



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, cocurricular 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: Taxonomy & Systematics 1.1 Taxonomy: Basic terminology and Introduction <ul style="list-style-type: none">• 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	(05)

- 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 *Paramecium 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 anemone)
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 1.1 Concepts of Ecology, Environment, Population, Community, Ecosystem, Biosphere, Autecology and synecology.	(02)
2.	Ecosystem 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.	(08)
3	Population 3.1 Characteristic of population: Density, Natality, Mortality, Fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion. 3.2 Exponential and logistic growth, 3.3 Population regulation – density-dependent and independent factors. Population interactions, Gause's Principle with laboratory and field interactions, 3.4 Quadrant, line and belt transect methods.	(08)
4.	Community 4.1 Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Eco tone and edge effect; Ecological succession with one example.	(07)
5.	Animal interactions 5.1 Introduction to Animal interactions 5.2 Types of Animal interactions with at least to suitable examples of each 5.2.1-Competition: Interspecific and intraspecific	(05)

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 **quadrant 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.	<p>Phylum Aschelminthes</p> <p>1.1 Introduction to phylum Aschelminthes</p> <p>1.2 Salient features of Phylum Aschelminthes</p> <p>1.3 Classification of Phylum Aschelminthes (Class Nematoda only with two examples – <i>Ascaris lumbricoides</i> (common round worm), <i>Wuchereria bancrofti</i> (Elephantiasis)).</p> <p>1.4 Economic importance of class Nematoda.</p>	(04)
2.	<p>Phylum Annelida</p> <p>2.1 Introduction to Phylum Annelida</p> <p>2.2 Salient features of Phylum Annelida.</p> <p>2.3 Classification of Phylum Annelida up to classes with examples of following classes (names of examples only).</p> <p>Class Polychaeta (e.g: <i>Nereis pelagica</i> (<i>neries</i>/ sand worm, <i>Aphrodita aculeata</i> (=Aphrodite/ seamouse)</p> <p>Class Oligochaeta (e.g.: <i>Pheritima posthuma</i> (earthworm),</p> <p>Class Hirudinea (e.g: <i>Hirudinaria granulosa</i> common cattle leech)</p> <p>2.4 Economic importance of Annelida with reference to earthworms as friends of farmers and in their role in vermicomposting.</p>	(06)
3.	<p>Phylum Arthropoda</p> <p>3.1 Introduction to Phylum Arthropoda</p> <p>3.2 Salient features of Phylum Arthropoda</p> <p>3.3 Classification of Phylum Arthropoda with specific classes and mentioned examples (names only)</p> <p>Class:Crustacea:<i>Palaemon palaemon</i> (Prawn) <i>Brachyura</i> spp. crabs)</p> <p>Class: Chilopoda: <i>Scolopendra</i> sp. (centipede)</p> <p>Class: Diplopoda: <i>Julus</i> sp. (millipede)</p>	(06)

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: Cephalopoda:e.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: *Asterias rubens* (Sea Star):** Classification, Habit
Habitat, External Morphology, Digestive system, Water vascular
System and autotomy and regeneration

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

5.6 Economic importance of Echinodermata.

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)
- 4.1 Introduction
- 4.2 Structure of plasma membrane: Fluid mosaic model.
- 4.3 Transport 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)
- 5.1 Introduction 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 and Brusca, G. J (2003): Invertebrate (2nd 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 (7th 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 Edition John Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. 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.