

# **NEHRU GRAM BHARATI VISHWAVIDYALAYA**

**KOTWA- JAMUNIPUR- DUBAWAL  
ALLAHABAD (UTTAR PRADESH)**



## **SYLLABUS**

*For the*

**M.Sc. – ZOOLOGY**

**(A Four Semester Course)**

*Based on*

*Choice Based Credit System (CBCS)*

## **M.Sc. – ZOOLOGY (*Choice Based Credit System (CBCS)*)**

The syllabus for M. Sc. Zoology based on semester with credit based pattern comprises of four semesters. The examination shall be of 15 (Fifteen) theory papers and one Dissertation each of 100 marks. The papers in all semesters are equivalent to 3 credits except first paper of semester IV which is equivalent to 2 credits, hence total credits of 15 theory papers are 44 ( $14 \times 3 = 42 + 2 = 44$ ). There shall be six practical and one dissertation/project work. The 100 marks have been allotted to practical in all semester practical and also 100 marks to dissertation work. In the semester III and IV there are two practical exam and each has 50 marks (Practical examination I + Practical examination II =  $50 + 50 = 100$ ). The Practical examination -I will be based on general papers (paper 1 and 2) while Practical examination II will be based on elective papers (paper 3 + 4 in III semester and paper 2 and 3 in IV semester). The practical examination will be conducted by external examiner separately for elective paper. The total credit of practical and dissertation will be 28 ( $3 \times 6 = 18 + 4 + 6$ ). In the each semester there is one seminar. The Examination in each theory paper shall be of three hours duration except the first paper of the fourth semester having two hours and that of each practical shall be of 6 hours. The seminar shall be conducted during the First, Second and Third semester. At the end of Fourth semester candidate has to submit a Dissertation work/ Project work. The dissertation work will be based on elective papers. The evaluation of the dissertation work/Project work will be based on open house power point presentation. The structure of syllabus for M. Sc. Zoology (Semester with credit based pattern) is given in the following table.

## M.Sc. – Zoology CBCS pattern

M.Sc. – Zoology (Semester I)							
Paper No.	Code	Paper Title	Credit	Lectures	Marks		
					IA	End Semester Exam	Total Marks
<b>Paper I</b>	ZOO501	Non Chordata	3	54	20	80	100
<b>Paper II</b>	ZOO502	Evolution & Animal distribution	3	54	20	80	100
<b>Paper III</b>	ZOO503	Biological tools and Techniques, Microscopy	3	54	20	80	100
<b>Paper IV</b>	ZOO504	Biochemistry and Cytology	3	54	20	80	100
<b>Practical</b>	ZOO531+ ZOO532	<b>Paper (I &amp; II)+Paper (III+IV)</b>	6		20	80	100
		<b>Total</b>	<b>18</b>				<b>500</b>
M.Sc. – Zoology (Semester II)							
Paper No.	Code	Paper Title	Credit	Lectures	Marks		
					IA	End Semester Exam	Total Marks
<b>Paper I</b>	ZOO505	Chordata	3	54	20	80	100
<b>Paper II</b>	ZOO506	Mammalian Physiology & Vertebrate Endocrinology	3	54	20	80	100
<b>Paper III</b>	ZOO507	Developmental Biology & Animal Behaviour	3	54	20	80	100
<b>Paper IV</b>	ZOO508	Ecology & Biostatistics	3	54	20	80	100
<b>Practical</b>	ZOO533+ ZOO534	<b>Paper (I &amp; II)+Paper (III+IV)</b>	6		20	80	100
<b>Total</b>			<b>18</b>				<b>500</b>
M.Sc. – Zoology (Semester III)							
Paper No.	Code	Paper Title	Credit	Lectures	Marks		
					IA	End Semester Exam	Total Marks
<b>Paper I</b>	ZOO509	Biotechnology and Immunology	3	54	20	80	100
<b>Paper II</b>	ZOO510	Molecular Biology and Cytogenetics	3	54	20	80	100
<b>Paper III</b>	ZOO511	Elective Paper – I <i>Environmental Biology/Cell Biology/ Fishery Science</i>	3	54	20	80	100
<b>Paper IV</b>	ZOO512	Elective Paper – II <i>Environmental Biology/ Cell Biology/ Fishery Science</i>	3	54	20	80	100
<b>Practical</b>	ZOO535+ ZOO536	<b>General paper (I &amp; II)+Elective Paper (I&amp; II)</b>	6		20	80	100
<b>Total</b>			<b>18</b>				<b>500</b>

