in biologically important molecules.	**(02L)**
3.	Plasma membrane: Ultrastructure, membrane proteins; membrane transport – channels, carriers and pumps; membrane potential and synaptic transmission.	**(04L)**
4.	Endomembrane system: (Endoplasmic reticulum, Golgi complex, Lysosomes); protein trafficking – secretory and endocytic pathways.	**(04L)**
5.	Mitochondria: Structure, genetic system, functions; protein import	**(03L)**
6.	Nucleus: Ultrastructure – nuclear envelope, nuclear lamina, nuclear pore complex, nucleolus.	**(03L)**
7.	Cell Cycle: Phases, check points, mechanism of regulation; regulators of cell cycle progression – MPF, cyclins and cyclin dependent kinases (CDKs).	**(03L)**
8.	Cytoskeleton: Types, chemistry, organisation, associated proteins and their role.	**(03L)**
9.	Cancer: Types, development, causes; characteristics of cancer cell, tumour viruses, oncogene and tumour suppresser gene.	**(03L)**
10.	Cell signalling: Signalling molecules and their receptors, cell surface receptors,significance of cell signalling.	**(03L)**
	Developmental Biology:	
1.	**Introduction to developmental biology:** Early theories of Developmental biology Concepts of Developmental biology – Growth, cell division, cell differentiation, cell communication, signalling, patterning, induction and competence.	**(3L)**
2.	**Model Organisms:** Invertebrate: *Drosophila melanogaster*, Pisces: Zebra Fish- *Danio rerio*, Amphibians: *Xenopuslaevis*, Birds: Chicken, Mammals: Mouse**.**	**(3L)**
3.	**Gametogenesis:** Spermatogenesis: spermatogenesis, structure of sperm, regulation of sperm motility, Oogenesis: structure of ovum, previtellogenesis, vitellogenesis and post-vitellogenesis	**(2L)**
4.	**Fertilization:**: Concept of fertilization, types of fertilization, Species specific sperm attraction, recognition of egg & sperm, acrosome reaction, signal transduction, molecular strategy to avoid polyspermy in fertilization	**(4L)**

5. **Types of eggs:** Based on amount of distribution of yolk, Cleavage: types and significance. **(2L)**

6. **Morphogenesis:** Blastulation: Amphiouxus, Frog, Chick, Mid Blastula Transition, **(5L)**

Comparative study of Gastrulation in Amphioxus, Frog, Chick

Neurulation: Frog, Chick

Organogenesis: Development of the vertebrate eye –formation of eye field, cell differentiation

7. **Pattern formation: Setting up the body axis** **(4L)**

1. Animal vegetal axis: Amphibians,
2. Dorsal ventral axis: Amphibians
3. Antero-posterior axis: *Drosophila*-role of bicoidnanos hunchback.

8. **Organizers:** **(2L)**

Spemann and Mangold: Primary embryonic induction, Functions of organizer, Molecular mechanisms of Amphibian axis formation

9. **Regeneration:** **(3L)**

Limb regeneration: Salamander, Regeneration in Hydra

10. Apoptosis, aging and senescence. **(2L)**

REFERENCE BOOKS:

1. Karp Gerald (2010) *Cell Biology*. 6th Edition, John Willey & Sons (Asia) Pte. Ltd.
2. Cooper Geoffrey M. (1997) *The Cell: A Molecular Approach*. ASM Press, Washington D.C., U.S.A.
3. Sadava David E. (1993) *Cell Biology – Organelle Structure and Function*. Jones &Barlett Publishers, Boston, London.
4. Hardin Jeff, Gregory Bertoni and Lewis J. Kleinsmith (2012) *World of the Cell*. 8th Edition, Pearson Education, Inc., San Francisco, U.S.A.
5. Alberts B., A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter (2008) *Molecular Biology of the Cell*. 5th Edition, Garland Science, New York, U.S.A.
6. Lodish H., D. Baltimore, A. Berk, L. Zipursky, M. Matsudaira and J. Darnell (1995) *Molecular Cell Biology*. Eds. 3, Scientific American &

W. H. Freeman, New York.

7. De Robertis E. D. P. and De Robertis E. M. E. (1987) *Cell and Molecular Biology*. 8th Edition, Lea and Febiger, Philadelphia.
8. Loewy A. G., P. Siekevitz, J. R. Menninger and J. A. N. Gallant (1991) *Cell Structure & Function*. Saunders College Publishing, U.S.A.
9. Nelson D. L. and Cox M. M. (2008) *Lehninger Principles of Biochemistry*. 5th Edition, W. H. Freeman & Co. NY.
10. *Developmental Biology*, 9th edition (2010), S.F. Gilbert. Publisher – Sinauer,Associates Inc.
11. *Principles of Development*, 3rd edition (2007), Lewis Wolpert, Publisher-Oxford,University Press.
12. *An Introduction to Embryology*, 5th edition (2004), B. I. Balinsky. Publisher – ThomasAsia Pvt. Ltd.
13. *Developmental Biology*, (2001), R. M. Twyman, Publisher - Bios Scientific, Publishers LTD.
14. Analysis of Biological Development , 2000, Klaus Kalthoff, McGraw-Hill Science/Engineering/Math; 2nd Ed edition.

Course Code and Course Name:

ZOUT 113 Genetics and English in Scientific Communication. (4 Credit: 60 Lecture)

Semester I

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

Genetics:

CO1: Define the basic terminologies in genetics.

CO2: Identify genetic disorders based on Karyotypes and traits.

CO3: Explain the concept of Mendelian genetics, gene, gene regulation and multiple alleles.

CO4: Discuss Linkage and crossing with their types and significance.

CO5: Explain the principles of Population genetics.

CO6: Illustrate the modified Mendelian laws of inheritance.

CO7: Justify the inheritance of qualitative and quantitative traits.

CO8: Solve the problems based on gene frequency.

English in Scientific Communication:

CO1: Write the outline of a scientific paper.

CO2: Write the title, abstract, discussion and citations of a given scientific article.

CO3: Prepare a scientific presentation using PowerPoint.

CO4: Explain language as a tool for effective scientific communication.

CO5: Use the formal elements of specific types of scientific writing.

CO6: Critically analyze data from research; incorporate it into assigned writing clearly, concisely, and logically; and attribute the source with proper citation.

CO7: Practice the unique qualities of professional rhetoric and writing style, such as sentence conciseness, clarity, accuracy, honesty, avoiding wordiness or ambiguity, using direct order organization, readability, coherence and transitional devices.

CO8: Justify the importance of plagiarism check and Proof-read given article.

Sr. No.	Name of the topic	Lectures allotted
1.	Recapitulation of Mendelian principles; Practical applications of genetics in brief	**(02L)**
2.	Classical concept of a gene:Allele, pseudoalleles, multiple alleles (blood groups)	**(02L)**
3.	Gene interactions and epistasis and their types.	**(02L)**
4.	Linkage and crossing over: Linkage, linkage groups, types of crossing over, sex linkage, sex limited and sex influenced characters, Recombination,recombination maps in diploids for 2 point and 3 point test cross, (determination of gene order with suitable examples)	**(06L)**
5.	Quantitative genetics : Polygenic inheritance, heritability and its measurementsand Quantitative Traits Locus mapping	**(03L)**
6.	Principles of Population Genetics: Hardy-Weinberg law and its application for autosomal genes. Calculations of gene frequencies with suitable examples.	**(05L)**
7.	Somatic cell genetics and its applications.	**(02L)**
8.	Microbial genetics : Methods of genetic transfers – transformation, conjugation, transduction	**(03L)**

9.	Extra chromosomal inheritance:Inheritance of Mitochondria.	**(01L)**
10.	Human genetics: dominant and recessive disorders, physical traits.	**(04L)**
	English in Scientific Communication:	
1.	Language as a communication tool; relationship among reading, writing, listening and speaking	**(2L)**
2.	Pragmatic competence:co-operative principles and politeness principles	**(1L)**
3.	Organisation of English language: sentence structure, basic grammar, sequence and tenses, syntax, paragraphs, paraphrases and précis writing, synonyms and antonyms	**(3L)**
4.	Common errors in written and spoken English: tautology, double negative, double positive, superfluous words	**(2L)**
5.	Oral presentation: How to prepare a presentation, power point slides, use of communication and IT, voice, speed of delivery, obstacles in effective communication	**(2L)**
6.	Drafting of a researchproject for financial assistance from funding agency, writing of scientific paper using word processor.	**(2L)**
7.	Outline of a scientific research paper: 7.1Hypothesis, theory and concept 7.2Title designing, framing Abstract and Keywords 7.3 Introduction: statement of the problem and justification; aim, objectives, need, significance and rationale of the study, review of literature. 7.4Materials and Methods: contents, importance of measurements, reproducibility etc. 7.5Observations and Results: text and data presentation, tables, graphs, histograms, diagrams, photographic plates, legends and captions 7.6Discussion: logical sequence and critical analysis of ideas and evidences, data conclusion 7.7 References: finding references from journals, books and databases; Citation - styles of citations 7.8Summary, Acknowledgements	**(14L)**
8.	Editing and correcting: proof-reading symbols, jargons and abbreviations	**(3L)**
9.	Plagiarism: meaning, types, avoiding plagiarism.	**(1L)**

REFERENCE BOOKS:

1. Genetics, 3Rd Edn by Strickberger, Pearson India, 2015, Paperback, 9789332555105
2. Principles of Genetics,Gardner, E.J., Peter & Simmons, M.J. and Snustad, D.P. 8thEdn.John Wiley and Sons, New York, 2006.
3. Concepts of Genetics. William S Klug and Michael R Cummings. 10thEdn. Pearson Education India, 2016.
4. Lewin, Benjamin. Genes IX. John Wiley and Sons, New York,2008.
5. Genetics By Verma,PS. And Agrawal, VK., S.Chand and Co.,New Delhi
6. Genetics By Gupta, PK., Rastogi Publication, Meerut
7. Genetics By Sarin,C., Tata McGraw Hill,New Delhi
8. Genetics: Daniel J Fairbanks, W. Ralph Andersen; Brooks / Cole Publ. co. (1999).
9. iGenetics: A Molecular Approach, 3rdEdn by Peter J Russell, Pearson India, 2016, Paperback, 9789332571624
10. O'Conner M. and F. P. Woodford (1975) Writing Scientific Papers in English. Elsevier-ExcerptaMedica-North Holland Publ., Amsterdam.
11. Trelease S. F. (1958) How to Write Scientific and Technical Papers. Williams and Wilkins Co. Baltimore, U.S.A.
12. Day Robert (1996) How to Write and Publish a Scientific Paper. Cambridge University Press.
13. McMillan V. (1997) Writing Papers in the Biological Sciences. Edn. 2, W. H. Freeman, New York.
14. Winkler Anthony C. and Jo Ray McCuen-Metherell (2008) Writing the Research Paper, A Handbook. 7th Edition, Wadsworth Cengage Learning, Boston, M.A., U.S.A.
15. Vijayalakshmi G. and C. Sivapragasam (2008) Research Methods – Tip & Techniques. M.J.P. Publishers, Chennai.
16. *Kothari C. R.* (*2009*) *Research Methodology*: *Methods* & *Techniques.* 2nd Revised Edition, New Age International Publishers, New Delhi.
17. Levinson Stephen C. (2003) Pragmatics. Cambridge University Press, Cambridge.
18. Yule George (2012)Pragmatics (Oxford Introduction to Language Study

ELT). Oxford University Press.

19. Quirk Randolph and Greenbaum Sidney (2006) A University Grammar of English. Pearson Education Ltd.
20. Editors of Merriam Webster (2006) Webster's English Usage Guide. Federal Street Press, Springfield, M. A., U.S.A.
21. Wren P. C. and H. Martin (2016) High School English Grammar and Composition. Blackie ELT Books (A Division of S. Chand & Co. Pvt. Ltd.), New Delhi, India.
22. American Psychological Association(2010)Publication Manual of the American Psychological Association. 6th Edition, Washington D.C.
23. Modern Language Association(2016)MLA Handbook. 8th Edition, The Modern Language Association of America.

Course Code and Course Name:

ZODT 114 Biostatistics (2 Credits= 30 lecturers)

Semester I

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

CO1: Explain the application of sampling in biological sciences**.**

CO2: Explain standard Probability distributions.

CO3: Explain the concept and types of central tendency.

CO4: Explain the concept of correlation and regression with their properties.

CO5: Classify the given data.

CO6: Graphically represent the given data.

CO7: Illustrate the measures of dispersion with examples.

CO8: Solve statistical problems.

Sr. No.	Name of the topic	Lectures allotted
1.	**Introduction:** 1.1 Applications and Uses of Statistics 1.2 Population & sample, Different types of Sample 1.3 Exercise & Problems.	**(02L)**
2.	**Data Classification:** 2.1 Some important terms (Class frequency, class- limits, Class-width, class mark) 2.2Frequency distribution, Cumulative frequency, Graphical representation of data (Histogram, Pie-Diagram, Ogive-Curve.) 2.3 Exercise & Problems	**(3L)**
3.	**Measures of central tendency:** 3.1 Concept of central tendency, Types of central tendency (Arithmetic mean, Median and mode) combined mean. 3.2 Partition values (Quartiles, Deciles, and Percentiles), Box plot. 3.3 Exercise & Problems.	**(3L)**
4.	**Measures of dispersion:** 4.1 Concept of dispersion, absolute and relative measure of dispersion. 4.2 Different measures of dispersion (Range, Quartile- Deviation, Variance and standard-deviation, Coefficient of Variation) combined variance 4.3 Exercise & Problems.	**(4L)**
5.	**Correlation and Regression:** 5.1 Bivariate data, concept of correlation, Types of Correlation, Scatter diagram, Karl Pearson's coefficient of correlation and its properties. 5.2 Concept of regression, Linear regression, regression Coefficients and its properties. 5.3 Exercise & Problems.	**(5L)**
6.	**Probability and probability distribution:** 6.1 Some important terms (types of experiment, sample Space and types of sample space, events and types of events.) 6.2 Definition of probability (mathematical and classical) Conditional	**(5L)**

probability. Concept of random variable Univariate Probability Distribution and its mathematical expectation.

6.3 Some standard probability distributions (binomial, Poisson and normal) their probability distribution, mean, variance, and properties of these distribution.

6.4 Exercise & Problems.

7. Test of hypothesis: (8L)

7.1 Some important terms (hypothesis, types of hypothesis, Test, Critical region, acceptance region, type I error, type II error, level of significance, p-value)

7.2 Test for mean and equality of two population means, Test for proportion and equality of two population proportions.

7.3 chi-square test for goodness of fit, Unpaired and paired t test. F test for equality of two population variances.

7.4 Software used for Statistical analysis

7.5 Exercise & Problems.

Course Code and Course Name:

ZODP 114 Practical Biostatistics. (2 Credits- 60 Hours)

Semester I

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

CO1: Construct frequency distribution chart.

CO2: Graphically represent the given data.

CO3: Solve the statistical problems based on Central Tendency, Dispersion, Correlation andregression.

CO4: Apply computer software for statistical analysis.

CO5: Solve numerical problems on test of hypothesis using biological data.

Sr. No	ZODP 114 Practical Biostatistics	No. of Practicals
1.	Construction of frequency distribution and its graphical representation.	**(1P)**
2.	Measures of Central Tendency.	**(2P)**
3.	Measures of Dispersion	**(2P)**
4.	Correlation and Regression.	**(1P)**
5.	Computation and application of binomial & Poisson probabilities.	**(1P)**
6.	Computation and application of normal probabilities.	**(2P)**
7.	Test for means and proportions	**(1P)**
8.	Chi-square test of goodness of fit.	**(1P)**
9.	Paired and unpaired t- test, F-test.	**(2P)**
10.	Statistical analysis with Computer software packages	**(2P)**

REFERENCE BOOKS:

1. Principles and Practice of Biostatistics: Dr J.V. Dixit
2. Statistical Methods: Snedecor G.W. & Cochran W.G.
3. Statistical Methods: Dixon W.S. and Massey
4. Biostatistics for the Biological and Health Sciences, 2nd Edition by Marc M. Triola, Mario F. Triola, Jason Roy,Published by Pearson Copyright © 2018
5. Biostatistics: Basic Concepts and Methodology for the Health Sciences, 10ed, ISV by Wayne W. Daniel, Wiley Publication.

Course Code and Course Name:

ZODT 114 Freshwater Zoology. (2 Credits= 30 lecturers)

Semester I

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

CO1: Enlist the diagnostic features of shrimps.

CO2: Explain the types of aquatic habitats.

CO3: Discuss the aquatic adaptations of common freshwater forms.

CO4: Explain the adaptations in freshwater Turtles and Crocodiles.

CO5: Illustrate the physicochemical properties of water.

CO6: Demonstrate the effect of pollutants on freshwater bodies

CO7: Justify the presence of zooplanktons and aquatics forms in freshwater bodies.

Sr. No.	Name of the topic	Lectures allotted
1.	Introduction to freshwater habitats. Lotic habitat: Major rivers in India Lentic habitat: Lakes, ponds, wetlands and ephemeral water bodies. Thermal stratification in lakes.	**(02L)**
2.	Physico-chemical conditions of freshwater and its implications on freshwater biota. Physical conditions: Water current, water colour, turbidity and temperature. Chemical conditions : pH, carbon dioxide, dissolved oxygen, hardness, acidity and alkalinity, nitrate, phosphate and sulphates.	**(7L)**
3.	General characters of plankton with special emphasis on the characters used in taxonomy and reproduction: Rotifera, Copepoda, Cladocera and Ostracoda.	**(4L)**
4.	Introduction to minor phyla: Gastrotricha, Bryozoa and Tardigrada (water bears).	**(2L)**
5.	Diversity and economic importance of freshwater Crustacea and Mollusca.	**(2L)**
6.	Locomotory and respiratory adaptation in freshwater insect orders: Ephemeroptera,Odonata, Plecoptera, Coleoptera, Diptera and Hemiptera. .	**(2L)**
7.	Diversity and distribution of vertebrates in the freshwater bodies of India. (Excluding fishes)	**(2L)**
8.	Adaptive physiology of freshwater fauna: Osmotic and ionic, thermal, respiratory, reproductive and life cycle, mechanical, locomotory and sensory adaptations.	**(6L)**
9.	Anthropogenic impact on freshwater: Waste and pollution, sewage and silage, mining waste, agricultural chemicals, industrial outflows and invasions. Eutrophication : Causes and problems.	**(3L)**

Course Code and Course Name:

ZODP 114 Practical Freshwater Zoology. (2 Credits = 60 lectures.)

Semester I

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

CO1: Identify commercially important freshwater fish.

CO2: Identify the aquatic adaptations in common freshwater forms.

CO3: Prepare the culture of *Paramecium* and *Daphnia*.

CO4: Estimate the hardness and chloride content in water samples.

CO5: Analyze the Zooplanktons from local freshwater bodies.

CO6: Evaluate the bio-indicators of pollution in freshwater.