<b>M.Sc. – Zoology (Semester IV)</b>							
<b>Paper No.</b>	<b>Code</b>	<b>Paper Title</b>	<b>Credit</b>	<b>Lectures</b>	<b>Marks</b>		<b>Total Marks</b>
					<b>IA</b>	<b>End Semester Exam</b>	
<b>Paper I</b>	ZOO513	Skill Development	2	36	20	80	100
<b>Paper II</b>	ZOO514	Elective Paper – III Environmental Biology/ Cell Biology/ Fishery Science	3	54	20	80	100
<b>Paper III</b>	ZOO515	Elective Paper – IV Environmental Biology/ Cell Biology/ Fishery Science	3	54	20	80	100
<b>Paper IV</b>	ZOO516	Dissertation /Project	6	54	20	80	100
<b>Practical</b>	ZOO537+ ZOO538	<b>General paper (I)+Elective Paper (III+IV)</b>	4		20	80	100
<b>Total</b>			<b>18</b>				<b>500</b>
<b>Grand Total</b>		<b>Credits: Semester (I +II+III+IV)</b>	<b>18+18+18+18=72</b>				
		<b>Marks :</b>	<b>500+500+500+500=2000</b>				

## Pattern of theory papers & allocation of marks (Seats - 30)

**M.Sc. - SEM I to SEM IV (Four papers)**

### **1. THEORY:**

**Total Marks: 100/Paper: Internal Assessment (20 Marks) + End Semester Exam (80 Marks)**

**Internal Assessment (EA):**

Cumulative test (CT) – Sessional	10 Marks
Assignment	10 Marks
<b>Total</b>	<b>20</b>

**End-Semester Exam (ESE) – 80 Marks**

- Divided into 3 parts, **Total no. of questions – 9**
- **Part 1:** Question 1(Compulsory) – **20 marks** (10 Objective / Very short answer ques)
- **Part 2:** Section A – **Five Questions from Unit 1, 2 & 3** (Question 2 - 6)  
(Students have to **attempt any three**), Each question Carries **12 Marks**  
(**Contains Short answer as well as long answer questions**)
- **Part 3:** Section B - **Three Questions from Unit 4 & 5** (Question 7 - 9)  
(Students have to **attempt any two**), Each question Carries **12 Marks**  
(**Contains Short answer as well as long answer questions**)

### **2. PRACTICAL:**

The practical mark in each semester is 100. Twenty marks will be given internally while 80 marks will be given external by external examiner.

**a. M.Sc. - SEM I (ZOO531+ZOO 532)**

- **Total Marks** -100  
Practical (Based on Paper I & II) + Practical (Based on III & IV): 100 Marks

**b. M.Sc. - SEM II (ZOO533+ZOO534)**

- **Total Marks** - 100  
Practical (Based on Paper I & II) + Practical (Based on III & IV): 100 Marks

**b. M.Sc. - SEM III (ZOO535+ZOO536)**

- **Total Marks** - 100  
General Practical (Paper I & II) + Elective Practical (I & II): 100 Marks

**c. M.Sc. - SEM IV (ZOO537+ZOO538)**

- **Total Marks** - 100  
General Practical (Paper I) + Elective Practical (III& IV): 100 Marks

### **3. DISSERTATION/PROJECT: (ZOO516)**

#### **M.Sc. – SEMESTER IV**

➤ **Total Marks** - **100**

- A. Topic will be based on Major elective paper opted by the students. Dissertation/Project will be based on practical in nature include laboratory based work.
- B. Dissertation/Project work would be assigned at the end of Semester II to enable students to initiate work on the same.
- C. Dissertation/Project report will be submitted and presented via open house power point presentation in presence of external examiner.