Sr. No.	ZODP 114 Practical Freshwater Zoology	No. of Practicals
1.	Estimation of total carbon dioxide and chloride form given water sample.	**(1P)**
2.	Estimation of phosphates forms given water sample**.**	**(1P)**
3.	Estimation of total nitrate from given water sample.	**(1P)**
4.	Estimation of calcium and total hardness of given water sample.	**(1P)**
5.	Estimation of total alkalinity of given water sample.	**(1P)**
6.	Collection, preservation and identification of zooplankton from freshwater habitat. (Prepare permanent slides and Identify up to genus level using taxonomic key).	**(2P)**
7.	A qualitative and quantitative analysis of zooplankton from a given freshwater sample using Lackey's drop count method/ Sedgwick rafter counting cell.	**(1P)**
8.	Identification of economically important freshwater crustaceans and fishes**.**	**(1P)**
9.	Study of locomotory and respiratory adaptations in aquatic insects and larvae (*Ranatra, Notonecta, Gerris, Bellostoma and Dytiscus*).	**(1P)**
10.	Study of aquatic and semiaquatic adaptations in amphibians and reptiles.	**(1P)**
11.	Estimation of primary productivity with dark and light bottle method	**(1P)**
12.	To prepare and maintain a culture of paramecium, Daphnia and Hydra	**(2P)**
13.	A Compulsory visit to local freshwater body and preparation of report on physicochemical conditions and faunal organisms.	**(1P)**

REFERENCE BOOKS:

1. Limnology: lake and river ecosystem, Robert G. Wetzel. Academic Press,

3rd edition.

2. Treatise of Limnology. Hutchinson G. E. John Willy Publication, New York (3 volumes).
3. Field Guide to freshwater invertebrates of North America. Thorp and Rogers. Academic press.
4. Environmental Physiology of Animals. Pat Wilmer, Graham Stone and Ian Johnston. Wiley-Blackwell; 2nd edition.
5. Current status of freshwater resources of India. Kailash Chandra, Gopi K.C., Rao D.V., Valarmathi K. and Alfred J.R.B. Zoological survey of India, 2017.
6. Freshwater Ecology: Concepts and Environmental Applications of Limnology. Academic press, 2nd edition.
7. Freshwater invertebrates of the United States. Robert Pennak. A Wiley-Interscience Publication.
8. Freshwater Biology. Whipple and Ward. John Wiley & Sons Inc; 2nd edition (December 1959).
9. Freshwater Invertebrates: Ecology and General Biology. Thorp and Covich. Academic Press, 4th edition.
10. Limnological Methods. Paul and Welch. Mcgraw –Hill publication.
11. Limnological analysis. Wetzel Robert G., Springer Publication.

Course Code and Course Name:

ZOUP 115 Basic Zoology Lab-1. (4 Credits- 120 hours)

Semester I

Note: A total of 30 practicals are to be conducted. 10 practicals from each module are to be conducted. 1 practical is of 4 clock hour duration.

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

CO1: Identify the developmental stages of chick embryo, cell structures and phases of cell division

CO2: Identify the grammatical mistakes from the given paragraph and common errors in written and spoken presentations.

CO3:Write a scientific project and research article along with its proof reading.

CO4: Demonstrate the working of different microscopes, colorimetric and spectrophotometric methods,cell fractionation and ligature in *Drosophila* larvae,

CO5:Determine the gene distance and order, genotype and phenotype ratios and allelic frequencies from the given data.

CO6: Estimate sugar and protein by suitable biochemical method, and isolate protein from biological source.

CO7: Prepare acid and base solutions of desired strength, buffers, bacterial Culture, chick embryo culture and *Drosophila* culture.

CO8: Prepare temporary slide of various cells to demonstrate the cell morphology and cell division, giant chromosome and pedigree analysis chart.

CO9: Calculate % retention and % elution of amino acids on given ion exchanger.

Sr. No.	Name of the Practical	No. of Practicals
	Module-I Biochemistry and Biochemical Techniques	
1.	Preparation of Acid & Alkali solutions and acid-base titration **(Compulsory)**	**1P**
2.	Principle and working of Colorimetry and spectrophotometry	**1P**
3.	To prepare Buffers of known pH and molarity and measurement of pH of various samples, Buffering capacity	**1P**
4.	Units and specific activity of enzymes.	**1P**
5.	Effect of substrate concentration on enzyme activity **(Compulsory)**	**1P**

6	Determine the concentration of Vitamin C by titration method from various sources.	**1P**
7.	Estimation of Sugar (Glucose) by Folin Wu method. **(Compulsory)**	**1P**
8.	Isolate proteins by salting out / by adjusting isoelectric point. **(Compulsory)**	**1P**
9.	Estimation of protein by Biuret method method**.(Compulsory)**	**1P**
10	Principle and uses of different microscopes	**1P**
11	Principles of electrophoresis, separation of proteins using Gel electrophoresis.**(Compulsory)**	**1P**
12.	To find out the capacity and nature of a given ion-exchanger. Investigate the % retention and %elution of amino acids on a given ion exchanger	**1P**
13	To study the effect of different solvents for a given dye using thin layer chromatography **(Compulsory)**	**1P**
14.	Enzyme isolation and purification by fractionation methods.	**2P**
	Module-II Cell Biology and Developmental Biology	
1	Study of ultrastructure of cell organelles. **(Compulsory)**	**1P**
2	Study of different types of cells. **(Compulsory)**	**1P**
3	Temporary preparation of human cheek epithelial cells. **(Compulsory)**	**1P**
4	Study of different stages of mitosis in suitable material. **(Compulsory)**	**1P**
5	Study of meiosis in Grasshopper testes / Onion flower buds / *Aloe vera* with emphasis on all stages of prophase. **(Compulsory)**	**1P**
6	Limits of cleanliness (To check for microbial flora)	**2P**
7	Cell fractionation – Nuclei, mitochondria observation, nuclear count.	**2P**
8	Mounting of chick embryos and preparation of permanent mounts **(Compulsory)**	**1P**
9	Filter paper ring method for *in vitro* culturing of chick Embryo & observations.	**1P**
10	Gross anatomy and histology of chick embryo upto 72 hrs. Brain, heart, lens, ear development.**(Compulsory)**	**1P**
11	Study of embryonic and post-embryonic development using frog egg as a model system**.**	**1P**
12	Study of life cycle of *Drosophila melanogaster*.**(Compulsory)**	**1P**
13	Study of effect of ligature in Drosophila / House fly larva	**1P**
14	Study of regeneration in *Hydra/ Planaria*.	**1P**

15	Study the early developmental stages in any freshwater snail.	**1P**
	Module-III Genetics and English in Scientific communication	**1P**
1	Study of sex linked inheritance in *Drosophila sp*.	**1P**
2	Study of monohybrid and Dihybrid ratio in *Drosophila sp*.**(Compulsory)**	**1P**
3	Determination of gene distances and gene order for a given three-point test cross**.(Compulsory)**	**1P**
4	Polytene chromosomes of *Drosophila or Chironomous*-examination of puff and bands**.(Compulsory)**	**1P**
5	Estimation of allelic frequencies, heterozygote frequencies in human populations**.(Compulsory)**	**1P**
6	Pedigree Analysis: Sex-Linked, Autosomal dominant and recessive.	**1P**
7	Culturing *E.Coli* on solid and liquid media	**1P**
8	English vocabulary, word formation, basic grammar-verb, adverb, adjective, noun, pronoun **(Compulsory)**	**1P**
9	Syntax, paraphrasing and précis writing, synonyms, antonyms, abbreviations.	**1P**
10	Spoken English: pronunciation, diphthong, accent, clarity, speed, punctuation, simplicity and syntax	**1P**
11	Common errors in written and spoken presentation- Tautology, double negatives and double positives, sequence and tenses, ambiguity, spellings, jargons**.**	**1P**
12	Outline of a scientific paper; preparation of a research project.	**1P**
13	Writing abstracts, conclusion/ summary and acknowledgements, key words and suggest a suitable title to the given abstract/paper**(Compulsory)**	**1P**
14	Assigning legends to given graphs, figures and captions to given tables, Deciphering the given pictorals**.**	**1P**
15	Study of proof correction symbols; proof- reading the given text & correcting the proofs.	**1P**
16	How to write materials and methods ,observation section of a research paper**.**	**1P**
17	Write discussion section for the given discussion-less research paperand writingCitations/ Bibliography **(Compulsory)**	**1P**
18	Oral presentation: Rhythm, style, control, mock presentation of 10 minutes.	**1P**

M.Sc. Zoology (Semester - 2)

Course Code and Course Name:

ZOUT 121: Molecular Biology and Bioinformatics. (4 Credits = 60 lectures)

Semester II

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

CO1: Explain the DNA structure & types, topology, Physical properties; chromatin structure and organization.

CO2: Discuss genome organization, DNA and Protein sequencing with their application in evolutionary studies.

CO3: Explain the mobile DNA elements.

CO4: Explain mechanism of DNA damage and repair.

CO5: Illustrate the process of DNA replication, transcription, translation and their regulations.

CO6: Illustrate the database tools with their significance.

CO7: Schematically represent the processes of central dogma.

CO8: Justify the post translational and post transcriptional modifications.

Sr. No.	Name of the topic	Lectures allotted
1.	**DNA structure and topology** :-Structure of chromatin, nucleosome, chromatin organization and remodeling, higher order organization - chromosome, centromere, telomere, Histones and its effect on structure and function of chromatin, type of DNA **(A,B,Z)**	**(5L)**
2.	**Physical propertiesof DNA:** Tm, hypo and hyper chromicity, solubility, mutarotation and buoyancy**.**	**(2L)**
3.	**Genome organization:** C value paradox and genome size, Cot curves, repetitive and non-repetitive DNA sequence and their importance Cot ½ and, kinetic and sequence complixicity, satellite DNA**.**	**(2L)**
4.	**DNA Replication:** DNA replication in *E. coli*, Origin of replication, , types of *E. coli* DNA polymerases, details of replication process, regulation of replication, connection ofreplication to cell cycle. Different models of replication for linear and circular DNA replication features of single stranded	**(10L)**

phages. Eukaryotic DNA replication, multiplereplicons, eukaryotic DNA polymerases, ARS in yeast, Origin Recognition Complex(ORC), regulation of replication.

5. **DNA damage and repair:** Different types in DNA damages, Different DNA repair systems: Nucleotide excision repair, Base excision repair, mismatch repair, recombination repair, Double strand break repair, transcriptional coupled repair, Nick Translation and SOS Repair **(5L)**

6. **Transcription:**Transcriptional Unit in prokaryotes and eukaryotes, role and significance of promoter, enhancer, intron, exon, silencer, Transcriptional factors, mechanism of prokaryotic gene transcription, type and structure of RNA polymerase, post transcriptionalprocessing: Capping, polyadenylation and splicing in eukaryotes and significance, Ribonucleoproteins(SnRNPs&ScRNPs) **(8L)**

7. **Gene regulation and expression** in prokaryotes- Lac, arabinose and Trp operon**.** **(3L)**

8. **Protein synthesis:** Genetic Code ribosome structure, activation of amino acids, peptide bond formation and translocation of peptides, post-translational modifications, inhibitors of protein synthesis **(6L)**

9. **Mobile DNA elements:** Transposable elements in bacteria, IS elements, composite transposons, replicative, non-replicative transposons, Mu transposition Controlling elements in Tn A and Tn 10 transposition, SINES and LINES. Retroviruses and retrotransposon. **(4L)**

Bioinformatics

1. **Introduction** **(2L)**

Introduction to Bioinformatics and Bioinformatics web resource (NCBI, EBI, ExPASy, PubMed, OMIA), Applications of Bioinformatics

2. **Databases – Tools and their uses** **(4L)**

Biological databases, Primary sequence databases, Nucleic acid sequence databases (GenBank, EMBL-EBI, DDBJ),Protein sequence data bases (UniProtKB, PIR, PDB) Secondary sequence databases, Derived databases - PROSITE, BLOCKS, Pfam/ Prodom, Structure databases and bibliographic databases

3. Sequence alignment methods (4L)

BLAST, FASTA

Significance of sequence alignment

Pairwise sequence alignment (Needleman &Wunsch, Smith & Waterman methods) Multiple sequence alignment (PRAS, CLUSTALW)

4. Predictive applications using DNA and protein sequences (5L)

Evolutionary studies: Concept of phylogenetic trees, Parsimony and Bayesian approaches, synonymous and non-synonymous substitutions, convergent and parallel evolution, Pharmacogenomics: Discovering a drug: Target identification Protein Chips and Functional Proteomics: Different types of protein chip, detecting and quantifying; applications of Proteomics

Metabolomics: Concept and applications

REFERENCE BOOKS:

1. *Genes IX*, 9th edition (2008), Benjamin Lewin, Publisher - Jones and BarlettPublishers,Inc.
2. *Molecular Biology of the Gene*, 5th Edition (2004), James D. Watson, Tania Baker,
3. Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick. Publisher -Pearson Education, Inc. and Dorling Kindersley Publishing, Inc
4. Bioinformatics - Concepts, Skills, and Applications; S.C. Rastogi& others; CBS Publishing; 2003.
5. Bioinformatics - A practical guide to analysis of Genes & Proteins; Andreas D Baxevanis& B F Francis; John Wiley; 2000.
6. Introduction to Bioinformatics; 1st Edition; T K Attwood, D J parry-Smith; Pearson Education, 11th Reprint; 2005.
7. Bioinformatics; 1st Edition; C S V Murthy; Himalaya Publishing House; 2003
8. Bioinformatics sequence and genome analysis; David W. Mount; Cold spring harbor laboratory press; 2004
9. Basic Bioinformatics; S. Ignacimuthu, S.J.; Narosa Publishing House; 1995

10. An Introduction to Bioinformatics Algorithms; Neil C. Jones and Pavel A. Pevzner; MIT Press, First Indian Reprint; 2005
11. Bioinformatics - Managing Scientific Data; Zoe Lacroix, Terence Critchlow; Morgan Kaufmann Publishers (Elsevier Science); 2003 (for the V unit)
12. Phylogenetics: Theory and Practice of Phylogenetic Systematics; Second edition; Bruce S. Lieberman; Wiley-Blackwell; 2011
13. Molecular Evolution: A Phylogenetic Approach; Roderick D.M. Page, Dr Edward C. Holmes; Well Publishing; 1998
14. Essential Bioinformatics; JinXiong; Cambridge University Press; 2006
15. Proteomics - From Protein Sequence to Function; 12 S. R. Pennington, M. J. Dunn; First edition; Springer publications; 2001
16. Proteomics; Timothy Palzkill; Springer; 2002
17. Metabolomics - A Powerful Tool in Systems Biology; Jens Hřiriis Nielsen, Michael C. Jewett; Springer; 2007
18. Systems Metabolic Engineering; Dr. Christoph Wittmann, Sang Yup. Lee; Springer; 2012
19. Bioinformatics (Bios Instant Notes); Second Edition (Special Indian Edition); T. Charlie Hodgman, Andrew French and David R. Westhead; Garland Science (Taylor and Francis Group); 2010
20. Understanding Bioinformatics; Marketa Zvelebil and Jeremy O. Baum; Garland Science (Taylor and Francis Group); 2008
21. Bioinformatics Computing – The complete practical guide to bioinformatics for life scientists; Bryan Bergeron; Eastern Economy Edition; Prentice-Hall of India Pvt. Ltd., New Delhi; 2003
22. Bioinformatics; Prakash S. Lohar; MJP Publishers, Chennai; 2009
23. A text book of Molecular Biology- J.Pal and S. Ghaskadabi, Oxford Publication- India.
24. Freifelders Essentials of Molecular Biology, Malacinski G.M (2006) (Fourth Edition). Narosa Publishing House, New Delhi.
25. Karp's Cell and Molecular Biology: Concepts and Experiments, 8th Edition by Gerald Karp, Janet Iwasa, et al. 2016, Wiley Publication

Course Code and Course Name:

ZOUT 122 Endocrinology and Parasitology. (4 Credits= 60 lecturers)

Semester II

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

Endocrinology:

CO1: Discuss the roles of Pituitary gland and pineal body.

CO2: Explain hormonal regulation of biomolecules and mineral metabolism.

CO3: Describe the role of osmoregulatory and gastrointestinal hormones.

CO4: Explain the role of hormones in moulting, change in body colour of crustaceans; yolk synthesis in amphibians; insect development.

CO5: Explain the hormonal regulation of metabolism.

CO6: Illustrate the mechanism of hormone action and role of hormone receptors.

CO7: Justify hormones as coordination molecules.

CO8: Justify the significance of biological clocks and rhythms.

Parasitology:

CO1: Define the terminologies of parasitology.

CO2: Explain the concepts of animal association with examples.

CO3: Describe the role of parasites in public health and hygiene.

CO4: Explain the morphology and life cycle of common parasites.

CO5: Explain the pathogenicity and control measures of common parasites.

CO6: Illustrate the process of parasitic infections to human.

CO7: Justify the importance of control strategies against parasitic infections.

CO8: Justify the significance of vectors and disease transmission.

Sr. No.	Name of the topic	Lectures allotted
	Endocrinology:	
1.	Hormones as chemical messenger, types of hormones-protein and non-protein	**(2L)**
2.	Hormone receptors; on the plasma membrane, cytoplasm & nucleus	**(2L)**
3.	Mechanism of hormone action- signal transduction cascade**.**	**(2L)**
4.	Hypothalamic hypophysiotropins	**(2L)**

5.	Adenohypophysial hormones: ACTH, PRL, STH and TSH	**(4L)**
6.	Control of chromatophores: Pituitary, pineal	**(2L)**
7.	Hormonal regulation of carbohydrates, protein & lipid metabolism: pancreatic hormones glucocorticoids	**(3L)**
8.	Osmoregulatory hormones: ADH, mineralocorticoids, renin-angiotensin	**(2L)**
9.	Gastrointestinal hormones	**(2L)**
10.	Control of calcium and phosphate metabolism	**(2L)**
11.	Endocrine mechanism in crustacean: X & Y organs, regulation of metabolism, heart, salt and water balance, reproduction, colour change, moulting	**(3L)**
12.	**Chronobiology**: Introduction, significance, Clocks, Rhythm and Calendar, The biological timing system: Concepts and methods, Types: Ultradian, circadian and circannual rhythms.	**(4L)**

Parasitology

1	**Host-Parasite systems:** 1.1Preadaptation to infectiousness, Myasis: Classification according to tissue,vectors specific, sub specific, accidental; clinical presentation humans, syndrome,symptoms, diagnostic, control method prevention, treatment.; Transmission: Types, categories: A. Conspecific: Contact, Transplacental,Transovarian, B. Heterospecific: Mechanical (Indirect & Direct), Biological, Paratenic,Hyper parasitic, Parasitoidal. 1.2 Manipulation of Host behaviour, Parasitism & Altruism, parasites & socialbehavior of hosts, parasitism & life history, parasitic effects benefiting the host.	**(7L)**
2	**Type study:** Classification geographical distribution, morphology, life-cycle, transmission,pathogenicity, treatment and prophylaxis of: 2.1 Protozoa: *Trypanosoma*Sps. ,*Leishmania*Sps. 2.2 Platyhelminthes: *Schistosoma*Sps., *Echinococcus*Sps. 2.3 Nematoda: *Ancylostoma*Sps., *Dracunculus*Sps.	**(8L)**
3	**Genetics & Molecular Biology:** 3.1*Trypanosoma:* Diploid & Sexual stage, Molecular characteristics of surface coat,Variable surface glycoprotein (VSG) and VSG gene expression. *3.2 Plasmodium:* Diploid & haploid stages, Chromosome polymorphism, gene	**(7L)**

encoding Circumsporozoite protein &merozoites S- antigens, surface antigendiversity. Resistance of Malaria to drugs, its mechanism & assessment.

3.3 Platyhelminthes: Inseminative behaviour, parthenogenesis and polyspermy, sexdetermination, sex linked inheritance in Schistosomes.

4 Serology & immunodiagnostic methods: (6L)

4.1 Serology & antibody synthesis, preparation & demonstration of specific antigensof *Entamoeba, Plasmodium, Trypanosoma*&*Leishmania*

4.2Immunodiagnostic assays, Immunodiffusion, haemogglutination test, Radioimmuno assay, ELISA, complement fixationtest.

5. Prophylaxis & control: Biologic, Genetic, Chemical, Physical & Other methods. **(2L)**

REFERENCE BOOKS:

1. Bentley, P.J. (1998). Comparative vertebrate endocrinology, edn.3, CambridgeUniversity Press, London.
2. Bollander, F. (1994). Molecular endocrinology, edn.2,Acad. Press, SanDiego.
3. Hadely, M.E. (1996). Endocrinology. Edn.4, Prentice Hall, Upper Saddle Park.
4. Thomdyke, M.C. and Goldsworthy, G.J. (1988). Neurohormones in Invertebrates. Cambridge University Press.
5. Hoar, W.S. and Hickman, C.P., Jr. (1983). A laboratory companion for general and comparative physiology. Edn.3, Prenticed- Hall, Englewood Cliffs, N.J., USA.
6. Kobayashi, H. Malsumolo, A. and Ishii, S. (Eds.) (1992).Atlas of endocrine organs: vertebrates and invertebrates. Springer Verlag, Berlin.
7. Zarrow, M.X., Yachim, J.M. and McCarthy, J.L. (1964). Experimental endocrinology: a sourcebook of basic techniques. Academic Press, New York
8. Comparative protozoology, Ecology, Physiology, Life history, Anderson, O.R. , Springer verlag, Berlin.
9. General Parasitology, Cheng T. C., Academic Press.
10. Modem Parasitology, Cox F.E.G.,Eds.Parasitology in focus, facts &

trends, Melhorn h.,Eds., SprigerVerlag, Beriin.

11. Medical Parasitology, Piakarsky G. L., Springer Verlag, Berlin.
12. Modern Parasitology, Cellular immunological & immunological aspects, Wyler D. J., Eds.,
13. Molecular Parasitology: Protozoan parasites and their MoleculesWalochnik, J, Duchene M, 2016

Course Code and Course Name:

ZOUT 123 Comparative Animal Physiology & Environmental Biology.

Semester II **(4 Credits= 60 lecturers)**

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

Comparative Animal Physiology:

CO1: Explain the physiology of processes like digestion, respiration, muscle contraction and excretion.

CO2: Describe the mechanism of thermoregulation in both poikilotherms and homeotherms.

CO3: Explain the mechanism of chemical communication in vertebrates.

CO4: Comment on the structure and functions of various sense organs.

CO5: Illustrate the concept of osmotic regulation in various animals with suitable examples.

CO6: Compare the physiology of regulatory mechanisms in various groups of animals.

CO7: Justify the survival strategies of organism in varied climatic conditions.

CO8: Justify the evolution of various life processes in living forms.

Environmental Biology:

CO1:List the endangered, endemic and extinct animal species of India.

CO2:Identify various types of natural resources, human impact on these resources, and common resourcemanagement practices.

CO3:Explain the structure and impact of biogeochemical cycles, ecosystems and energy transformation across trophic levels.

CO4: Describe concepts in population ecology and their significance.

CO5: Discuss environmental hazards and risks and the socio-economic implications.

CO6: Illustrate the impact of climate and anthropogenic factors on biodiversity with reference to India.

CO7: Illustrate the wildlife management practices and their significance.

CO8: Analyze the impact of lifestyle on the environment and animal life.

Topic No.	Name of the topic	Lecturesallotted
1.	**Digestion:** Physiology of digestion.	**(03L)**
2.	**Respiration:** Respiratory Surfaces: comparison of ventilation associated with gills and pulmonary respiration. Blood pigment, role in Oxygen transport.O2 dissociation curves physiological and ecological significance, CO2	**(04L)**
3.	**Muscle contraction:** Structure (light & electron microscopic) of the skeletal muscle, proteins of the myofilaments, nature of actin-myosin interaction, sarcoplasmic recticulum and role of Ca++ in contraction	**(04L)**
4.	**Osmotic regulation:** Concepts of osmole, osmolarity and tonicity, ionic regulation, Hyper-and hypo-osmotic regulators, ureosmotic animals.	**(04L)**
5.	**Excretion:** Basic processes in urine formation, renal function in animals specially the mammalian kidney, Renal pressure system, Comparative biochemistry of nitrogen excretion.	**(04L)**
6.	**Thermoregulation:**Biokinetic Zones, tolerance and resistance. Thermobiological terminologies. Compensatory patterns in piokilotherms. Critical temp, and zone of thermal neutrality. Mechanism of thermoregulation in homeotherms.	**(04L)**
7.	**Chemical Communication**: Nuerosecretion, neuroheamal& endocrine organs.	**(03L)**
8.	**Sense organ:** classification & functions (details of photoreception as a model).Reflexes, Principles of neural integration**.**	**(04L)**
	Environmental Biology	
1.	Introduction: Fundamentals of Ecology, Ecosystems: Definition and, concept of ecosystems, energy flow in ecosystems, Nutritional Flux. Development and evolution of the ecosystems. Biogeochemical cycles, Food-chains, ecotone, edge effects, ecological niche, and ecosystem stability**.**	**(5L)**
2.	Environmental Microbiology: Microbes - classification and their	**(2L)**

applications in the environmental sciences. Cultivation and growth of microorganisms. Microorganisms and their association with man, animals and plants. Microbes as anti-microbial agents.

3. Biomes and Habitat Diversity: Classification of biomes, major biotic elements of each biome and their characteristics. Human impact on the natural environment. **(2L)**

4. Biological diversity of India: Definition and nature, India's biogeographically history, physiography, climate and its impact on biodiversity. Indian forest and vegetation types and diversity of flora and fauna. **(4L)**

5. Population and Community Ecology **(2L)**

6. Wetlands Forests and Semi-Arid Habitats of India: Definition and types of wetlands, important wetlands and their conservation issues. Forests and semi-arid habitats and their distribution in India, ecological status of forests and arid lands, and their conservation. **(3L)**

7. Endangered, Endemic and Extinct Species of India: Threatened species categories of IUCN, threatened species of animals and the reasons, Red data book, Biodiversity hotspots of India. **(4L)**

8. Wildlife management and conservation. Protected Areas Network in India: Goals of management, Strategies for planning. Factors influencing wildlife management such as habitats, population, behaviour, food-habits, health, etc., tools for data collection and analysis. Human land-use and wildlife management units, important projects for the conservation of wildlife in India, Role of local communities in wildlife management. **(6L)**

9. Introduction to human animal conflict. **(2L)**

REFERENCE BOOKS:

1. Comparative animal physiology, Clifford Ladd Prosser, John Wiley & Sons
2. Animal physiology, Richard W. Hill, Gordon A. Wyse. Harper and Row

3. Comparative animal physiology, Philip Carew Withers, Saunders College Pub., 1992
4. Fundamentals of Ecology: E. P. Odum
5. Modern concepts in Ecology: H: D. Kumar
6. Microbes, Man and Animals: The Natural History of Microbial Interactions: Linton, A. H. andBurns, R.G. John Wiley and Sons.
7. Elements of Microbiology: Pelczar, M.J. and Chan ECS, McGraw Hill.
8. General Microbiology: Stainer, R.Y, Adelberg, EA and Ingraham, J.L. . Macmillan Press.
9. Microbial Methods for Environmental Biotechnology: Grainer, J.M. and Lynch, J.M. . Academic Press.
10. Microbiological Methods for Environmental Scientists and Enginners
11. Gaudy, A.F. and Guady, E.T. McGraw Hill.

Course Code and Course Name:

ZODT 124: Metabolic Pathways.(2 Credits= 30 lecturers)

Semester II

CO1: Define basic terminologies of metabolic pathways.

CO2: Explain the laws of thermodynamics, concept of free energy and ATP as currency molecule.

CO3: Describe the Concepts and regulation of metabolism.

CO4: Discuss the oxidation of fatty acids and its significance.

CO5: Illustrate the electron transport chain and oxidative phosphorylation.

CO6: Illustrate the reactions, energetics and regulation of glycolysis, glycogen biosynthesis, TCA cycle, Purine and Pyrimidine metabolism

CO7: Write the general reactions of various metabolic pathways.

CO8: Justify the role of enzymes in metabolism

Sr. No.	Name of the topic	Lectures allotted
1.	Basic law of thermodynamics, internal energy, enthalpy, entropy, concept of free energy, redox potentials, high energy compounds, structure and function of ATP.	(4L)
2.	Concepts of metabolism, Metabolic pathways-Catabolic and anabolic, regulation of metabolic pathways	(2L)
3.	Carbohydrate Metabolism 1. Steps of Glycolysis (EMP Pathway). 2. PFK 3. Regulation of Glycolysis. 4. Glycogenesis, Glycogenolysis and Glyconeogenesis 5. Inborn errors of metabolism- Von- Gerkes disease, Tarui'sdisease, Galactosemia, Maple syrup urine	(7L)
4.	Electron transport chain and oxidative phosphorylation.	(3L)
5.	Citric acid cycle: Detailed study, energetics, regulation and significance, Role of PDH.	(4L)
6.	Oxidative degradation of amino acids: transamination, oxidative deamination.	(2L)
7.	Biosynthesis of purine and pyrimidine nucleotides	(3L)
8.	A Lipid metabolism: Introduction, oxidation of even chain saturated fatty acids, oxidation of unsaturated fatty acids, oxidation of odd chain fatty acids, omega (ω)-oxidation of fatty acids, Ketogenesis. Transport of Fatty Acids.	(5L)

Course Code and Course Name:

ZODP 124: Practical in Metabolic Pathways. (2 Credits- 60 Hours)

Semester II

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

CO1: Identify the common diseases/conditions caused due to errors in metabolism.

CO2: Explain the principle of Colorimetry and Spectrophotometry.

CO3: Use the basic equipment in biochemistry lab.

CO4: Illustrate the enzyme activity from suitable material.

CO5: Demonstrate the effect of various physical and chemical factors on enzyme activity.

CO6: Demonstrate the absorption studies of biomolecules.

CO7: Estimate the concentration of cholesterol, uric acid, amino acids and starch.

CO8: Separate biomolecules by chromatographic methods.

Sr. No.	ZODP 124: Practical in Metabolic Pathways.	No. of Practicals
1.	Estimation of Starch.**(Compulsory)**	**(1P)**
2.	Separation amino acids by paper chromatography	**(2P)**
3.	Estimation of uric acid in wall Lizard excreta/ Human blood any other suitable material.**(Compulsory)**	**(1P)**
4.	To find absorption spectrum of haemoglobin, BSA, Tyrosine.	**(1P)**
5.	Estimation of Protein by Lowry et al Method.**(Compulsory)**	**(1P)**
6.	Estimation of Sugar by DNSA method.	**(1P)**
7.	Separation of amino acids by TLC **(Compulsory)**	**(1P)**
8.	Estimation of free amino acids by Ninhydrin method.**(Compulsory)**	**(1P)**
9.	Estimation of cholesterol.	**(1P)**
10.	Study α-Amylase Activity in Germinating Seeds.	**(2P)**
11.	Determination of saponification value of a fat.	**(1P)**
12.	Study the effect of pH and temperature on enzyme activity**.**	**(1P)**
13.	Study of human diseases caused due to errors in metabolic pathways with the help of pictures/charts/models/laboratory reports.	**(1P)**

REFERENCE BOOKS:

1. Biochemistry, 3rd Ed. (2005), Voet Donald and Voet Judith G. John, Publisher: Wiley & sons, New York.
2. Biochemistry 6th Ed, (2007) Berg Jeremy, Tymoczko John, StryerLubert, Publisher: W. H. Freeman, New York.
3. Lehninger's Principles of Biochemistry, 4th edition, (2005) Nelson D. L. and Cox M. M. W. H. Freeman & Co. NY.
4. Biochemical Calculations, 2nd Ed., (2010) Segel Irvin H., Publisher: John Wiley and Sons, New York.
5. Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.
6. Biochemistry, Geoffrey Zubay, William C Brown Pub; 4th edition (June 1999)
7. Principles and Techniques of Biochemistry and Molecular Biology, 6th

edition (2008), Keith Wilson and John Walker, Publisher–Cambridge University Press.

8. Biochemical Methods, 2018, S.Sadashivam, New Age International Pvt Ltd Publishers; Third edition.
9. An Introduction to Practical Biochemistry,2017, David Plummer, McGraw Hill Education; 3th edition.
10. Medical Biochemistry,2018- John W Baynes and Marek H. Dominiczak, Publisher- Elsevier; 5th edition.
11. Harper's Illustrated Biochemistry, 2018, Victor W.Rodwell, David A., Bender, Kathleen M.,Botham, Peter J.,Kennelly, P. AnthonyWeil, McGraw-Hill; Illustrated edition,
12. Principles of Medical Biochemistry-2016, Gerhard Meisenberg, William H. Simmons,Elsevier; 4th edition.

Course Code and Course Name:

ZODT 124: Ichthyology(2 Credits= 30 lecturers)

Semester II

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

CO1: Identify the common fishes in India.

CO2: Explain the general characters and evolution of fishes.

CO3: Explain the fish morphology and anatomical modifications.

CO4: Illustrate the physiology of reproductive and endocrine organs in fish.

CO5: Discuss the signs, symptoms and control measures of common diseases in fish.

CO6: Justify the role of respiratory and excretory organs in survival of fishes.

CO7: Classify fishes upto order level.

CO8: Setup aquarium and manage it.

Topic No.	Name of the topic	Lecture allotted
1.	Introduction, general characteristics, evolutionary succession and fossil history of fishes. The early evolution of fishes: Chondrichthian fishes - Sharks, Skates and Rays.	**(3L)**
2.	Eschmeyer's classification of fishes and diagnostic characters up to orders (one major order from each class).	**(4L)**
3.	External morphology, body form, appendages, pigmentation, skin and scales.	**(1L)**
4.	Food and feeding habits, Digestive system and its anatomical modifications.	**(2L)**
5.	Respiratory mechanism: Respiratory gills and lungs. Accessory respiratory organs: Origin of air breathing organs; skin, buccopharynxopercular cavity and air bladder.	**(2L)**
6.	Circulatory system: Heart and accessory pumps.	**(2L)**
7.	Excretion and Osmoregulation: Glomerular and aglomerular kidneys; Nitrogen (ammonia, urea, TMAO) excretions. Water and salt balance in steno- and euryhayline fishes. Role of skin and gills.	**(3L)**
8.	Reproduction: Structure of gonads, gametogenic cycles; spawning.	**(2L)**
9	Nervous system and Sense organs: Organization of the central and peripheral nervous systems. Olfactory, taste buds, touch receptors, photoreceptors, lateral line and internal ear	**(3L)**
10	Endocrine system: Pituitary gland, urohypophysis, adrenal gland, gonads, and thyroid gland.	**(2L)**
11	Fish pathology: Signs of sickness and effects on fish; Pathological procedure for diagnosis of fish diseases,Symptoms and control measures of viral, bacterial, fungal, protozoan, worm and crustacean diseases.	**(2L)**
12	Ornamental Fish production and management: World trade of ornamental fishes. Different varieties of exotic and indigenous ornamental fishes. Principles of a balanced aquarium. Fabrication, setting up and maintenance of freshwater aquarium. Water quality management. Water filtration system – biological, mechanical and chemical. Types of filters. Aquarium plants and their propagation methods. Lighting and aeration. Aquarium accessories and decoratives. Aquarium fish feeds. Dry, wet and live	**(4L)**

feeds. Breeding and rearing of ornamental fishes. Common diseases and their control. Conditioning, packing, transport and quarantine methods. Trade regulations and wild life act in relation to ornamental fishes.

Course Code and Course Name:

ZODP 124: Practical in Ichthyology (2 Credits – 60 hours)

Semester II

Sr. No.	Name of the Practical	No.ofPracticals.
1.	Study of fish evolution with the help of charts/models/Pictures.	**(1P)**
2.	General external characters, fins and scales (permanent slides & temporary preparations and submission during examination).	**(1P)**
3.	Classification of fishes (one example from each order); use of diagnostic keys.	**(2P)**
4.	Length-weight relationship, condition factor, gonado-somatic index of any one fish species.	**(1P)**
5.	Adaptations of fishes (adhesive organs, accessory respiratory organs, stomachless fishes, spiral valve, electric organs and sense organs.)	**(1P)**
6.	Study of Weberian ossicles in Heteropneustes/ Labeo.	**(1P)**
7.	Anatomical observations, demonstration and detailed explanation of fish in general, Digestive, urino-genital system, Endocrine glands of carp/ catfish/ Tilapia.	**(1P)**
8.	Identification of fish developmental stages: egg, spawn, fry fingerling and adult.	**(1P)**
9.	Cranial nerves (V, VII, IX & X) and eye ball musculature and innervations in Scoliodon/ carp/ catfish.	**(1P)**
10.	Histology of digestive, respiratory, excretory, reproductive and endocrine organs.	**(1P)**
11.	Study of common diseases in fish their diagnosis and control strategies.	**(1P)**
12.	Setting up of an aquarium and its management and study of breeding behaviour of gourami, Siamese fighting and swordtail.	**(2P)**
13.	Visit to fish farm/ fish breeding centre/fish market and preparation of detail visit report.	**(1P)**

REFERENCE BOOKS:

1. Bal D. V. & K. V. Rao (1984). Marine Fisheries. Tata McGraw-Hill, New Delhi.
2. Bone Q., N. B. Marshall & J. H. S. Blaxter (1995). Biology of Fishes, Edn.2, Blackie, Academic % Professional (Chapman & Hall), London.
3. C. Vandujn. Diseases of fishes – Narendra Publishing House, New Delhi.
4. Hoar W. S. & D. J. Randall (1969). Fish Physiology. Vols. I onwards, Academic Press, New York.
5. Jayaram K. C. (1981). The freshwater fishes of India. Pakistan, Bangladesh, Burma and Sri Lanka- A Handbook. Zool. Survey of India, Academic Press, New York.
6. Khanna, S. S. (1984). An Introduction to Fishes. Central Book Depot., Allahabad.
7. Lagler K. E., J. E. Bardach, R. R. Miller D.R.M. Passino (1977). Ichthyology, Edn.2, Wiley, New York.
8. Rahul P. Parihar. Textbook Of Fish Biology & Indian Fisheries
9. Talwar P.K. & A.G. Jhingran (1991). Fish and Fisheries of India and Adjacent Countries, Vols. I & II. Oxford & I.B.H., New York.
10. Wake, M.H. (Ed.) (1979). Hyman's Comparative Vertebrate Anatomy. Edn.3, University of Chicago Press, Chicago
11. Wedemeye G. A. Environmental stress and fish diseases –Narendra. Publishing House.
12. William N. Eschmeyer (2019). Eschmeyer'sCatalog of Fishes (Vol. 1, 2 & 3). Published by the California Academy of Sciences, San Francisco © 1998.

Course Code and Course Name:

ZOUP 125 Basic Zoology Lab-2(4 Credits, 120 hours)

Semester II.

Note: A total of 30 practicals are to be conducted. 10 practicals from each module are to be conducted. 1 practical is of 4 clock hour duration.

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

CO1: Identify the various parasites and parasitic stages of common parasites, nitrogenous wasteproducts of animals, feshwater planktons and slides of endocrine glands.

CO2: Explain the principle and significance of gonadectomy, thyrodectomyand pancreactomy.

CO3: Demonstrate the role of eye stalk and insulin in sugar level in crab.

CO4: Demonstrate the retro cerebral complex in cockroach.

CO5: Demonstrate the RBCs of common vertebrates and effect of various osmolarities.