#### **NOTE:**

1. Minimum marks for passing the examination in each semester shall be 36% in each paper and 40% in aggregate of a semester. The minimum overall credit is 2.5 for the promotion to the candidate in the next semester.
2. If a candidate fails to obtained minimum credit i.e. 2.5, he/she will be consider as back paper examination. The back paper exam will be held with junior batch of the same semester.
3. A candidate can be allowed 2 times back paper exam only in all the papers.
4. If candidate fails to clear his/her semester after 2 attempt of back paper, his/her earlier registration will be cancelled and the candidate will only be allowed for examination after re-registration.

**M.Sc. – Semester I**  
**Zoology (FIRST PAPER)**  
**ZOO501: Non-Chordates**

*Non-Chordates*

<b>Unit-1</b> (Credit – 0.5)	<b>9 Lectures</b>		
<b>1. Protozoa</b>			
1.1 Locomotory organs			
1.2 Nucleus and reproduction			
<b>2. Porifera</b>			
2.1 Canal system			
2.2 Skeletal system			
<b>Unit-2</b> (Credit - 0.5)	<b>9 Lectures</b>		
<b>3. Cnidaria</b>			
3.1 Nematocysts			
3.2 Polymorphism			
3.3 Metagenesis in <i>Obelia</i>			
3.4 Coral reef			
<b>4. Helminths (Platyhelminthes, Aschelminthes):</b> Parasitic adaptation & host-parasite relationship			
<b>Unit-3</b> (Credit – 1.0)	<b>18 Lectures</b>		
<b>5. Annelida</b>			
5.1 Coelom			
5.2 Trochophore larva: structure and significance			
5.3 Metamerism			
<b>6. Mollusca</b>			
6.1 Nervous system in Cephalopoda			
6.2 Modifications of foot			
6.3 Sense organs			
<b>Unit-4</b> (Credit – 0.75)	<b>12 Lectures</b>		
<b>7. Arthropoda</b>			
7.1 Respiratory organs			
7.2 Crustacean larvae and their significance			
7.3 Insect mouth parts and mode of feeding			
7.4 Hormonal regulation of metamorphosis in insects			
<b>8. Echinodermata:</b> larval forms and their significance			
<b>Unit-5</b> (Credit - 0.25)	<b>6 Lectures</b>		
<b>9. Salient features and affinities of following minor phyla</b>			
9.1. Mesozoa	9.2 Ctenophora	9.3 Rotifera	9.4 Phoronida

***BOOKS RECOMMENDED***

1. Barnes: Invertebrate Zoology (4th ed 1980, Holt-Saunders International)
2. Barnes: The Invertebrates – A synthesis (3rd ed 2001, Blackwell)
3. Marshall: Parker & Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
4. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
5. Nigam: Zoology of Non Chordate (2007, Vishal Publication)
6. Kotpal: A text book of Invertebrate (2009, Rastogi Publication)

**M.Sc. – Semester I**  
**Zoology (SECOND PAPER)**  
**ZOO502: Evolution & Animal distribution**

*Section A: Evolution*

- Unit-1** (Credit - 0.25) **5 Lectures**
- 1. The geological time scale of Evolution**
  - 2. Origin and early history of life**
    - 2.1 Theories about the origin of life
    - 2.2 Theories of evolution: Lamarckism, Darwinism and Modern Synthetic theories
- Unit-2** (Credit – 0.75) **12 Lectures**
- 3. Population as unit of evolution**
    - 3.1 Gene frequencies in Mendelian population
    - 3.2 Hardy-Weinberg Equilibrium
    - 3.3 Major evolutionary forces: Mutation, Selection, Random genetic drift, Migration
    - 3.4 Adaptive radiation: Major features
- Unit-3** (Credit – 1.25) **22 Lectures**
- 4. Species**
    - 4.1 Concepts of species
    - 4.2 Modes of speciation
    - 4.3 Isolating mechanisms
  - 5. Molecular Evolution**
    - 5.1 Evolution of Protein & Nucleic acid
    - 5.2 Molecular clock
    - 5.3 Molecular phylogeny