CO6: Demonstrate the effect of body size, oxygen consumption and Insulin on aquatic animal.

CO7: Determine the bleeding and clotting time, heartbeat of crab, species richness in selected area, physico- chemical properties of soil and water.

CO8:Perform Sterilization of lab equipment, prepare microbial culture, Isolate Bacterial, liver DNA and RNA from given sample, quantify and resolve them using electrophoretic procedures, analyse protein sample by PAGE and SDS PAGE and construct phylogenetic tree using tools inbioinformatics.

Sr. No.	Name of the Practical	No. of Practicals
	Module-I Molecular Biology and Bioinformatics	
1.	Lab Safety Techniques and sterilization**.**	**1P**
2.	Isolation of bacterial DNA and estimation by UV spectrophotometry **(Compulsory)**	**2P**
3.	Isolation of Liver DNA and quantification, Agarose gel electrophoresis of isolated DNA**.(Compulsory)**	**2P**
4.	Isolation of RNA and agarose gel electrophoresis.	**1P**
5.	Concept of biological database, gene and protein search by BLASTA and	**1P**

	FASTA **(Compulsory)**	
6	To analyse protein on native PAGE and SDS-polyacrylamide gel electrophoresis.**(Compulsory)**	**2P**
7.	Construction of phylogenetics tree for DNA and protein **(Compulsory)**	**1P**
8.	Demonstration of DNA amplification by PCR	**1P**
	Module- II Endocrinology and Parasitology	**1P**
1	Histology of invertebrate and vertebrate neurosecretory and endocrine structures.(Compulsory)	**1P**
2	Blood sugar regulation in the crab- role of eye stalk. **(Compulsory)**	**1P**
3	Study of retrocerebral complex of the cockroach.	**1P**
4	Introduction of alloxan diabetes in the mouse/ rat / human. **(Compulsory)**	**1P**
5	Gonadectomy in the mouse/ rat.	**2P**
6	Pancreatectomy in the mouse/ rat.	**1P**
7	Effect of insulin on blood sugar, hepatic and muscle glycogen of the rat/human. **(Compulsory)**	**1P**
8	Thyroidectomy in the rat.	**1P**
9	Study of life cycle, role as vector & control measures of: Ticks(*Argas, Boophilus*) Mosquito – any two from- *Anopheles/ Aedes/ Culex* Any two flies: *Tabanus/ Phlebotomus/ Sarcophaga*.Cyclops. **(Compulsory)** (Specimen, Slides or charts may be used.)	**2P**
10	Ectoparasites&Endoparasites of wild rat, cattle, dog, chick & human including stages in excreta.	**2P**
11	Study of life cycle of parasitic protozoa: *Trypanosoma, Leishmania.***(Compulsory)**	**1P**
12	Study of life cycle of helminth parasites: *Schistosoma. Echinococcus, Ancylostoma, Dracunculus***(Compulsory)**	**2P**
13	Study of Parasites from digestive tract of Cockroach/gut / parasites of hen. (Compulsory)	**1P**

	Module-III Comparative Animal physiology and Environmental Biology	
1	Study of nitrogenous waste products of animals from different habitats**. (Compulsory)**	**1P**
2	Study of RBCs in different vertebrates and in different physiological conditions.	**1P**
3	Study of relation of Body size and oxygen consumption in aquatic animals (crab/fish). **(Compulsory)**	**1P**
4	Estimation of sugar in rat/crab/human blood. **(Compulsory)**	**1P**
5	Determination of bleeding time & clotting time of human blood. **(Compulsory)**	**1P**
6	Determination of the heart beat in the crab-effect of temperature & ions.	**1P**
7	Effect of eye stalk ablation on glucose in the haemolymph of the crab.	**1P**
8	A visit to aquatic ecosystem and methods for water and plankton collection**. (Compulsory)**	**2P**
9	Plankton identification and quantification from river / lake water samples. **(Compulsory)**	**2P**
10	Vegetation studies by line, quadrates and belt transect methods and their analysis.	**2P**
11	Preparation of media for microbial culture, Isolation and culturing of microbes from soil/water samples**. (Compulsory)**	**2P**
12	Water analysis for physico-chemical characteristics**.(Compulsory)**	**1P**
13	Physico-chemical analysis of soil. **(Compulsory)**	**1P**

Note: Latest edition of the recommended books may also be used

Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Degree Program in Zoology

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Zoology) Part-II

(for Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2020-2021

Title of the Course: M.Sc. (Zoology)

Preamble

Zoology is a major subject of Basic Sciences which deals with all aspects of animal biology. It includes an interesting range of highly diverse topics. The advancements in biological Sciences demands, a zoology student to be a master of many areas in the subject. This Postgraduate degree program has been designed by the Board of Studies in Zoology of Savitribai Phule Pune University with a tangible understanding of what is needed from zoologists and what zoologists need to pursue as a skilled career. It emulates closely the Benchmark Statement for Biosciences and the guidelines laid down by the University Grants Commission, New Delhi. This Newly designed Curriculum is an appropriate blend of the classical aspects in Zoology which has been the "backbone" knowledge required for all zoologists and the recent and specialized areas. The flexibility in the Curriculum allows the students to choose their areas of interest leading to enhanced employability. Students will be provided sufficient number of hours for their skill development through the Lab Courses and the Project component. The lab courses have differing flavours and priorities to make a good zoologist. This degree offers specialization in areas like Genetics, Animal Physiology and Entomology along with a range of core courses like Biochemistry, Molecular Biology, Comparative Animal Physiology, Developmental Biology, Environmental Biology etc. Various cross cutting issues relating to Environmental biology have been aptly included to develop the students' sense towards human wellbeing. The field trip/surveys and study tours are included to gives the student an enticing taste of what life is specially outside the walls of the classroom. On successful completion of the programme, the students are expected to understand the key life processes of human and other animal groups, the functioning of molecules, cells, tissues, organs and systems. Also the students will gain increased confidence to use initiative and judgement to make decisions in complex and changeable situations and reflect critically and analytically on personal experience and make informed decisions about further study, training and employment opportunities. The Master of Science (M.Sc.) in Zoology is a Postgraduate program under the Faculty of Science and Technology of Savitribai Phule Pune University Pune. The curriculum designed encompasses subjects like Physiology, Entomology, Genetics, Cell Biology, Developmental Biology, Endocrinology, Biochemistry, Molecular Biology, Freshwater Zoology, Environmental Biology etc. Both classical and applied subjects of Zoology have been rightly blended to offer holistic understanding of the subject.

The Choice Based Credit System (CBCS) will be implemented through this curriculum. This curriculum would certainly felicitate students to develop a strong base of the fundamentals and specialize in the desired area of their fondness and abilities. The students pursuing this program

would get a privilege to select optional subjects of their choice. A total of 210 hours for theory lectures and 180 hours for laboratory work have been prescribed in each semester including a research project (advisable to be start at the first year in consultation with the department staff) to inculcate the research culture amongst students. This newly designed curriculum will allow students to acquire the skill in handling scientific instruments planning and performing in the laboratory and exercising critical judgement, independent thinking and problem solving skills.

M.Sc. Zoology - Course structure & Distribution of Credits

M.Sc. Zoology, Part –I,

Semester-I

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)	Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	**ZOUT 111** Biochemistry and Biochemical Techniques	-			-	4
2	**ZOUT 112** Cell Biology and Developmental Biology	-			-	4
3	**ZOUT 113** Genetics and English in Scientific Communication.	-			-	4
4	-	**ZODT 114** Theory. ---------- **ZODP 114** Practical	Biostatistics/ Freshwater Zoology Zoology Practical Paper-1	2 2	-	4
5	-	-			**ZOUP 115** Basic Zoology Lab-I	4
	Total Credit of Semester 1					**20**

M.Sc. Zoology, Part-I, Semester-II

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)	Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	**ZOUT 121** Molecular Biology and Bioinformatics	-			-	4
2	**ZOUT 122** Endocrinology and Parasitology	-			-	4
3	**ZOUT 123** Comparative Animal Physiology and Environmental Biology.	-			-	4
4	-	**ZODT 124** Theory. ---------- **ZODP 124** Practical	Metabolic pathways / Ichthyology	2	-	4
			Zoology Practical Paper-2	2		
5	-	-			**ZOUP 125** Basic Zoology Lab- II	4
		Total Credit of Semester 2				**20**

M.Sc. Zoology, Part-II, Semester - III

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)	Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	ZOUT 231 Special Paper (any one) Animal Physiology-I/ Entomology-I/ Genetics-I	-			-	4
2	ZOUT 232 Fundamentals of Systematics and Economic Zoology	-			-	4
3	ZOUT 233 Research Methodology and Insect Physiology and Biochemistry	-			-	4
4	-	ZODT 234 Theory --------- ZODP 234 Practical	Immunology/ Genetic Toxicology/ Zoology Practical Paper- 3	2 2	-	4
5	-	-			ZOUP 235 Special Lab I	4

M.Sc. Zoology, Part II, Semester – IV

Sr. No.	Core Compulsory Theory Paper (CCTP)	Choice Based Optional Paper (CBOP)	Theory/ practical	Credit	Core Compulsory Practical Paper (CCPP)	Credit
1	ZOUT 241 Special Paper-Any One- Animal Physiology-II/ Entomology-II/ Genetics-II	-			-	4
2	ZOUT 242 Mammalian Reproductive Physiology and Aquaculture				-	4
3	-	ZODT 243 Theory	Histology and Histochemistry/ Pest Control	2	-	4
		ZODP 243 Practical	Zoology Practical Paper-4 (Practicals corresponding to ZOUT 241and ZODT 243)	2		
4	-	ZODT 244 Theory	Pollution Biology/ Apiculture	2	-	4
		ZODP 244 Practical	Zoology Practical Paper-5 (Practicals corresponding to ZOUT 242 and ZODT 244)	2		
5	-	-			ZOUP 245 (Project)	4
	Total Credit of Semester 4					**20**

Equivalence of Previous Syllabus:

Semester-I

Old Course (2013 Pattern)	New Course (2019 Pattern)
ZY101T: Biochemistry-I	ZOUT 111 Biochemistry and Biochemical Techniques
ZY102T: Cell Biology	ZOUT 112 Cell Biology and Developmental Biology
ZY103T: Genetics	ZOUT 113- Genetics and English in Scientific Communication.
ZY104T: Biostatistics	ZODT 114 Biostatistics
ZY105T: Skills in scientific communication and Writing	ZOUT 113 Genetics and English in Scientific Communication.
ZY106T: Freshwater Zoology	ZODT 114 Freshwater Zoology
ZY101P:Practicals in Biochemistry	ZOUP 115 Basic Zoology Lab-I
ZY102P: Practicals in Cell Biology	
ZY103P: Practicals in Genetics	
ZY105P: Practicals in Skills in scientific communication and writing	
ZY106P: Practicals in Fresh water zoology	ZODP 114 Zoology Practical-1
ZY104P: Practicals in Biostatistics	
Old Course (2013 Pattern)	
ZY101T: Biochemistry-I	
ZY102T: Cell Biology	
ZY103T: Genetics	
ZY104T: Biostatistics	
ZY105T: Skills in scientific communication and Writing	
ZY106T: Freshwater Zoology	
ZY101P:Practicals in Biochemistry	
ZY102P: Practicals in Cell Biology	
ZY103P: Practicals in Genetics	
ZY105P: Practicals in Skills in scientific communication and writing	
ZY106P: Practicals in Fresh water zoology	
ZY104P: Practicals in Biostatistics	

Semester-II

Old Course (2013 Pattern)	New Course (2019 Pattern)
ZY201T: Biochemistry-II	ZODT 124Metabolic pathways
ZY202T: Molecular Biology	ZOUT 121 Molecular Biology and Bioinformatics
ZY203T: Developmental Biology	ZOUT 112 Cell Biology and Developmental Biology
ZY204T: Endocrinology	ZOUT 122 Endocrinology and Parasitology
ZY205T: Comparative Animal Physiology	ZOUT 123 Comparative Animal Physiology & Environmental Biology
ZY206T: Biochemical Techniques/Ichthyology	ZOUT 111 Biochemistry & Biochemical Techniques ZODT 124 Ichthyology
ZY201P:Practicals in Biochemistry-II	ZOUP 125 Basic Zoology Lab-II
ZY202P: Practicals in Molecular Biology	
ZY203P: Practicals in Developmental Biology	
ZY204P: Practicals in Endocrinology	
ZY205P: Practicals in Comparative Animal Physiology	

Semester-III

Old Course (2013 Pattern)	New Course (2019 Pattern)
ZY 301**T** Animal Physiology I (special)	ZOUT 231 Special Paper Animal Physiology-I
ZY 301**T** Entomology I (special)	ZOUT 231 Special Paper Entomology-I
ZY 301**T** Genetics I (special)	ZOUT 231 Special Paper Genetics-I
ZY 302**T** Immunology	ZODT 234 Immunology
ZY 302**T** Environmental Biology	---
ZY 303**T** Genetic toxicology	ZODT 234 Genetic toxicology

ZY 303**T** Aquaculture	ZOUT 242- Aquaculture
ZY 304**T** Insect Physiology and Biochemistry	ZOUT 233- Insect Physiology and Biochemistry
ZY 305**T** Research methodology	ZOUT 233- Research methodology
ZY 306**T** Parasitology	--
ZY 307**T** Fundamentals of Systematics	ZOUT 232- Fundamentals of Systematics
ZY 308**T** Insect Ecology	--
ZY 309**T** Toxicology I	--
ZY 301P Practicals in Animal Physiology I (special)	ZOUP 235 Special Lab I
ZY 301 P Practicals in Entomology I (special)	
ZY 301 P Practicals in Genetics I (special)	ZODP 234 Practical
ZY 302 P Practicals in Immunology	
ZY 302 P Practicals in Environmental Biology	
ZY 303 P Practicals in Genetic toxicology	
ZY 303P Practicals in Aquaculture	
ZY 304P Practicals in Insect Physiology and Biochemistry	
ZY 305P Practicals in Research methodology	
ZY 306**P** Practicals in Parasitology	
ZY 307P Practicals in Fundamentals of Systematics	
ZY 308P Research Project	
ZY 309P Practicals in Toxicology I	

Semester-IV

Old Course (2013 Pattern)	**New Course (2019 Pattern)**
ZY 401**T** Animal Physiology II (special)	ZOUT 241- Animal Physiology II (special)
ZY 401**T** Entomology II (special)	ZOUT 241- Entomology II (special)
ZY 401**T** Genetics II (special)	ZOUT 241- Genetics II (special)
ZY 402**T** Economic Zoology	ZOUT 232- Economic Zoology
ZY 402**T** Bacteria and phage Genetics	--

ZY 403**T** Mammalian Reproductive Physiology	ZOUT 242- Mammalian Reproductive Physiology
ZY 403**T** Biodiversity assessment	--
ZY 404**T** Histology and Histochemistry	ZODT 243 Histology and Histochemistry
ZY 405**T** Pollution Biology	ZODT 244 Pollution Biology
ZY 406**T** Apiculture	ZODT 244 Apiculture
ZY 407**T** Pest control	ZODT 243 Pest control
ZY 408**T** Toxicology II	--
ZY 401 P Practical Animal Physiology II	ZODP 243 Practical ZODP 244 Practical ZOUP 245 (Project)
ZY 401 P Practical Entomology II	
ZY 401 P Practical Genetics II	
ZY 402 P Practical Economic Zoology	
ZY 402 P Practical Bacteria and phage Genetics	
ZY 403 P Practical Mammalian reproductive physiology	
ZY 403 P Practical Biodiversity assessment	
ZY404 P Practical Histology and histochemistry	
ZY405 P Practical Pollution biology	
ZY406 P Practical Apiculture	
ZY308 P Research Project	
ZY 408 P Practicals in Toxicology II	

Detailed Syllabus with Recommended Books:

Program outcomes (POs): **After successfully completing the M.Sc. Zoology program students will be able to:**

PO1. **Zoology knowledge**: Apply the knowledge of Zoology, Life Sciences and allied subjects to the understanding of complex life processes and phenomena.

PO2. **Problem analysis**: Identify, review research literature, and analyse complex situations of living forms.

PO3. **Design/development of solutions**: Design processes/strategies that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in real situations.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and ICT tools for understanding of the subject.

PO6. **The Postgraduate and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability**: Understand the impact of the natural and anthropogenic activities in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. Identify a range of invertebrates and vertebrates and justify their conservation.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the work/research practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex life activities with the scientific community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of Zoology and management principles and apply these to one's own work, as a member and leader in a team.

PO12**. Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Following is the syllabus of each course along with the course outcomes:

M.Sc. Zoology, Part II, Semester – III

Course Code and Course Name:

ZOUT231: Animal Physiology- I (Special Paper) (4 Credits: 60 Lectures)

Semester III

After successfully completing this course, students will be able to: CO1:

CO1: Explain the membrane physiology and its dynamics.

CO2: Explain the concept of nutrition and digestion.

CO3: Explain the structure, contraction and types of contraction of muscle.

CO4: Illustrate bioluminescence and animal electricity with examples and its significance

CO5: Correlate the organisms Internal and external environments with homeostasis and biological Clocks.

CO6: Diagrammatically represent the mechanism of respiration, gas exchange and transport of O_2 and CO_2

Sr. No.	Name of the topic	Lectures allotted
1.	**External and Internal environment** 1.1 External environment: the atmosphere, aquatic & terrestrial environment 1.2 Internal environment: Extracellular and intra cellular environment 1.3 Homeostasis and regulation: tolerance and resistance, acclimatisation and acclimation, regulatory mechanism. 1.4 Biological clock and their regulation: Circadian rhythms lunar and tidal rhythm, circa annual rhythm, photoperiodism.	**(08L)**
2.	**Membrane Physiology** 2.1 Membrane structure, membrane permeation, diffusion mediated transport, dynamics of semi permeable membrane. 2.2 Resting membrane potential, diffusion, equilibrium potential, Goldman-Hodkin- Katz potential, conductance, current, capacitance 2.3 Excitable cell membrane: action potential, role of various ion channels, role of Na+ K+ pump, properties of action potentials	**(10L)**
3.	**Physiology of Digestion** 3.1 Nutritive requirements (concept of balanced diet), Regulation of hunger, satiety 3.2 Digestion and absorption in the G.I tract: carbohydrate, lipids & protein 3.3 Control and regulation of digestion 3.4 Calorimetry and BMR	**(09L)**
4.	**Respiration** 4.1 Internal and external respiration; Anatomy of respiratory system 4.2 Pulmonary respiration: Partial pressure, inspiration and expiration, Lung volume and capacities	**(10L)**

	4.3 Gas exchange across the pulmonary and systemic capillaries 4.4 Gas transport; O2 transport, CO2 transport and abnormalities in the blood gas content 4.5 Neuronal control of respiration, role of central and peripheral receptors 4.6 Other functions of respiratory system, waste elimination	
5.	**Muscle Physiology** 5.1 Structure of skeletal muscle and molecular basis of skeletal muscle contraction, types of contraction, twitch summation and tetanus, relation between muscle length and tension, velocity of contraction 5.2 Chemical basis of muscle contraction 5.3 Innervation of muscles, excitation and contraction coupling 5.4 Skeletal muscle fiber types, contractile machinery of smooth muscle	**(09L)**
6.	**Bioluminescence and Animal electricity** 6.1 Bioluminescence: phyletic distribution, structure of luminescent organs, biochemical and molecular mechanism. 6.2 Animal electricity: electro receptors electro organs and their structure and functions	**(08L)**
7.	**Buoyancy** 7.1 Definition, density reduction 7.2 Gas floats with examples 7.3 Swim bladder with example	**(06L)**

REFERENCE BOOKS:

1. Animal Physiology: Adaptation and Environment (1997) Knut Schmidt-Nielsen Publisher: Cambridge University Press.
2. Principles of Animal Physiology (2006), C. D. Moyes and P. M. Schulte. Publisher - Pearson Education Inc. and Dorling Kindersley Publishing Inc.
3. Text book of Medical Physiology 10th edition (2001), A. C. Guyton and J. E. Hall. Publisher - W. B. Saunders Company, Philadelphia. –
4. Principles of Anatomy and Physiology, 11th edition (2006), G. J. Tortora and B. Derrickson. Publisher-John Wiley and Sons Inc.
5. Endocrinology, 5th edition (2008), Mac. E. Hadley. Publisher-Pearson Education Inc. and Dorling Kindersley Publishing Inc.
6. Comparative Vertebrate Endocrinology 3rd edition (1998), P. J. Bentley. Publisher Cambridge University Press.
7. Vertebrate Endocrinology 3rd edition (1997), D. O. Norris. Publisher- Academic Press: An imprint of Elsevier.
8. The World of the Cell, 7th edition, (2005), Wayne M. Becker, Lewis J. Kleinsmith, Jeff Hardin., Publisher - Benjamin Cummings.
9. Principles of Animal Physiology (2nd Edition) (2007) Christopher D. Moyes , Patricia M.