*Section B: Animal distribution*

- Unit-4** (Credit - 0.5) **10 Lectures**
- 1. Geological and geographical distribution of animals**
  - 2. Continental drift**
  - 3. Zoo-geographical regions**
    - 3.1 Distribution
    - 3.2 Faunal characteristics with reference to mammals
    - 3.3 Geographical lines
- Unit-5** (Credit – 0.25) **5 Lectures**
- 4. Barriers influence animal distribution**
  - 5. Pattern of distribution**
  - 6. Paleozoology: Animal fossils: Nature, age & importance**

***BOOKS RECOMMENDED***

1. Freeman and Herron: Evolutionary Analysis (1998, Prentice Hall)
2. Futuyma: Evolutionary Biology (1998, Sinauer)
3. Hartl and Clarke: Principles of Population Genetics (1989 & 1997, Sinauer)
4. Mayr: Populations, Species & Evolution: An Abridgement of Animal Species & Evolution (1971, Belknap Press)
5. Moody: Introduction to Evolution. (1978, Kalyani Pub)
6. Ridley: Evolution. (1993, Blackwell)
7. Savage: Evolution. (1963, Holt, Rinehart and Winston)
8. Stebbins: Processes of Organic Evolution. (1979, Prentice- Hall of India)
9. Strickberger: Evolution. (2000, Jones and Bartlett)
10. Colbert: Introduction to vertebrate evolution (2001, Wiley eastern private ltd.)
11. Arora: Organic Evolution (2010, Himalaya publishing house)

**M.Sc. – Semester I**  
**Zoology (THIRD PAPER)**  
**ZOO503: Biological tools and Techniques, Microscopy**

**Section A: Biological tools and Techniques**

**Unit-1** (Credit – 0.75) **12 Lectures**

**1. Centrifugation**

- 1.1 Basic principles
- 1.2 Types of rotors
- 1.3 Ultracentrifuge

**2. Spectrophotometry**

- 2.1 Types of spectrophotometer
- 2.2 Beer-Lambert's law, molar extinction coefficient
- 2.3 Absorption spectrum
- 2.4 Principles of UV- Vis spectrophotometry

**Unit-2** (Credit – 1.0) **18 Lectures**

**3. Electrophoresis**

- 3.1 Principles
- 3.2 Agarose- and polyacrylamide gel
- 3.3 Isoelectrofocussing
- 3.4 Two-dimensional gel electrophoresis

**4. Chromatography**

- 4.1 Principles
- 4.2 Paper and thin layer chromatography
- 4.3 Column chromatography: Gel filtration, Ion exchange & Affinity
- 4.4 Introduction to HPLC

**Unit-3** (Credit – 0.25) **6 Lectures**

**5. Radio-tracer techniques**

- 5.1 Introduction: Kinds & Applications of radioisotopes
- 5.2 Safety measures

**6. Principles of Autoradiography, liquid & solid scintillation counter**

**Unit-4** (Credit - 0.25) **6 Lectures**

**7. Microtomy**

- 7.1 Paraffin
- 7.2 Freezing

**8. Estimation of proteins**

- 8.1 Western blotting
- 8.2 ELISA, RIA

**9. Principles of cryopreservation**

**Section B: Microscopy**

**Unit-5** (Credit – 0.75) **12 Lectures**

**1. Principles of microscopy**

**2. Types of microscopes and their biological applications**

- 2.1 Light microscope: numerical aperture, limit of resolution, types of objectives, ocular and stage micrometers
- 2.2 Phase-contrast microscope, Fluorescence microscope, Confocal microscope
- 2.5 Transmission and scanning electron microscopes (TEM & SEM)