Schulte

10. Animal Physiology, Third Edition (2012) Richard W. Hill, Gordon A. Wyse, Margaret Anderson
11. Functional Anatomy and Physiology of Domestic Animals 4th Edition (2009) William O. Reece Animal Physiology 2nd Edition Richard W. Hill Publisher: Sinauer Associates, Incorporated
12. Eckert's Animal Physiology (2004) Roger Eckert, D.J. Randall, Warren Burggren, Kathleen French Publisher: W.H.Freeman & Co Ltd
13. Principles of Animal Physiology (2013) Christopher D. Moyes, Patricia M. Schulte • Publisher: Pearson Education Limited
14. Environmental Physiology of Animals (2004) Pat Willmer, Graham Stone, Ian Johnston • Publisher: Blackwell Publishing Ltd
15. Introduction to Animal Physiology (1998) Ian Kay Publisher: Bios Scientific Publishers Ltd

Note: Use the latest editions of the recommended books

Course Code and Course Name:

ZOUT 231 : Entomology- I (Special Paper) **4 Credits: 60 Lectures**

Semester III

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

CO1: Define entomology and Insects and understand origin and evolution of insects and their relation to other arthropods.

CO2: Give outline of Classification of insects up to family with distinguishing characters and examples of each order and family.

CO3: Explain the structure, chemical composition and functions of Integument and Derivatives of Integument.

CO4: Explain the structure, modifications of insect body regions and their appendages.

CO5: Explain the Comparative anatomical and histological structure of various body systems.

CO6: Explain the location structure and functions of various Endocrine and Exocrine glands.

CO7: Explain the location and structure of Light and Sound producing organs in various insects

Sr. No.	Name of the topic	Lectures allotted
1.	Introduction to Entomology: Definition, Origin, Evolution and Inter-relationship of insects with other arthropods.	**(04L)**
2.	General outline of Classification and Phylogeny of insects up to family : Aptrygote insects (4 orders), Exopterygote insects (16 orders) and Endopterygote insects (9 orders).	**(19L)**
3.	Integument : Structure, chemical composition and functions. Derivatives of Integument: Cuticular appendages & Processes.	**(02L)**
4.	Comparative study of : Head and its appendages; Thorax and its appendages ; Abdomen and its appendages.	**(09L)**
5.	Comparative anatomical and histological study of the following : Digestive system, Respiratory system, Circulatory system, Excretory system, Reproductive system, Nervous system and Sense organs.	**(20L)**
6.	Endocrine and Exocrine glands and Hormonal action.	**(04L)**
7.	Light and Sound producing organs.	**(02L)**

REFERENCE BOOKS:

1. A Text book of Entomology-By H. H. Ross (John Wiley and Sons, Ins. New York,).
2. An Introduction to Entomology- By J. H. Comstock (Ithaca, New York).
3. General & Applied Entomology- By K. K. Nayar, T.N. Anathakrishnan & B.V. David, (Tata McGraw-Hill, New Delhi).

4. General Entomology, 2nd edition- By M.S. Mani Oxford & IBH Publishing Company, New Delhi.
5. Imm's text book of entomology by O. W. Richards and R. G. Davies (Methuen and com, London) vol. I and II
6. Introduction to comparative Entomology- By R. M .Fox and J. W. Fox (Reinhold, New York)
7. Modern Entomology, 2nd edition- By D. B. Tembhare (Himalaya Publication House, Bombay).
8. Principles of insect morphology- By R. E. Snodgrass (Tata Mc-Graw Hill Bombay).
9. The Insect: Structure & Function- By R. F. Chapman (E.L.B.S., & E.U.P. London).

Note: Use the latest editions of the recommended books

Course Code and Course Name:

ZOUT 231 : Genetics- I (Special Paper) (4 Credits: 60 Lectures)

Semester III

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

CO1: Define the basic terminologies in Genetics

CO2: Elaborate the advantages of model organisms used in genetic studies

CO3: Apply molecular methodologies in genetic analysis

CO4: Estimate gene frequencies

Sr. No.	Name of the topic	Lectures allotted
1.	Model Genetic System: Life cycles, genetic nomenclature and advantages of the following organisms commonly used in genetic studies: 1.1 T phages 1.2 *E.coli* *1.3 Saccharomyces cerevisiae* and *Schizosaccharomyces pombe* *1.4 C. elegans* *1.5 Drosophila* 1.6 Zebra fish 1.7 Mouse	6L
2.	Advanced Population Genetics: 2.1 Recapitulation of basic concepts and Hardy-Weinberg law. 2.2 Estimation of gene frequencies in population through mutation, migration and selection, selection-mutation equilibrium, derivation and genetic equations for above. 2.3 Assortative mating, inbreeding and genetic drift.	12L
3.	Quantitative genetics: 3.1 Concept of continuous variation, phenotypic variance and its partitioning into subcomponents. 3.2 Co-variance, correlation and regression, degree of genetic determination, measurement of heritability, quantitative inheritance in humans.	12L
4.	Evolutionary Genetics: 4.1 Genetic polymorphism. 4.2 Selection strategies and effects. 4.3 Genetics of speciation: classical and modern concepts. 4.5 Use of molecular information in understanding phylogenetic relationship.	12L
5.	Applications of Molecular methodologies in genetic analysis: 5.1 Introduction to gene localization on chromosomes. 5.2 Chromosomal Probes and Paints. 5.3 Gene Therapy: *Ex vivo* and *In vivo* gene therapy and two examples of gene delivery system. 5.4 Reverse Genetics.	12L

	5.5 History of Human genome project: Strategies, methodologies, and current status.	
6.	Genetics in Toxicology: 6.1 History of genetic toxicology and role of FDA, EPAand its guidelines and regulation. 6.2 Role of model organisms in genetic toxicology studies. 6.3 Screening tests: use of test systems- Bacterial, Yeast, *Drosophila* and Mammalian system.	06L

REFERENCE BOOKS:

1. An Introduction to Genetic Analysis – A.J.F. Griffiths, J. Doebley, C. Peichel, D.A. Wassarman (12th ed.) W.H. Freeman Publ. 2020.
2. Concepts of Genetics – W.S. Klug and M.R. Cummings (12th ed.) Pearson Publ. 2019.
3. Genetics : A conceptual approach – B.A. Pierce (6th ed.) W.H. Freeman Publ. 2016.
4. Lewin's GENES XII – J.E. Krebs, E.S. Goldstein, S.T. Kilpatrick. Jones and Bartlett Publ. 2018.
5. Human Molecular Genetics – T. Strachan and A. Read (5th ed.) Garland Science Publ. 2018.
6. Genetics – M.W. Strickberger (3rd ed.) Pearson India Publ. 2015
7. Principles of Genetic Toxicology – D. Brusick. Springer (reprint of Basic Book Publ) 2013.
8. Principles of Genetics – E.J. Gardner, M.J. Simmons, D.P. Snustad (8th ed.) John Wiley & Sons 2006.
9. Genetics: Analysis of Genes and Genomes – D.L. Hartl and E.W. Jones (6th ed.) Jones & Bartlett Publ. 2004.
10. Strickberger's Evolution – B. Hall (4th ed.) Jones and Bartlett Publ. 2008.

Note: Use the latest editions of the recommended books

Course Code and Course Name:

ZOUT 232 : Fundamentals of Systematics and Economic Zoology (4 Credits: 60 Lectures)

Semester III

After successfully completing this course, students will be able to: CO1:

Fundamentals of Systematics

CO1: Explain principles, methods of biological classification and diversity in kingdom Animalia.

CO2: Explain the importance of taxonomic keys and taxonomic characters.

CO3: Explain the principles of zoological classification and nomenclature

CO4: Discuss the various taxonomic procedures and molecular phylogenetics & phylogeography.
CO5: Illustrate the methodologies used in systematics.

Economic Zoology

CO1: Illustrate the lac culture, apiculture, prawn culture, vermiculture, Poultry, dairy industry and Piggery.

CO2: Explain the role of insects of economic importance.

CO3: Explain parasitic roundworms of animal and plants.

CO4: Signify the role of parasitic and soil protozoan in human welfare.

CO5: Justify the use of animals in pharmaceutical research.

CO6: Explain coral reef and its significance.

Sr. No.	Name of the topic	Lectures allotted
	Fundamentals of Systematics	
1.	Fundamental of Systematics: Biological classification, Hierarchy of Categories and taxa.	2L
2.	Taxonomic keys: Types of taxonomic keys, their merits and demerits. International code of Zoological nomenclature: Its operative principles, interpretation and application of important rules, zoological nomenclature, formation of names	7L
3.	Taxonomic procedures: taxonomic collection preservation, curetting process and identification.	3L
4.	Species concepts: Definition and types (Allopatric, sympatric, parapatric, sibling etc.)	2L
5.	Kingdoms of Life: General outline of kingdoms including Monera & Protista. Broad outline & Diversity in kingdom Animalia (Major and Minor phyla).	5L
6.	Methodologies in systematics: Morphology based taxonomy, Numerical taxonomy, Cyto-taxonomy and chemotaxonomy, Molecular systematic, DNA fingerprinting & Molecular markers for detection/evaluation of polymorphism, RFLP, RAPD etc.	8LL

7.	Molecular phylogenetics and phylogeography.	3L
	Economic Zoology	
1.	Animal husbandry: Poultry, Piggery, Dairy industry and wool industry.	08L
2.	Economic importance of insects: Apiculture, Lac culture, Sericulture, House hold insect and stored grain pest and Agricultural pest.	10 L
3.	Economic importance of amphibian, reptiles and birds.	02 L
4.	Vermiculture industry in India.	01 L
5.	Prawn culture	01 L
6.	Nematodes- parasitic roundworms of animals and plants.	01 L
7.	Helminthes as human and animal parasites.	02 L
8.	Concept of Coral reef and its significance.	01 L
9.	Sponge culture and its importance in industry.	01 L
10.	Parasitic protozoan's and their role in human welfare, soil protozoan's and their role in agriculture.	02 L
11.	Model animals in pharmaceutical industry.	01 L

REFERENCE BOOKS:

Fundamentals of Systematics :

1. Kato., The biology of biodiversity, Springer.
2. Avise J.C., Molecular markers, Natural history and evolution, Chapman and Hill, NY.
3. Wilson A.O., biodiversity, Academic Press, Washington.
4. Principals of systematic Zoology by Ernst Mayr.

Economic Zoology :

1. Economic Zoology: An Introductory Text-Book in Zoology, with Special Reference to Its Applications in Agriculture, Commerce, and Medicine, Herbert Osborn, Ulan Press (August 31, 2012)
2. Economic Zoology-Shukla and Upadhaya, Rastogi Publication, 2017
3. A Textbook of Economic Zoology, Dr Sanjeev Jain, Indian Books and Periodicals 2018.
4. Economic Zoology-Manju Yadav , Discovery Publication 2013
5. Economic Zoology-K.R.Ravindranathan , Om Publications 2013
6. Textbook of Economic Zoology- P.R.Venkitaraman Sudharsana Puubl. Kochi 1983
7. A Handbook on Economic Zoology , Dr Jawaid Ahsan And Dr Subhas Prasad Sinha S. Chand Group.
8. Encyclopedia of Economic Zoology, A.A. Khan. Anmol Publications
9. Economic Zoology by. Manju Yadav, Discovery Publishing House Pvt. Limited. Economic Zoology by Malhotra ,Prakash, Adhyayan Puhlishers & Distributers
10. Introduction to Economic Zoology, Sarkar, Kundu and Chaki, New Central Book Agency; New edition edition (14 May 2014)

Course Code and Course Name:

ZOUT 233 : Research Methodology and Insect Physiology and Biochemistry

(4 Credits: 60 Lectures)

Semester III

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

Research Methodology

CO1: demonstrate knowledge of research processes (reading, evaluating, and developing)

CO2: perform literature reviews using print and online databases.

CO3: select and define appropriate research problem and parameters to prepare a project proposal.

CO4: identify, explain, compare, and prepare the key elements of a research proposal/report.

CO5: compare and contrast quantitative and qualitative research paradigms

CO6: Use sampling methods, measurement scales and instruments, and appropriate uses of each.
CO7: Justify the rationale for research ethics,

Insect Physiology and Biochemistry

CO1: Explain the structure, Chemistry of integument and sclerotization.

CO2: Describe the process of digestion and metabolism

CO3: Explain the characteristics of haemolymph and types of haemocytes.

CO4: illustrate the structure, physiology and biochemistry of flight muscle.

CO5: Demonstrate the process of excretion, detoxification and water balance

CO6: Justify the role of insect hormones in physiological processes.

Sr. No.	Name of the topic	Lectures allotted
	Research Methodology	
1.	Research: Meaning, Objectives, Types of research, Planning research project – Identifying Research problems, selection of problem – formulation of a problems. Literature review- Collection of literature- Books - Journals. Digital library and search of articles - Key words and search - Internet – Google Scholar – Pub med – Inflibnet – Medline	04L
2.	Data Collection: Meaning, Methods and Tools of Data Collection Hypothesis Sampling, Data Processing, Analysis and Interpretation of Data.	03L
3.	Research Design: Meaning and Objectives, Characteristics of good research design, components of the research design & steps in scientific research process.	02L
4.	Quantitative methods**:** Biostatistics used for analysis of Biological data	02L

5.	Computer application**:** bioinformatics, databases and their applications	03L
6.	Tools and techniques**:** • Techniques used Purification and characterization of biomolecules: Recapitulation of centrifugation, chromatography and electrophoresis. • NMR, MALDI-TOF, X-ray crystallography, Circular Dichroism CD • Microscopic techniques including Fluorescence microscopy, Confocal microscopy, Atomic force microscopy and live cell imaging FACS analysis.Real time PCR, DNA microarray, New generation DNA sequencing, Protein Microarray.	10L
7.	Dissertation structure –Components - Writing Introduction – review of literature – Materials & Methods – Presentation of results – Discussion of Results based on literature – Arriving conclusions – Briefing of Summary – Arrangement and how to quote reference in thesis -Appendix.	02L
8.	Publishing of Articles in National and International Journals - Selection of Journals – ISSN Number – Peer reviewed Journals – Science citation index – impact factor and its importance.	01L
9.	Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism - Citation and acknowledgement Patent Criteria and procedure of patenting, patenting biological material.	03L
	Insect Physiology and Biochemistry	
10.	Integument: Structure, Chemistry, sclerotization, functions.	03 L
11.	Digestion and absorption of proteins, Carbohydrates and lipids.	03 L
12.	Fat body: Structure, physiology, biochemistry, functions. Integration of carbohydrate, fat and acid metabolism	04 L
13.	Ventilatory mechanisms and their control	03 L
14.	Haemolymph: Physico-chemical characteristics of plasma: types and structure of haemocytes, functions.	03 L
15.	Muscle: structure, physiology and biochemistry of flight muscles	03 L
16.	Excretion and water balance: Structure and function of Malpighian tubules. Water balance and nitrogen excretion.	04 L
17.	Endocrines, neurosecretory hormones, chemistry, function and mechanism of hormone action, moulting and juvenile hormones; chemistry and physiology, other peptide and steroid hormones	04 L
18.	Microsomal and extra-microsomal enzymes insecticide degradation and detoxification.	03 L

REFERENCE BOOKS:

Research Methodology

1. Kothari, C.R. (1985): Research Methodology: Methods and Techniques, Wiley Eastern.
2. Dominowski, R.L. (1980): Research Methods, Prentice Hall Inc., New Jersey.
3. Mishra, R.P. (1980): Research Methodology, Handbook Concept Publishing Company, New Delhi.
4. IIPS (1996): Research Methodology, IIPS, Mumbai.
5. Research and Writtings – By-P. Ramdas , A.Wilson srunai M.J.Publisher (2009).
6. Scientific thesis writings and Paper presentations-N.Gurumani. M.J.Publisher (2010).
7. Anderson, Durston&Polle 1970: Thesis and assignment, writing Wiley Eastern Limited

8. G. Vijayalakshmi and C. Sivapragasam. (2008) Research Methods –Tip & Techniques, MJP
9. Publishers, Chennai. WWW.mjppublishers.com
10. Malter K, 1972: Statistical analysis in Biology, Chapmen Hall, London.
11. Cohen, L. Lawrence, M., & Morrison, K. (2005). Research Methods in Education (5th edition). Oxford: Oxford University Press.
12. Leedy, P. D. (1980). Practical Research: Planning and design. Washington: Mc Millan Publishing Co., Inc.
13. Singh, Y. K. (2006). Fundamental of Research Methodology and Statistics. New Delhi. New International (P) Limited, Publishers

Insect Physiology and Biochemistry

1. Fundamentals of insect physiology, Blum N.S., John Wiley and sons, NY
2. An introduction to insect physiology, Bursell, e. academic press, NY
3. Insect biochemistry and function Candy D.J. and Kilby D.A. Chapman and hall, London
4. Comprehensive insect physiology, biochemistry and pharmacology, Kerkut G.A and Gilbert L.I., Vol 1 to 13 Pergamon press, Oxford, NY
5. The Insects: Structure and Function. Forth ed., Chapman R. F. (1998), Cambridge University Press, UK.
6. Insect Physiology. Prakash, M. (2008), Discovery Publishing House Pvt. Ltd., New Delhi.
7. Physiological Systems in Insects. Second ed., Klowden, Marc (2007), Elsevier, USA
8. The Principles of Insect Physiology, Seventh ed. Wigglesworth, V.B. (1972), Chapman and Hall, London.

Course Code and Course Name:

ZODT 234 : Immunology **(2 Credits: 30 Lectures)**

Semester III

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

CO1: List the primary and secondary immune organs.

CO2: Explain the concepts of immunity, self-nonself immune response, autoimmune disease.

CO3: Explain the theories of antibody synthesis and generation of antibody diversity.

CO4: Explain the principle and application of the common techniques used in Immunology

CO5: Illustrate the events and dynamics of inflammation

CO6: Compare the MHC molecules and diseases associated with HLA.

CO7: Differentiate between active and passive immunization

CO8: Compare the three pathways of complement fixation pathway.