**BOOKS RECOMMENDED**

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
2. Freifelder: Physical Biochemistry ( 2nd ed 1982, Freeman)
3. Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques (6th ed 2006, Cambridge Univ Press)
4. Karp: Cell and Molecular Biology (2007, Wiley)
5. Lodish et al: Molecular Cell Biology (2007, Freeman)
6. Rana: Bio-techniques: Theory & Practice (2007, Rastogi publications)

**M.Sc. – Semester I**  
**Zoology (FOURTH PAPER)**  
**ZOO504: Biochemistry and Cytology**

**Section A: Biochemistry**

**Unit-1** (Credit – 1.0) **17 Lectures**

**1. Carbohydrates**

- 1.1 Chemistry
- 1.2 Metabolism: Glycolysis, Krebs's Cycle, Oxidative phosphorylation, Glycogen metabolism
- 1.3 Peptidoglycan

**2. Protein structure**

- 2.1 Amino acid: Chemistry & properties
- 2.2 Primary, Secondary, Tertiary & Quaternary structure
- 2.3 Forces stabilizing tertiary structure, Ramachandran plot, Domains and motifs

**Unit-2** (Credit – 0.5) **8 Lectures**

**3. Enzymes**

- 3.1 Enzyme kinetics: Lowering of activation energy, Derivation of Michaelis-Menten equation, Michaelis-Menten and Lineweaver-Burk plots
- 3.2 Mechanism of action
- 3.3 Inhibition: types & mechanism
- 3.4 Allosteric enzymes, isoenzymes & ribozymes

**4. Vitamins & Coenzyme: Structure & Function**

**Unit-3** (Credit - 0.25) **5 Lectures**

**5. Lipids: Chemistry, metabolism of fatty acid, cholesterol**

**6. Bioenergetics**

- 6.1 Thermodynamics laws and their applications
- 6.2 High energy containing compounds

**7. Buffers**

- 7.1 pH and its determination,
- 7.2 Preparation and Capacity of buffers, Bio-buffers

**Section B: Cytology**

**Unit-4** (Credit – 1.0) **18 Lectures**

**1. Cell Membrane**

- 1.1 Lipid bi-layer and membrane proteins
- 1.2 Transport across the cell membrane, Channels and transporters
- 1.3 Passive transport: Diffusion, facilitated diffusion & osmosis, Active transport

**2. Proteins targeting and sorting**

- 2.1 Signal peptide and SRP dependent targeting of translational complex
- 2.2 Processing of proteins in RER
- 2.3 Targeting to plasma membrane and lysosome
- 2.4 Targeting of nuclear and mitochondrial proteins

**Unit-5** (Credit – 0.25) **6 Lectures**

**3. ATP production in Mitochondria**

- 3.1 Structure: assemblies of respiratory chain and Fo- F<sub>1</sub> ATPase
- 3.2 Oxidative phosphorylation: mechanism and chemiosmotic concept

**4. Cell signaling**

**5. Apoptosis: mechanism and significance**

**BOOKS RECOMMENDED**

1. Berg et al: Biochemistry (5<sup>th</sup> ed 2001, Freeman)
2. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2004, Pearson)
3. Harper's Review of Biochemistry (22<sup>nd</sup> ed 1991, Lange Medical Books)
4. Stryer L.: Biochemistry (5<sup>th</sup> ed 2002, Freeman)
5. Rawn: Biochemistry (2<sup>nd</sup> ed 1989, Neil Patterson)
6. DeRobertes & DeRobertes: Cell & Molecular Biology (1987, Lee & Febiger)
7. Karp: Cell & Molecular Cell Biology (2002, John Wiley & Sons)
8. Gupta P K: Cytology (2009, Global media publications)

**M.Sc. – Semester I**  
**Zoology**  
**ZOO531+ZOO532: PRACTICAL EXAM**

**Total marks: 100 (Internal assessment: 20 marks + External: 80 marks)**

**Internal Assessment: 20 marks (Based in internal practical assessment in practical class)**

**External Practical Examination**

Sl. No.	Content	Marks
1	Non Chordata (Display)/Models	15
2	Non Chordata (Permanent slide preparation)	5
3	Chromatography	10
4	Microtomy	5
5	Biochemistry	10
6	Cytology	5
7	Spotting (1-10)	10
8	Viva voce	5
9	Class record & Attendance	10
10	Seminar	5
	<b>Total</b>	<b>80</b>

**Non Chordata**

**1. Preparation of permanent slides**

- Porifera: Gemmules, spicules
- Arthropoda: *Cyclops*, Megalopa/Zoea
- Mollusca: glochidium larva, osphradium, radula, *Pila* gills, *Unio* gills

**2. Display/Models**

- Arthropoda: Nervous system of *Squilla*
- Mollusca: nervous system of *Loligo*, *Sepia* & *Aplysia*

**3. Spotting**

- Study of museum specimens
- Study of prepared slides

**Biological tools & Techniques**

- Preparation of buffer and measurement of pH using pH meter
- **Chromatography:** Separation of amino acids by paper chromatography & Rf value calculation.

- **Microtomy:** Fixation of animal tissue. Paraffin block preparation, section cutting, stretching, staining, mounting

### Microscopy

- Study of different components of student's microscope and its assembly
- Measurement of microscopic object using ocular and stage micrometers

### Biochemistry

- Preparation of extract for enzyme assay (Urease & alkaline phosphatase)
- Study of alkaline phosphatase activity
  - a. Standard curve preparation
  - b. Effect of enzyme concentration and determination of total and specific activity
  - c. Effect of pH on enzyme activity
  - d. Effect of temperature on enzyme activity
  - e. Effect of time on enzyme activity
  - f. Effect of substrate concentration on enzyme activity
  - g. Determination of  $K_m$  and  $V_{max}$  by Michaelis-Menten and Lineweaver-Burk Plot

### Cytology

- Preparation of mitochondria and barr body
- Study of different stages of cell cycle

### List of museum specimens & slides

#### 1. Museum Specimens:

<b>Porifera</b>	:	<i>Leucosolenia, Sycon, Grantia, Ciona, Spongilla, Euspongia</i>
<b>Cnidaria</b>	:	<i>Physalia, Millipora, Aurelia, Rhizostoma, Alcyonium, Tubipora, Gorgonia, Pteroids, Adamsia, Madrepora, Fungia</i>
<b>Platyhelminthes</b>	:	<i>Planaria, Fasciola, Taenia solium</i>
<b>Aschelminthes</b>	:	<i>Ascaris (Male &amp; Female)</i>
<b>Annelida</b>	:	<i>Nereis, Heteroneries, Aphrodite, Chaetopterus, Pontobdella</i>
<b>Mollusca</b>	:	<i>Chiton, Dentalium, Patella, Aplysia, Doris, Pecten, Pinctada, Teredo, Loligo, Sepia, Octopus, Nautilus</i>
<b>Arthropoda</b>	:	<i>Lepus, Balanus, Sacculina, Mysis, Eupagurus, Limulus, Julus, Scolopendra, Lepisma</i>
<b>Echinodermata</b>	:	<i>Astropecten, Clypeaster, Holothuria, Antidon</i>