Sr. No.	Name of the topic	Lectures allotted
1.	Introduction to Immune system. 1.1. Overview of Immunology 1.2. Innate and Adaptive immunity; Humoral immunity and cell mediated immunity 1.3. Primary and secondary lymphoid organ. Tissue, cells and molecules of the human immune system. 1.4. Immediate response to infection: inflammation, cell migration, acute phase response interferons and NK cell. 1.5. Concept of immunity (self- non self, antigen) and active and passive immunization (natural and artificial)	07L
2.	Antibody structure, antibody classes, subclasses, structure-function relationship, iso, idio and allo types., T cell receptors.	04L
3.	Theories of antibody synthesis, generation of antibody diversity (molecular basis), antibody class switching.	03L
4.	MHC, HLA and disease association, immune deficiencies and disorders. Antigen processing & Immunogenetics.	05L
5.	Immunological Tolerance, Autoimmunity	02L
6.	Hypersensitivity.	01L
7.	Immunological memory, types of vaccines and vaccination	02L
8.	Immunotechniques: Antigen-antibody reaction and complement system and complement fixation test.	02L
9.	Hybridoma principle and application, ELISA, immunofluorescence, immunoelectrophoresis, RIA and monoclonal-polyclonal antibody and its application.	04L

REFERENCE BOOKS:

1. Immunology: Kindt T. J., Goldsby R.A. , Osborme B. A., Kuby J. : freeman WH publications.
2. Essential immunology, IvonRoitt, Blackwell Scientific publication, London.
3. Immunology, Roitt I. V., Butterworth Publishers, USA.

Course Code and Course Name:

ZODT 234 : Genetic Toxicology (2 Credits: 30 Lectures)

Semester III

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

CO1: Define genotoxicity test systems.

CO2: Describe basic toxicological principles and describe how different chemicals are taken up by, processed in and eliminated from the body

CO3: Inspect physical and chemical genotoxic agents being exposed in his/her environment

CO4: Illustrate physical and chemical genotoxic agents.

CO5: Explain efficiency mechanisms of physical chemical genotoxic agents

CO6: Relate genotoxicity and DNA repair mechanisms and relate types of mutation and DNA repair

CO7: Judge about proper genotoxicity test for mutation types

Sr. No.	Name of the topic	Lectures allotted
1.	Toxicology: Definition and its subdivisions, scope and significance of genetic toxicology	03L
2.	Mutations at molecular, functional and chromosomal levels. Mechanisms of Mutagenesis End point mutations and its function, carcinogenicity and transformation. Biological significance of mutagenesis	07L
3.	Mutagenic agents in human environment. Applications of genetic toxicology to human and environmental monitoring	05L
4.	Methodologies used in detection of mutation, functional, cytogenetic effects. Use of Ames test, mammalian systematics, Drosophila etc.	05L
5.	Screening chemicals for genotoxic properties: Screening tests, hazard assessment, Risk analysis tests. Common assays used for testing mutagenic activity using bacteria, yeasts, insects, plants, animals.	07L
6.	Genetic toxicology and its role in the study of congenital malformations	03L

REFERENCE BOOKS:

1. Chemical mutagens- principles and methods for their detection, Ed. Hollander, A. Vol. 1-5, Plenum press
2. Chemical mutagenesis in mammals and men. Eds. Vogel, F. and Rohtborn, G. Springer Verlag

3. Mutagenic effects of Environmental contaminants, Eds. Suttoa, H.E. and Harris, M.I., Academic press
4. Mutation research (section on genetic toxicology testing)
5. Genetic Toxicology: Principles and methods, Parry J.M., Parry E.M. (eds) Springer Publ. (2012)
6. Principles of Genetic Toxicology, Second Edition, David Brusick, Springer Science+Business Media New York

Course Code and Course Name:

ZODP 234 : Zoology Practical Paper-3 (Immunology) (2 Credits: 60 Hours)

Semester III

Note: A total of 15 practicals are to be conducted. 1 practical is of 4 clock hour duration.

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

CO1: Identify the pattern of identity of antigen- antibody reaction.

CO2: Identify the microscopic structure of the lymphoid organs.

CO3: Demonstrate immunoelectrophoresis technique.

CO4: Demonstrate the double diffusion techniques.

CO5: Detect the human blood groups by antigen -antibody reactions

CO6: Prepare the human blood smear to identify various blood cells.

Sr. No.	Name of the topic	Lectures allotted
1.	Double diffusion or Ouchterlony technique (using kit). **(Compulsory)**	(2P)
2.	Demonstration of Immunoelectrophoresis (using kit). **(Compulsory)**	(2P)
3.	Separation of e gamma globulins from the serum using native PAGE.	(2P)
4.	Histology of lymphoid organs: skin, spleen, thymus, ileum lymph node and bone marrow. **(Compulsory)**	(1P)
5.	To study the differential count of WBCs. **(Compulsory)**	(1P)
6.	Cell counting and viability testing using splenocytes (from goat spleen)	(2P)
7.	To estimate the antigen concentration by rocket electrophoresis (kit using). **(Compulsory)**	(2P)
8.	To study the immunology of blood transfusion (universal donor, universal recipient, Bombay blood group and erythroblastosis foetalis). **(Compulsory)**	(1P)
9.	Blood group analysis with reference to cross matching.	(1P)
10.	Demonstration of Various routes of egg inoculations for vaccine production using dye. (amniotic, yolk sac, allantoic and chorio-amniotic)	(1P)
11.	Enzyme detection: acid phosphatase, alkaline phosphatase, esterase	(1P)

Course Code and Course Name:

ZODP 234 : Zoology Practical Paper-3 (2 Credits: 60 Hours)

Semester III

Note: A total of 15 practicals are to be conducted. 1 practical is of 4 clock hour duration.

Sr. No.	Name of the topic	Lectures allotted
1.	Dominant lethal test in *Drosophila* **(Compulsory)**	2 P
2.	Sex linked recessive lethal test in *Drosophila* **(Compulsory)**	2 P
3.	Micronucleus test in mouse	2 P
4.	Bone marrow chromosome analysis in mouse	2P
5.	Auxotroph mutation induction in Bacteria	2P
6.	Ame's test **(Compulsory)**	2P
7.	Study of Drosophila mutants and maintaining *Drosophila* culture. **(Compulsory)**	2P
8.	DNA analysis using electrophoretic technique	2P
9	Temporary stained preparation of blood smear	1p

Course Code and Course Name:+

ZOUP 235 : Special Lab I (4 Credits: 120 Hours)

Semester III

Note: A total of 30 practicals are to be conducted. 10 practicals from each module are to be conducted. 1 practical is of 4 clock hour duration.

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

Module-I: Animal Physiology-I

CO1: Demonstrate the effect of body size and salinity on oxygen consumption in given animal.

CO2: Demonstrate the effect of starvation on liver and muscle glycogen in given animal

CO3: Demonstrate the effect of exercise on breathing, pulse rate and blood lactate level.

CO4: Demonstrate the effect of pH, temperature and inhibitors on salivary amylase.

CO5: Map the taste buds on human tongue

Module-II: Fundamentals of Systematics and Economic Zoology

CO1: Identify museum specimen/pictures of minor phyla, Invertebrates, Protochordates and Vertebrates.
CO2: Identify animals with the help of taxonomic keys.
CO3: Collect and preserve animal samples using common methods.

CO4: Write scientific report of field/ institutional visit.

CO5: Compare the methods of collection and curation of insects.

CO6: Identify the poultry breeds.

CO7: Identify edible freshwater fish from nearby area.

CO8: Demonstrate the apiculture equipment.

CO9: Demonstrate the methods of prawn culture.

CO10: Compare various fishing tools, crafts and gears.

Module-III: Research Methodology and Insect Physiology and Biochemistry

CO1: Use MS excel in presentation and analysis of data using common statistical tests.
CO2: Suggest a suitable title for a research article.
CO3: Write the abstract, key words, result, discussion, conclusion and citations of references.

CO4: Write a research project to seek funding.

CO5: Conduct a scientific survey.

CO6: Perform protein purification experiment.

CO7: Demonstrate the heart and haemocytes of cockroach.

CO8: Demonstrate the effect of starvation on glycogen in insects.

CO9: Demonstrate the effect of temperature on water loss in cockroach.

CO10: Detect the amino acids in insect haemolymph by chromatographic method.

CO11: Determine the oxygen consumption in dragon fly nymph

CO12: Perform the assay of amylase activity in midgut of insect

Sr. No.	Name of the Practical	No. of Practicals
	Module-I: Practical Animal Physiology-I	
1.	Body size and oxygen consumption in aquatic animals **(Compulsory)**	**1P**
2.	Estimation of Respiratory Quotient by Warburg's Respirometer	**1P**
3.	Effect of salinity on oxygen consumption in aquatic animals **(Compulsory)**	**1P**
4.	Effect of exercise on breathing rate, pulse rate and blood lactate of man **(Compulsory)**	**1P**
5.	Effect of pH, temperature and incubation on human salivary amylase activity. **(Compulsory)**	**1P**
6.	Absorption spectra of blood pigment **(Compulsory)**	**1P**
7.	Mapping of taste areas on human tongue. **(Compulsory)**	**1P**
8.	Carbohydrates in mammalian gut **(Compulsory)**	**1P**
9.	Effect of starvation on liver and muscle glycogen in mouse **(Compulsory)**	**1P**

10.	Preparation of glycerinated muscle fibers and study of its properties. **(Compulsory)**	**1P**
11.	Phosphagen kinase in mouse and crab muscle phosphagen	**1P**
12.	Effect of load on muscles contraction in frog	**1P**
13.	LDH isoenzymes isolation and detection using agarose gel electrophoresis in heart / skeletal muscle of rat	**1P**
14.	Determination of Body Mass Index (BMI)	**1P**
	Module-I: Practical Entomology- I	
1.	Method of collection, preservation & presentation of insects.	**(02P)**
2.	Study of Taxonomy and diagnostic features up to family of Apterygote, Exopterygote and Endopterygote insects (at least one insect from each order). **(Compulsory- 3)**	**(06P)**
3.	Study of generalized insect: Grasshopper/ Cockroach i. Systematic position, Habit, Habitat and Important morphological features. ii. Dissection so as to study: Digestive, Nervous and Reproductive system and Retro-cerebral complex. **(Compulsory)**	**(03P)**
4.	Temporary mounting of mouth parts, antenna, legs, wings, spiracles and tympanum of a generalized insect. **(Compulsory)**	**(01P)**
5.	Dissection of an insect pest (Plant bug or any insect pest as per local availability and legal permissibility) so as to study taxonomy, diagnostic features and anatomy pertaining to digestive, nervous and reproductive systems.	**(03P)**
6.	Study of head capsule: Structure of head capsule, head orientations and modifications. Study of types of mouthparts and antennae. **(Compulsory- 1)**	**(02P)**
7.	Study of general structure of legs and their modifications. Study of general structure of a wing and its modifications. **(Compulsory)**	**(02P)**
8.	Study of abdominal appendages.	**(01P)**
	Module-I: Practical Genetics- I	
1.	Analysis of metric trait and estimation of phenotypic variance.	**[1P]**
2.	Partitioning of phenotypic variance in genetic and non-genetic components in a simulated population. Estimation of DGD.	**[1P]**
3.	Detection of polymorphism in a population – Biochemical (Enzyme, protein etc.)	**[1P]**
4.	To study population cage experiments using *Drosophila*: a) Genetic Drift b) Artificial selection- Experimental simulation and modeling.	**[1p]**
5.	Extraction of Genomic DNA (*Drosophila*).	**[2P]**
6.	*In-silico* design of PCR primers for a gene of interest.	**[1P]**
7.	Chromatography of *Drosophila* eye colour pigments (wild type and/ or eye colour mutants).	**[1p]**
8.	Microbial genetics: Basic methodology, colony count and growth curve.	**[2P]**
9.	Microbial genetics: Isolation of Auxotroph (Estimation of frequency) Replica plate technique.	**[2P]**
10.	Microbial genetics: Bacterial transformation and blue white selection. Calculation of transformation efficiency.	**[1P]**
11.	Study of conventions of nomenclature of genes, genotypes and gene products in different model systems.	**[2P]**
12.	Sex-linked recessive lethal test in *Drosophila*.	**[1P]**

	Module-II: Practical Fundamentals of Systematics and Economic Zoology	
	Practical Fundamentals of Systematics	
1.	To Study specimens of Minor phyla. **(Compulsory)**	**1**
2.	Study of museum specimens and slides of invertebrates, (2 examples from each phyla). **(Compulsory)**	**2**
3.	Study of museum specimens (protochordates and chordates,1or 2 examples of each phyla) **(Compulsory)**	**2**
4.	Identification of animals with the help of keys-House fly, Honey bee etc. **(Compulsory)**	**1**
5.	Identification of animals with the help of keys- Cockroach, Earthworm.	**1**
6.	Method of collection, Preservation, and Curetting of any insect Specimen **(Compulsory)**	**2**
7.	Visits to Scientific Institute like Zoological Survey of India/ Animal Museum and Report writing.	**2**
	Practical Economic Zoology	
1.	Study of Prawn culture on commercial basis.	**1P**
2.	Study of Apiculture equipments. **(Compulsory)**	**1P**
3.	Study of Poultry breeds, feeding utensils in poultry. **(Compulsory)**	**2P**
4.	Study of Fishing tools: crafts and gear **(Compulsory)**	
5.	Study of economic importance of freshwater fishes- *Catla*, Rohu, *Labeo*, *Mrigala*, *Notopterus*, *Mystus* sp., Clarius, *Channa*, *Heteropneustes*, *Reba*, *Wallago*. **(Compulsory)**	**2P**
6.	Collection and identification of locally available/cultured fishes.	**2P**
7.	A visit to piggery/ poultry/ pearl culture centre/ apiculture centre/ sericulture centre and report writing **(Compulsory)**	**1P**
	Module-III: Practical Research Methodology and Insect Physiology and Biochemistry	
	Practical Research Methodology	
1.	Selecting a title for the paper, writing the abstract and key words. **(Compulsory)**	**1P**
2.	Writing the Discussion Conclusions and Results: Citation of references **(Compulsory)**	**1P**
3.	Importance of scientific surveys, primary data and secondary data in research.	**1P**
4.	Writing a project proposal to a funding agency **(Compulsory)**	**1P**
5.	Use of MS Excel in data presentation.	**1P**
6.	Examples of some common statistical tests. **(Compulsory)**	**2P**
7.	Purification of a biomolecule.	**1P**
8.	Making a ICT enabled scientific presentation. **(Compulsory)**	**1P**
9.	Microscopic techniques.	**1P**
10.	Presentation of any ONE research paper. **(Compulsory)**	**1P**
	Practical Insect Physiology and Biochemistry	
1.	Kymographic study of ventilatory movement in beetle	**1P**
2.	Oxygen consumption in dragon fly nymph **(Compulsory)**	**1P**
3.	Study of heart and haemocytes of cockroach **(Compulsory)**	**1P**
4.	To determine the trehalase activity in haemolymph of any insect	**1P**
5.	Amino acid in haemolymph of any insect by chromatographic technique	**2P**

6.	Study of fat body glycogen of cockroach and effect of starvation **(Compulsory)**	**1P**
7.	Effect of temperature on water loss in cockroach **(Compulsory)**	**1P**
8.	Von Wisselinghs test for presence of chitin in insect cuticle **(Compulsory)**	**1P**

M.Sc. Zoology, Part II, Semester – IV

Course Code and Course Name:

ZOUT 241: Animal Physiology- II (Special Paper) **(4 Credits: 60 Lectures)**

Semester IV

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

CO1: Explain the composition of blood, types of blood cells, vascular dynamics and clotting.

CO2: Illustrate the anatomy and physiology of heart and cardiac cycle

CO3: Describe the excretory system, nitrogenous wastes and renal regulation

CO4: Illustrate the osmoregulatory mechanism in Invertebrates and Vertebrates

CO5: Discuss the neuronal physiology and various potentials.

CO6: Justify the location and structure of eye, ear and taste buds to their functions.

CO7: Justify energy utilization in physiological and metabolic activities.

Sr. No.	Name of the topic	Lectures allotted
1.	**Blood and blood vessels:** a) Blood composition and function, Haematopoiesis b) Blood clotting and it's molecular mechanism c) Blood vessels and blood pressure: Blood vessel types, Arteries, role as pressure reservoir and arterial pressure: Aeteriole:role in distribution in cardiac output and maintainance of arterial blood pressure, Capillaries and it's functions, veins:its role as blood reservoir and venous return d) Blood pressure-Hypertension and Hypotension	(08L)
2.	**Cardiac Physiology:** a) Anatomy of heart	(09L)

	b) Electrical activity of the heart pace makers, spread of cardial coupling, action potential of cardiac cells c) Elecrocardiography d) Mechanism events of cardiac cycle, Heart sound e) Neuronal and Hormonal control of heart f) Cardiovascular response of exercise	
3.	**Excretion & Osmoregulation:** a) Nitrogenous waste- ammonia and its excretion, urea, urea cycle, uric acid and its excretion, products of nucleoprotein metabolism, miscellaneous end product of nitrogen metabolism. b) Organ of excretion and urine formation c) Renal regulation and acid –base balance. d) Maintaining water and electrolyte balance and its regulation in aquatic invertebrates & vertebrate, moist skinned animals, arthropods, terrestrial, vertebrate and marine air breathing vertebrates.	(09L)
4.	**Neuronal Physiology:** a) Nerve cells : Structure & Function b) Excitation and conduction of nerve fiber: Resting membrane potential, Action potential, all or none law, electronic potential, saltatory conduction c) Ionic basis of excitation and conduction d) Neurotransmitter types and receptors: Metabolism of neurotransmitters, Neuropeptides e) Synapse and Neuronal integration f) Impact of drugs and disease on synaptic transmission	(8L)
5.	**Sensory Physiology**: a) Receptor types, receptor potential and receptor adaptation b) Eye-structure and physiology of vision c) Ear-Hearing and equilibrium, sound waves and it's characters, structure of ear and physiology of hearing and equilibrium d) Chemical senses : Taste and smell e) Tactile sensation / response	(09L)
6.	**Energy metabolism:** a) Metabolic rate b) Energy storage: Fat and glycogen c) Effect of O2 concentration: acclimation to low O2 level, anaerobic metabolism, lactic acid and glycolysis d) Problem of diving and deep sea hydro thermal vent e) Metabolic rate and body size: mammals, birds, marsupials & monotremes f) Energy cost of locomotion: running, swimming, flying g) Effect of high altitude	(12L)
7.	**Stress & Adaptation:** a) The Autonomic nervous system & HPA axis coordinate the stress response to an acute threat. b) The HPA axis modulates the immune system. c) Chronic stress causes deleterious effects. d) Plasma glucocorticoid concentration shows seasonal variations.	(05L)

REFERENCE BOOKS:

1. Principles of animal physiology. (2006), C. D. Moyes and P. M. Schulte. Publisher - Pearson Education Inc. and Dorling Kindersley Publishing Inc.
2. Text book of Medical Physiology. 10th edition (2001),. A. C. Guyton and J. E. Hall. Publisher - W. B. Saunders Company, Philadelphia.
3. Principles of Anatomy and Physiology, 11th edition (2006), G. J. Tortora and B. Derrickson. Publisher-John Wiley and Sons Inc.
4. Endocrinology, 5th edition (2008), Mac. E. Hadley. Publisher-Pearson Education Inc. and Dorling Kindersley Publishing Inc.
5. Comparative Vertebrate Endocrinology. 3rd edition (1998), P. J. Bentley. Publisher-Cambridge University Press.
6. Vertebrate Endocrinology. 3rd edition (1997), D. O. Norris. Publisher- Academic Press: An imprint of Elsevier.
7. The World of the Cell, 7th edition, (2005), Wayne M. Becker, Lewis J. Kleinsmith, Jeff Hardin., Publisher - Benjamin Cummings.
8. Molecular Cell Biology, 6th edition (2007). Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira, Publisher-W. H. Freeman.
9. Molecular Biology of the Cell, 5th edition (2007). Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Publisher - Garland Science.
10. An Outline of Energy Metabolism in Man, Gordon L. Atkins, William Heinemann Medical Books Limited, London 1981
11. Stress Physiology in Animals, Paul H.M. Balm, Blackwell; 1 edition (20 August 1999).
12. Sensory Systems: Anatomy, Physiology and Pathophysiology, Aage R. Moller, Academic Press 2003.

Course Code and Course Name:

ZOUT 241: Entomology- II (Special Paper) (4 Credits: 60 Lectures)

Semester IV

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

CO1: Explain Gametogenesis, Fertilization and oviposition.

CO2: Explain embryonic developmental stages such as Cleavage, Blastoderm and Germ band formation; Gastrulation, Blastokinesis, differentiation of germ layers, Segmentation and Appendages formation and organogenesis.

CO3: Explain post-embryonic developmental stages such as Nymph, Naiad, larva, Pupa and Metamorphosis.

CO4: Explain specialized reproductive mechanisms.

CO5: Explain Hadorn's experiments with imaginal disc, Regeneration and Aging.

CO6: Explain Occurrence, Initiation, Preparations for diapauses and its Controls.

Sr. No.	Name of the topic	Lectures allotted
1.	**Gametogenesis :** Spermatogenesis, Seminal transfer and spermatophore formation; Oogenesis, Structure and Types of insect eggs. Fertilization and oviposition.	**(08L)**
2.	**Insect embryonic development:** Cleavage and Blastoderm formation, Germ band formation, Gastrulation, Embryonic membranes, Blastokinesis, Dorsal closure and dorsal organ, Fate/ differentiation of germ layers, Segmentation, Appendages formation and organogenesis in brief.	**(18L)**
3.	**The post embryonic development:** Eclosion from the egg. The developmental stages: Nymph, Naiad, larva, Pupa, Emergence from the pupa/ cocoon. Metamorphosis and Growth.	**(20L)**
4.	**Specialized reproductive mechanism:** Oviparity, viviparity, polyembryony, paedogenesis and parthenogenesis.	**(04L)**
5.	Hadorn's experiments with imaginal disc, Regeneration and Aging.	**(06L)**
6.	**Diapause:** Occurrence, Initiation and Preparations for diapauses. Diapause development and Controls.	**(04L)**

REFERENCE BOOKS:

1. 'The Insect- structure and Function'- by R.F. Chapman , ELBS, London
2. 'A Text book of Entomology'- by H. H. Ross (John Wiley and Sons, Ins. New York,
3. 'Imms' Text Book of Entomology- by O. W. Richards and R. G. Davies, (Methuen &Cc., London,), Vols. I & II.
4. 'Embryology of Insects and Myriapods'- by O. A. Johanson and F.H. Butt, (McGraw Hill, New York,).
5. 'The ecology of insect populations in theory and practice'- by L.R. Clarks P. W. Geier, R.D. Hughes, R.F. Morris (Methuen, London).
6. 'Developmental system: Insects' Vol. I and II- by S. J. Counce and C.H. Waddington (Academic Press, London,).

Course Code and Course Name:

ZOUT 241: Genetics- II (Special Paper) (4 Credits: 60 Lectures)

Semester IV

Sr. No.	Name of the topic	Lectures allotted
1.	Solving problems (Numerical: Probability estimation) of Mendelian and non-mendelian genetics.	02L
2.	Basic Human Genetics: 2.1 History of Human Genetics 2.2 Pedigree- Gathering Family history, pedigree symbols, construction of pedigrees, Autosomal inheritance- Dominant &Recessive, Monogenic traits(Sex Linked inheritance, Sex Limited & Sex-influenced traits, mitochondrial traits), MIM number. 2.3 presentation of molecular genetic data in pedigrees 2.4 Complications to the basic pedigree patterns- non penetrance, variable expressivity, pleiotropy, late onset, dominance problems, genetic heterogeneity, genomic imprinting & uniparental disomy, spontaneous mutations, mosaicism & chimerism, male lethality, X- inactivation. 2.5 Parametric and non-parametric analysis, identifying recombinants & non recombinants in pedigree, two- point mapping- LOD score analysis, genetic & physical map distances, genetic markers.	12L
3.	Clinical Genetics : 3.1 Monogenic diseases- 3.1.1 Cystic Fibrosis 3.1.2 Tay-Sachs syndrome 3.1.3 Marphan syndrome 3.2 Triplet repeat based disorders 3.3 Inborn metabolic errors-	15L

	3.3.1 Disorders of carbohydrate metabolism 3.3.2 Disorders of nucleic acid metabolism 3.3.3 Disorders of lipid metabolism 3.3.4 Lysosomal storage disorders 3.3.5 Peroxisomal disorders 3.4 Disorders of Hematopoietic systems- 3.4.1 Overview of blood cell types & haemoglobin 3.4.2 Sickle cell anemia 3.4.3 Thalassemia 3.4.4 Hemophilia's 3.5 Prenatal and pre-implantation diagnosis 3.5.1 Indications for prenatal diagnosis 3.5.2 Indications for chromosomal testing 3.5.3 Non- invasive methods 3.5.4 Invasive methods	
4.	Epigenetics: concept and applications	2L
5.	Physical mapping methods: 5.1 Low resolution mapping- cell hybrids, radiation hybrid mapping, synteny homology. 5.2 Restriction maps, clone contig maps, STS map, EST map, DNA sequence map.	3L
6.	Immunogenetics: 6.1 Genetic basis of antibody diversity. 6.2 Regeneration of TCR diversity. 6.3 HLA polymorphism and disease association.	3L
7.	Oncogenetics : 7.1 Concepts of oncogenes and tumor suppressor genes. 7.2 Role of oncogenes. 7.3 Cytogenetic studies.	3L
8.	Behavioural Genetics: 8.1 Rothenbuhler's experiment on genetics of Bee behavior (hygienic and non-hygienic Trait). 8.2 Nature-nurture and behavior- 8.2.1 Genetic experiments to investigate animal behavior- 8.2.1.1 Selection studies. 8.2.1.2 Inbred strain studies. 8.3 Identifying genes for controlling behavior- 8.3.1 Induced mutations 8.3.2 Quantitative trait loci. 8.3.3 Synteny orthology. 8.4 Twin and adoption study designs. 8.5 Environmental influence- shared and non-shared environment. 8.6 Genetics of human behavioural defects- Schizophrenia.	5L
9.	Neurogenetics: 9.1 Genetics of Circadian rhythm (sleep-wake cycle), learning and memory mutants in *Drosophila*. 9.2 Psychopathology- Alzheimer's disease	3L

10.	*Drosophila* genetics: 10.1 History of *Drosophila* genetics. 10.2 Genetic basis of Sex determination and dosage compensation in *Drosophila.* 10.3 Maternal genes and formation of body axis. 10.4 Segmentation genes. 10.5 Homeotic gene functions. 10.6 Regulation of Hox- gene expression	6L
11.	Bacterial and phage genetics: 11.1 Bacteriophage lambda: morphology and structure of nucleic acids, lytic cycle and lysogeny. 11.2 T even and odd phages: bacteriophage T2, T4 and T7 morphology, nucleic acid structure and life cycle. Special features compared to lambda 11.3 RNA phages: Q beta and MS2, replication and concept of overlapping genes	6L

REFERENCE BOOKS:

1. An Introduction to Genetic Analysis – A.J.F. Griffiths, J. Doebley, C. Peichel, D.A. Wassarman (12th ed.) W.H. Freeman Publ. 2020.
2. *i*-Genetics : A molecular Approach – P.J. Russell. Pearson Publ. 2016.
3. Concepts of Genetics – W.S. Klug and M.R. Cummings (12th ed.) Pearson Publ. 2019.
4. Lewin's GENES XII – J.E. Krebs, E.S. Goldstein, S.T. Kilpatrick. Jones and Bartlett Publ. 2018.
5. Genetics – M.W. Strickberger (3rd ed.) Pearson India Publ. 2015
6. Genetics : The continuity of Life – D.J. Fairbanks and W.R. Andersen. Thomson Brooks / Cole Publ. 1999.
7. Principles of Genetics – E.J. Gardner, M.J. Simmons, D.P. Snustad (8th ed.) John Wiley & Sons 2006.
8. Genetics: Analysis of Genes and Genomes – D.L. Hartl and E.W. Jones (6th ed.) Jones & Bartlett Publ. 2004.
9. Developmental Biology – S.F. Gilbert (10th ed.) Sinauer Associates Inc. 2013.
10. Medical Genetics – L.B. Jorde, J.C. Carey, M.J. Bamshad (5th ed.) Elsevier 2015.
11. Genetics in Medicine (Thomson & Thomson) – R.L. Nussbaum, R.R. McInnes, H.F. Willard (8th ed.) Elsevier 2016.
12. Behavioral Genetics – V.S. Knopik, J.M. Neiderhiser, J.C. DeFries, R. Plomin (7th ed.) Worth Publ. 2016. An Introduction to Genetic Analysis – A.J.F. Griffiths, J. Doebley, C. Peichel, D.A. Wassarman (12th ed.) W.H. Freeman Publ. 2020.

Course Code and Course Name:

ZOUT 242: Mammalian Reproductive Physiology and Aquaculture

(4 Credits: 60 Lectures)

Semester IV

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

Mammalian Reproductive Physiology

CO1: Explain the male and female reproductive systems and sexual dimorphic characteristics

CO2: Explain the sexual cycles with examples

CO3: Illustrate the reproductive dysfunctions.

CO4: Diagrammatically represent the hormonal regulation of reproductive processes like pregnancy, lactation and parturition.

CO5: Prepare the flow chart to demonstrate the hormonal coordination of reproductive Processes

CO6: Justify the artificial control of reproduction.

Aquaculture

CO1: Identify the fish diseases and the causative organisms

CO2: Mention the various composite fish culture with significance of each type.

CO3: Describe the methods of freshwater prawn culture and its management.

CO4: Explain the methods of pearl culture and pearl harvesting.

CO5: Illustrate the preparation and management of fish culture ponds.

CO6: Demonstrate the methods of packaging and transport of fish and brood fish.

CO7: Illustrate techniques of fish harvesting, preservation & processing.

CO8: Compare the techniques used in fishery development.

Sr. No.	Name of the topic	Lectures allotted
	Mammalian Reproductive Physiology	
1.	Reproductive Systems: Anatomy of Male Reproductive System, Accessory organs and their function Spermatogenesis, Function of Sertoli cells, Blood Testisbarriers, inhibin, Leydig cell, Capacitation. Functions of Androgens.	05L

	Anatomy of Female Reproductive System.	
2.	Reproductive patterns: Environmental factors and breeding, continuous and seasonal breeders.	02L
3.	Sexual cycles: puberty, oestrous and menstrual cycles and its hormonal regulation. Ovarian cycle and its hormonal regulation. Cycling of non-pregnant uterus and vagina.	04L
4.	Hormonal regulation: GnRH, pituitary gonadotropins, behavioural effects, testicular hormones, testosterone derivatives, inhibin, ovarian hormones: Pituitary gonadal axis, Oestrogen, progesterone's feedback relationships Prostaglandins and their role in reproduction.	04L
5.	Fertilization, Gamete Transportation Pregnancy: conception and blastocyst formation, implantation and delayed implantation, hormonal regulation in pregnancy.	04L
6.	Placenta: formation, types and functions,	02L
7.	Parturition; birth process, Ferguson reflex, neuroendocrine control, purperium	02L
8.	Lactation: Anatomy and growth of mammary glands, Lactogenesis and galactopoiesis. Hormonal regulation and suckling reflex	02L
9.	Reproductive dysfunctions: Aging and reproduction. Climacteric, anatomical, endocrine and genetic disorders.	01L
10.	Artificial control of reproduction: increasing reproductive potential, artificial insemination, in vitro fertilization and embryo transfer, induced breeding, physical, physiological, surgical, chemical methods of contraception in male, female. Infertility: its causes and treatment, Recent advances in female contraception. Prenatal diagnostic test for genetic disorders-foetal ultra-sonography, Amniocentesis, Chorionic villi sampling,	04L
	Aquaculture	
1.	**Aquaculture concept and its scope** Nutritional value of fish	(1L)
2.	**Physicochemical parameter of water for fish culture** pH, Calcium, Total Alkalinity, Nitrate, Ammonia, Total hardness of fresh water	(3L)
3.	**Construction and management of fish culture pond:** Construction of ponds, management of ponds, Predatory and weed fishes and their control, Aquatic weeds and their control, Aquatic insects and their control, fish feeding: natural and artificial.	(3L)
4.	**Fish breeding: natural and induced.** Natural breeding in pond water, Induced breeding- Pituitary extract, selection of breeders, injection of pituitary extract, spawning, Advantages of induced breeding.	(2L)
5.	**Transport of fish seed and Brood fish**: causes of mortality in transport, methods for packaging and transport, open systems, closed systems, use of chemicals in live fish transport, anesthetic drugs, antiseptics & antibiotics.	(3L)
6.	**Fish culture:**Selection of cultivable fish, monoculture, composite culture, culture of Indian major carps, Culture of common carps, culture of cat fishes, paddy cum fish culture, mari culture, cage culture, integrated fish farming	(7L)
7.	**Fish preservation, processing and byproducts.** Fish preservation techniques, fish biproducts.	(2L)

8.	**Fish pathology:** bacterial, fungal, protozoan and worm diseases of fish.	(2L)
9.	**Fresh water prawn culture (*Macrobracium rosenbegii)*:** Seed procurement from natural resources, breeding and larval rearing of fresh water prawn, management of cultural ponds, harvesting and marketing.	(2L)
10.	**Pearl Culture:** Composition & quality of pearl, collection of oysters, rearing of oysters, insertion of nucleus, pearl formation, harvesting of pearls.	(2L)
11.	**Technologies in Fisheries development:** Geographic Information System (GIS) technology, Use of Information Communication Technology (lCT) in fishes: production aspects, marketing aspects.	(2L)

References:

Mammalian Reproductive Physiology

1. Austin C.R.and Short R.V.,Reproduction in mammals Books 1-5,Univ. of Cambridge
2. Hogarth P.H.biology of Reproduction,Blackie and Son, Glasgow, London.
3. Nalbandov,AV,Reproductive Physiology,Lea and Febiger ,Philadelphia
4. Turner and bagnara .General Endocrinology Sixth Edition, W.B. Saunders Company,

Aquaculture

1. Agustí, S. 1991. Light environment within dense algal populations: cell size influences on self-shading. Journal of Plankton Research, 13(4): 863–871.
2. Ahamad Ali, S. 1982. Relative efficiencies of pelletized feeds compounded with different animal proteins and the effect of protein level on the growth of the prawn Penaeus indicus. Proceedings of the Symposium on Coastal Aquaculture, Marine Biological Association of India, 1: 321–328.
3. Biswas, K. P. (2002), **A Text Book of Fish, Fisheries & Techonology**, Narendra Publishing House, Delhi.
4. Jain, K.K. 2003, Indused **breeding of carps by hypophysation.** In: Carp and Cat fish breeding & culture CIFE. PUBlication, Versova. Mumbai.
5. Jyoti, M. K. & Sharma, A. 2006. **Fishes, Aid to collection, preservation and identification** daya Publishing House, New Delhi.
6. Langur, R.K., 2002. **Management of carp rearing ponds**. 62-65. In: Carp and catfish breeding & culture. C.I.F.E.,Versova, Mumbai.
7. Mark, D.L. (1983) **Fish Diseases**. T.F.H. Publication Inc. New Jersey.
8. Sharma, B.D. and Sanjappa, M. 1993., **Flora of India**. Botanical Survey of India, Calcutta.1-639.
9. Sinha, V.R.P. 1999. **Rural Aquaculture in India**. RAP Publications, 21, Bankok, Thhailand.
10. Srivastava, C.B.L. 2005, **A textbook of Fisheries and Indian Fish**.
11. Tamot/P, Mishra,R, Somdutta (2008). Proceeding of taal, 2007 : In 12th Lake Conference : 318-324.

Course Code and Course Name:

ZODT 243: Histology and Histochemistry (2 Credits: 30 Lectures)

Semester IV

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

CO1: Explain the fundamental tissues in details.

CO2: Describe the process of histological preparations.

CO3: Illustrate the tools used in histological preparations.

CO4: Justify the use of various stains and dyes used in histochemical detection of biomolecules.
CO5: Justify the importance of Immunohistochemistry.

CO6: Draw the structures of various tissues and label them.

Sr. No.	Name of the topic	Lectures allotted
1.	Scope and importance of Histology and Histochemistry Fundamentals of histology: Epithelial, connective, muscular, nervous and other specialized tissues.	05L
2.	Tools in histology: Principles, design and functioning of microtomes, automated microtomes, ultra-microtome, cryostat, problems and troubleshooting.	04L
3.	Techniques in histology: General principles for the preparation of Tissue for Histological studies. Fixation – Principle, Aims and Objectives of fixatives. Chemical action of fixatives on cells and tissue components Processing of fixed samples, dehydration (procedure and significance), embedding, block making, Temporary and permanent preparations, whole mount preparation	05L
4.	Staining (staining methods histochemical and immunohistologial methods) dyes and dye binding reactive groups, mordants and mordanting	02L
5.	Fundamentals of histochemical techniques: Histochemical classification of Carbohydrates and Principle for the Identification of Carbohydrates- glycogen (Periodic acid/Shift method (PAS)	02L
6.	Histochemical localization of Mucopolysaccharides by KMNO4/AB and PAS method.	02L
7.	Histochemical classification of Proteins- Principles and mechanism for the identification of total Proteins and Glycoproteins (Bromophenol Blue & Congo red method). Importance of Enzyme histochemistry. -Localization of enzymes in tissues, Alkaline and Acid phosphates.	04L
8.	Histochemical localization of Nucleic Acids, DNA and RNA (Feulgen reaction &Pyroninmethod).	02L

9.	Application of Histochemical methods for the detection of various types of Carcinoma and Immunofloroscent techniques	02L
10.	Histochemical classification of Lipids. Principle for the demonstration of Lipids in various animal tissues (Copperpthyalocyanin method and Sudan Blank- B method)	02L

Reference books: -

1. Text book of Histology Roland lesson DL. WB Saunders Company, Tokyo.
2. Histology: Roland lesson and Thomas Leesan WB Saunders company Co., Canada
3. Histochemistry Vol. I II III A G E pearse Churchill Livingstone NY
4. Histochemistry in Focus,A source book of Technics and Research needs (2007), K.Shyamasundari and K.Hanmantha Rao,MJP Puplishers,Chennai.
5. An introduction to Functional Histology, Bourne, G.H. (1988), Churchil, London.
6. Histochemical Techniqes, Cassilmann,W.G.B (1988), Methuen, London

Course Code and Course Name:

ZODT 243: Pest Control **(2 Credits: 30 Lectures)**

Semester IV

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

CO1: Explain the Pest, nature of damage caused by pests and pest control.

CO2: Explain medical, veterinary, Household and stored grain pests.

CO3: Explain the Principles and methods of pest control including Biological control measures.

CO4: Explain the Integrated pest management (IPM)

CO5: Explain the Non- insect pest and their control: Rat, Bandicoots, Crabs, Snails, Slugs, Birds and Squirrels.

CO5: Explain the principle and working of pesticide appliances.

Sr. No.	Name of the topic	Lectures allotted
1.	Introduction of the pest control : Pest, pest control, types of pests and their importance and damage caused by pests.	**02L**
2.	Brief outline of medical and veterinary entomology with reference to important measures to control the vectors. Household and stored grain pest and their control measures.	**06L**
3.	Principles and methods of pest control: Cultural control measures, Physical control measures, Mechanical Control measures, Chemical control measures. Types and mode of action. Insecticidal formulations and dilutions. Drawbacks of chemical control.	**12L**

	Biological control measures: History, principles and scope of biological control. Biological agents: important groups of Parasitoids, predators and pathogens. Advantages and Drawbacks of Biological control, Biological Control Management.	
4.	Autocidal control : Chemosterilants and radiations for sterilization, Male sterile Theory, Hormones and Pheromones, Attractants and Repellants. Integrated pest management (IPM) : Principles and application	**06L**
5.	Non- insect pest and their control: Rat, Bandicoots, Crabs, Snails, Slugs, Birds and Squirrels.	**02L**
6.	Pesticide- Appliances: Sprayers and Dusters, Hazards of Pesticides and Antidotes.	**02L**

Reference Books

1. "Pest control- A Survey" By A. Woods. (McGraw-Hill, London, 1974).
2. Pest control" – By W. W. Kilgore and R. L. Doutt (Academic Press, New York, 1967).
3. Integrated Pest Management- By J. L. Apple and R. E. Smith, Plenum Publication Co., New Delhi.
4. An Introduction of Biological Control- By R.V.D. Boarscho, P. S. Y. Messenger and A. P. Gaiter, Plenum Publication Co.
5. Insect Pests and their Control- By Evans J.W., Asiatic Publ., New Delhi.
6. Applied Entomology, Vol- 1, 2nd Edition- By K.P. Srivastava, Kalyani Publishers, New Delhi.

Course Code and Course Name:

ZODP 243: Zoology Practical Paper- 4 (2 Credits: 60 Hours)

Semester IV

Note: A total of 15 practicals are to be conducted. 10 practicals from module I (Practicals corresponds to ZOUT 241) and 5 practicals from module II (Practicals corresponds to ZODT 243) are to be conducted. 1 practical is of 4 clock hour duration.

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

Animal Physiology- II

CO1: Determine the bleeding and clotting time of human blood.

CO2: Demonstrate the invertebrate heart.

CO3: Calculate the heartbeats of Daphnia/*Drosophila* larva.

CO4: Determine serum urea and protein and glucose in human blood and urine.

CO5: Justify the effects of various physical and chemical factors on frog heart and muscle.

Entomology- II

CO1: Identify the histological structure of male and female reproductive system of insect.

CO2: Identify the eggs of different insects.

CO3: Identify the different embryonic stages of insects.

CO4: Identify the different post-embryonic stages of insects.

CO5: demonstrate various body organs, systems and appendages of housefly and butterfly.

Histology and Histochemistry

CO1: Identify the various tissues with the help of permanent slides.

CO2: Demonstrate the effect of fixatives on tissues.

CO3: Detect the biomolecules with histochemical staining methods.

CO4: Sketch and label the microscopic details of tissues.

CO5: Prepare the permanent histological slides.

Pest Control

CO1 : Identify beneficial and harmful insects.

CO2 : Identify and classify insect pest of agricultural, veterinary and public health importance.

CO3 : Know the effects of contact insecticides and fumigants on behavior of insect pests.

CO4 : Determine the LD_{50}

CO5 : Behavior of insects to repellants and attractants.

CO6 : Know the principle and working of pesticide appliances.

CO7 : Identify and know the role of biological controlling agents.

CO8 : Know the non-insect pests.

Sr. No.	Name of the Practical	No. of Practicals
	Module- I : Practical Animal Physiology- II	
1.	Determination of bleeding time and clotting time in man **(Compulsory)**	1P
2.	Study of invertebrate (earthworm and crab) heart	1P
3.	Ionic effects on perfused heart of frog (with the help of ICT tool/ Charts/diagrams.)	1P
4.	Effect of adrenalin and acetylcholine on perfused heart of frog (with the help of ICT tool/ Charts/diagrams.) **(Compulsory)**	1P
5.	Osmotic stress and volume change in earthworm	1P
6.	Effect of temperature on water loss in cockroach **(Compulsory)**	1P
7.	Detection and measuring of heart beats (Manually) in Drosophila larva/Daphnia.	1P
8.	Detection of allantoin in mammalian urine **(Compulsory)**	1P
9.	Study of Glomerular filtration rate by creatinine clearance	1P
10.	Study of Types of heart (Myogenic and Neurogenic)	1P
11.	Estimation of SGOT/SGPT from blood sample (Source of blood**:** Local recognized pathology laboratory	1P
12.	Determination of protein, glucose in Urine. **(Compulsory)**	1P
13.	Determination of protein, glucose in Urine from diabetic patient. **(Compulsory)**	1P
14.	Qualitative Analysis: 1) Preparation and study of Urine crystals. 2)Estimation of serum urea. **(Compulsory)**	1P
15.	Normal & abnormal constituents of human urine **(Compulsory)**	1P
16.	Quantitative estimation of salt gain and salt loss by fresh water Crab.	1P
17.	Total RBC, WBC and Different WBC count- A comparative study of fish, goat and human. **(Compulsory)**	1P
18.	Estimation of blood Sodium, potassium, Calcium	1P
19.	Estimation of blood alkaline & acid phosphatases	1P
20.	Estimation serum uric acid **(Compulsory)**	1P
	Module- I : Practical Entomology- II	
1.	Histological studies of male reproductive system (Testes, Vas deference, Ejaculatory duct, Accessory gland and spermatogenesis). **(Compulsory)**	**(01P)**
2.	Histological studies of female reproductive system (Ovariole, lateral oviduct, common oviduct, Accessory glands, bursa copulatrix, spermatheca). **(Compulsory)**	**(01P)**
3.	Study of types of Eggs in insects. **(Compulsory)**	**(01P)**
4.	Early embryology of insect: cleavage, blastula, germ band, gastrula, embryo- 1 day old, 2 day old and 3 day old in suitable insect.	**(01P)**
5.	Study of post embryonic development of insects: Collection and study of types of Nymph, naiads, larvae and pupae. **(Compulsory)**	**(02P)**

6.	Dissection of House fly: The digestive system, Nervous system, Male and Female Reproductive System; Temporary mountings of antenna, halter, legs and ovipositor. **(Compulsory)**	**(03P)**
7.	Dissection of butterfly: The digestive system, Nervous system, Male and Female Reproductive System, Temporary mountings of antenna, scales and ovipositor. **(Compulsory- 2)**	**(03P)**
	Module- I : Practical Genetics- II	
1.	Methodology for constructing Human Pedigree.	**[1P]**
2.	Analysis and construction of typical pedigrees for autosomal dominant and recessive genes, sex linked dominant and recessive genes.	**[1P]**
3.	Preparation of metaphase chromosomal spreads from any vertebrate model system.	**[1P]**
4.	G banding and C banding on mouse metaphase spread	**[2P]**
5.	Study of courtship behavior in wild type and mutant *Drosophila*.	**[1P]**
6.	Study of maternal effect mutants : Bicoid and Nanos.	**[1P]**
7.	Preparation of metaphase chromosomal spread of 3rd instar larva of *Drosophila* (from brain Ganglion).	**[2P]**
8.	Measurement of olfaction activity in *Drosophila* larvae and Adult Fly [The olfaction trap assay for behavioural genetics and screening].	**[1P]**
9.	Measurement of Locomotory activity in *Drosophila* larvae and Adult Fly [flight escape assay for behavioural genetics and screening].	**[1P]**
10.	Larval mechanosensation assay in *Drosophila*.	**[1P]**
11.	Concept of genetic disorder databases and demonstration of use of OMIM.	**[1P]**
12.	Open field Activity test and Elevated plus maze test for anxiety levels in laboratory mice.	**[1P]**
	Module- II : Practical Histology and Histochemistry	
1.	Study of different types of tissue with help of permanent slides **(Compulsory)**	(2P)
2.	Preparation of different reagent/stains for histology **(Compulsory)**	(2P)
3.	Block preparation and sectioning **(Compulsory)**	(2P)
4.	Effect of fixatives, fixation of tissues	(1P)
5.	Comparative study of effect of fixative on a given tissue	(1P)
6.	Mucolpolysaccharide staining, AB pH 1.5, 2.5 **(Compulsory)**	(1P)
7.	Proteins and lipid staining by Sudan black **(Compulsory)**	(1P)
8.		
9.	Nucleic acid staining: methyl green, pyronine, feulgen stain **(Compulsory)**	(1P)
10.	Effect of fixatives on tissue sections- liver	(1P)
	Module- II : Practical Pest Control	
1.	Morphological and taxonomic study of insect pest of agricultural importance. (Any 10).	**(01)**
2.	Study of insect pests of veterinary and public health importance. **(Compulsory)**	**(01)**
3.	Study of Household and stored grain pests. **(Compulsory)**	**(01)**

4.	Study of effects of contact poison on pests: Chlorinated hydrocarbons, Organophosphates and Carbamate.	**(01)**
5.	Calculation of LD_{50} and effects on behavior. **(Compulsory)**	**(01)**
6.	Study of respiratory poisons (fumigants)- Carbon tetrachloride, ethylene dichloride and Nicotine. **(Compulsory)**	**(01)**
7.	Study of Pesticide appliances: Sprayers and Dusters.	**(01)**
8.	Study of Parasitoids, predators and pathogens in biological control.	**(01)**
9.	Study of Non- insect pests : Rat, Bandicoots, Crabs, Snails, Slugs, Birds and Squirrels.	**(01)**
10.	Study of insect attractants and repellants (any two). **(Compulsory)**	**(01)**

Course Code and Course Name:

ZODT 244: Pollution Biology **(2 Credits: 30 Lectures)**

Semester IV

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

CO1: Explain the organization of biosphere.

CO2: Explain in details the types of pollution.

CO3: Describe the pollution monitoring strategies.

CO4: Illustrate the bioassay methods.

CO5: Elucidate the methods to study the impact of pollutants.

CO6: Justify the importance of biomedical waste management.

Sr. No.	Name of the topic	Lectures allotted
1.	Biosphere: Introduction, hydrosphere, lithosphere, atmosphere. (2L)	2L
2.	Pollution: Types of pollution (Air, Water, Agricultural), pollutants and effect of pollution on health, on biosphere and on economy. Eutrophication: Definition, Limnology of lake, process of eutrophication (3L)	3L
3.	Noise pollution: Characteristics of sound, source, effects and control measures of noise pollution.	3L
4.	Pesticide pollution: Pesticides and their kinds, possible sources and pathways of pesticide Pollution. Impact of pesticides on living organisms	2L
5.	Radioactive pollution: Types, sources and effects, radioactivity assessments and control.	3L
6.	Bioassay: Purpose of bioassay, selection and test organisms, pollutant bioassay using fish	2L
7.	Pollution monitoring: strategies for water, soil, noise.	2L
8.	Histological, biochemical and physiological methods to study Impact of pollutants on animals.	3L

9.	Bioconcentration, Bioaccumulation and Biomagnifications of pollutants- Causes and Consequences.	3L
10.	Biological methods for assessment of environmental quality.	3L
11.	Biomedical waste – Handling and Management.	2L
12.	Environment protection act 1986	2L

References

1. Ecology, E.P. Odum, Amerind publ.
2. Environmental biology, P.D. Sharma, Rastogi Publ.
3. Environmental pollution, H.M. Dix, John Wiley Publ.
4. Pesticides in aquatic environment, M.A. Q. Khar, Plenum Press.
5. Environmental pollution and its control under international law, R.A. Malviya , Chay Publ.
6. Ecology, Ricklefs, freeman, W.H.
7. Limnology, Welch McGrew Hill Publ.
8. Practical Ecology – K.S. Rao, Ujjain (M.P) Anmol Publ. New Delhi (India)

Course Code and Course Name:

ZODT 244: Apiculture (2 Credits: 30 Lectures)

Semester IV

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

CO1: Explain the basic concepts of apiculture like systematics, colony organization, polymorphism, morphology and foraging.

CO2: Explain the tools and management of apiary.

CO3: Explain the importance of institutions pertinent to apiculture.

CO4: Discuss the setup of beekeeping business.

CO5: Illustrate the bee keeping as occupation.

CO6: Justify the presence of bees to increase the agriculture productivity.

Sr. No.	Name of the topic	Lectures allotted
1.	Biology of Bees : History, Classification and Biology of Honey Bees. Social Organization of Bee Colony.	05L
2.	Rearing of Bees : Introduction to apiculture practices and handling of Beehives. Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth Bee Pasturage Selection of Bee Species for Apiculture Bee Keeping Equipment Methods of Extraction of Honey (Indigenous and Modern)	11L
3.	Diseases and Enemies Bee Diseases and Enemies Control and Preventive measures, Hormones in Apiculture.	06L
4.	Bee Economy : Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis), Pollen etc.	03L

5.	Entrepreneurship in Apiculture Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens	05L

References:

1) Bees and Beekeeping D. P. Abrol ,Kalyani Publisher, New Delhi. 51
2) A Comprehensive guide to Bees and Beekeeping. D. P. Abrol. Scientific Publisher, New Delhi.
3) Honey bees and their management S. B. Withhead. Axis books Publisher, Jodhpur.
4) Honey bees: Diseases, Parasites, Pests, Predator and their management. N. Nagaraja and D. Rajagopal , M.J.P Publisher, Chennai.
5) A Handbook of Beekeeping Dharamsing and D. P. Singh (Agrobios India (Publisher), Jodhpur.
6) Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
7) Bisht D.S., Apiculture, ICAR Publication.
8) Singh S., Beekeeping in India, Indian council of Agricultural Research, NewDelhi.
9) Introduction to disease of bee –Bailey, L
10) World of honeybee –Butter C. G.
11) Beekeeping in India –Sardar Sing (ICAR).
12) The Principle of Insect Physiology-Wigglesworth, V.S.
13) Applied Zoology- B. B. Waykar, A. Y. Mahajan, B. C. More . (Prashant Publication Jalgaon)
14) D.K. Belsare Beekeeping for livelihood

Course Code and Course Name:

ZODP 244 : Zoology Practical Paper- 5 (*Practicals corresponding to ZOUT 242 and ZODT 244*)

(2 Credits: 60 Hours)

Semester IV

Note: A total of 15 practicals are to be conducted. 5 practicals from each module (**Module- I :** Practicals corresponding to ZOUT 242 MRP, **Module- II :** Practicals corresponding to ZOUT 242 Aquaculture and **Module- III :** Practicals corresponding to ZODT 244 Pollution Biology/ Apiculture) are to be conducted. 1 practical is of 4 clock hour duration.

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

Mammalian Reproductive Physiology

CO1: Identify the histological slides of reproductive organ/tissues.

CO2: Explain the various types of placenta in mammals.

CO3: Comment on merits and demerits of contraceptive devices/methods.

CO4: Illustrate the technique of gonadectomy.

CO5: Perform vaginal smear technique to identify the phases of oestrous cycle.

CO6: Distinguish the male and female anatomical features of reproductive system in mammals.

Aquaculture

CO1: Identify Indian oysters.

CO2: Identify the common freshwater fish used in culture farming.

CO3: Demonstrate the processing and storing methods for fish and prawn.

CO4: Test the freshness of fish/prawn by histological methods.

CO5: Test the freshness of fish/prawn by biochemical methods.

CO6: Prepare the culture of Daphnia and rotifers.

CO7: Estimate the productivity of water bodies.

Pollution Biology

CO1: Identify the bioindicators from given water sample.

CO2: Write a report on eutrophication of water body.

CO3: Determine the LC50 value for the given compound

CO4: Determine the biomass of given sample.

CO5: Analyze pH and salinity of given sample.

CO6: Estimate calcium and magnesium, sulphate from polluted water.

Apiculture

CO1: Identify the honey bees

CO2: explain the bee morphology and behaviour

CO3: Illustrate the bee enemies

CO4: Justify the rearing techniques and bee management

Sr. No.	Name of the Practical	No. of Practicals
	Module- I : Practical Mammalian Reproductive Physiology	
1.	Anatomy of male and female reproductive system in rat/Mouse **(Compulsory)**	1P
2.	Study of histological slides of male reproductive System-Testis, Vas deferens, Epididymis, Prostate, Seminal vesicle, Cowper's gland **(Compulsory)**	1P
3.	Study of histological slides of female reproductive System-Ovary, Uterus fallopian tube **(Compulsory)**	1P
4.	Vaginal smear technique in Rat	1P
5.	Study of placental types **(Compulsory)**	1P
6.	Study of Uterine smooth muscles	1P
7.	Study of contraceptive devices **(Compulsory)**	1P
8.	E-Demonstration of Orchiectomy or Vasectomy or Epididymoctomyin rat/ Mice	1P
9.	E-Demonstration of Ovariectomy in rat/Mice	1P
10.	Visit to artificial insemination Centre and family planning Centre.	1P
	Module- II : Practical Aquaculture	
1.	To Study Physico-chemical parameters of fresh water –pH, Turbidity, Calcium, Nitrate, Ammonia. **(Compulsory)**	1P
2.	Determination of total alkalinity and total hardness of fresh water.	1P
3.	Determination of dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) of fresh water. **(Compulsory)**	1P
4.	Study of conventional method for testing the soil of fresh water pond.	1P
5.	Study of control methods of aquatic weeds.	1P
6.	Study of induced breeding techniques by using pituitary extract.	1P
7.	Study of Indian major carps, prawns, and oysters. **(Compulsory)**	1P
8.	Study of fish disease (bacterial, fungal, protozoan), head and lateral line erosion and eye disease. **(Compulsory)**	1P
9.	Use of Geographic Information Technique (GIS) and Information and communication technology (ICT).	1P
10.	Visit to fish farm/ fish industry. **(Compulsory)**	1P
	Module- III : Practical Pollution Biology	
1.	Study of bio – indicators of pollution. **(Compulsory)**	1P
2.	Analysis of CO, CO_2, NO pollution level data in collaboration with district pollution dept. of Maharashtra state.	1P
3.	Study of Eutrophic ponds /lakes /river.	1P
4.	Visit to water filtration plant/Pollution. **(Compulsory)**	1P
5.	Analysis of pH and salinity from water /soil sample.	1P
6.	Determination of LC_{50} / LD_{50} for insecticide / pollution/molluscicide etc. **(Compulsory)**	1P
7.	Estimation of Biomass by:- i)Wet weight and ii) Dry weight.	1P
8.	Estimation of calcium and magnesium in polluted water. **(Compulsory)**	1P

9.	Soil analysis for calcium carbonate. **(Compulsory)**	1P
10.	Estimation of sulphate in polluted water.	1P
	Module- III : Practical Apiculture	
1.	Study of Honey bee species, Castes and Bee morphology. **(Compulsory)**	(3P)
2.	Study of Beekeeping equipment: Bee box and tools. **(Compulsory)**	(2P)
3.	Study of Bee products: Honey, Bees wax, Pollens, Royal Jelly, Propolis and Bee venom. **(Compulsory)**	(2P)
4.	Study of diseases and enemies of honeybee. **(Compulsory)**	(2P)
5.	Study of bee flora in the locality and observations on bee foraging Behaviour. **(Compulsory)**	(1P)
6.	A compulsory visit to an Apiary or Central Bee Research and Training Institute or a Beekeeper to gain a firsthand experience in handling bees.	(2P)