#### 2. Permanent Slides:

<b>Protozoa</b>	:	<i>Euglina, Paramecium</i> W.M. Binary Fission, Conjugation in <i>Paramecium, Monocystis, Plasmodium, Opalina, Balantidium, Entamoeba, Leishmania</i>
<b>Porifera</b>	:	Spongins fibres, gemmule, spicules, L.S. & T.S. of <i>Sycon</i>
<b>Cnidaria</b>	:	T.S. of Hydra through gonads, <i>Obelia</i> W.M., <i>Obelia</i> medusae, Ephydra Larva
<b>Helminthes</b>	:	Gravid proglottid of <i>Taenia</i> , Miracidium, Redia, Cercaria, Metacercaria, Cysticercus larva.
<b>Annelida</b>	:	T.S. <i>Nereis</i> , parapodium of nereis and heteroneries, trochophore larva,
<b>Arthropoda</b>	:	Megalopa, Mysis, Zoea, Nauplius, Daphnia, Cyclopes, Mouthparts of male and female, <i>Culex</i> and <i>Anopheles</i> , Pediculus W.M., <i>Cimex</i> W.M.
<b>Echinodermata</b>	:	T.S. of arm of starfish, pedicellaria, bipinnaria larva.
<b>Hemichordata</b>	:	T.S. of <i>Balanoglossus</i> through anterior and branchiogenital regions.

***BOOKS RECOMMENDED***

- Robert William Hegner: Practical Zoology (1922, The Macmillon company)
- P.S. Verma: Invertebrate Practical (2012, S. Chand & Co.)
- S.S. Lal: Invertebrate Practical (2009, Rastogi publications)
- Verma P.S., P.C. Srivastava: Practical Zoology (2012, S. Chand & Co.)

# M.Sc. – Semester II

## Zoology (FIRST PAPER)

### ZOO505: Chordata

#### *Chordata*

<b>Unit-1</b> (Credit – 0.75)	<b>12 Lectures</b>
<b>1. Origin of Chordata</b>	
<b>2. Characteristic features and affinities of the following lower chordates</b>	
2.1 Hemichordata	
2.2 Protochordata	
a. Urochordata	
b. Cephalochordata	
2.3 Cyclostomes	
<b>Unit-2</b> (Credit – 0.75)	<b>12 Lectures</b>
<b>3. Origin of Gnathostomes</b>	
<b>4. Pisces</b>	
4.1 Peculiar features of Lung fishes (Dipnoi)	
4.2 Lateral line system	
4.3 Electric organs	
<b>5. Amphibia:</b> Origin & evolution of Tetrapodes	
<b>Unit-3</b> (Credit -0. 25)	<b>6 Lectures</b>
<b>6. Reptile</b>	
6.1 Origin of reptiles	
6.2 Skulls in reptiles	
6.3 Mesozoic reptiles	
<b>Unit-4</b> (Credit – 0.25)	<b>6 Lectures</b>
<b>7. Aves</b>	
7.1 Origin of birds	
7.2 Flightless birds	
7.3 Modification of beak, feet and palate in birds	
<b>Unit-5</b> (Credit – 1.0)	<b>18 Lectures</b>
<b>8. Mammal</b>	
8.1 Origin of mammals	
8.2 Characteristic features of monotremes, marsupials & placentals	
8.3 Adaptive radiation in placentals	
8.4 Hominid evolution: anatomical, geographical and cultural	

#### ***BOOKS RECOMMENDED***

1. Prasad & Kashyap: A Textbook of Vertebrate Zoology (14<sup>th</sup> ed 2011, New Age publication)
2. Harvey et al: The Vertebrate Life (2006)
3. Colbert et al: Colbert's Evolution of the Vertebrates (5th ed 2002, Wiley - Liss)
4. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
5. Jordan and Verma: Chordate Zoology (1998, S. Chand)
6. Kotpal: The Birds (4th ed 1999, Rastogi Publications)
7. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
8. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
9. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
10. Sinha, Adhikari and Ganguli: Biology of Animals, Vol. II (1988, New Central Book Agency)
11. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)

**M.Sc. – Semester II**  
**Zoology (SECOND PAPER)**  
**ZOO506: Mammalian Physiology & Vertebrate Endocrinology**

**Section A: Mammalian Physiology**

**Unit-1** (Credit – 0.75) **12 Lectures**

**1. Homeostasis**

**2. Digestion and nutrition**

2.1 Digestion and absorption of macronutrients and their regulation

2.2 Basal metabolic rate and its measurement

2.3 Obesity and starvation

**3. Circulation**

3.1 Types

3.2 Blood: Composition & function, Haemopoiesis

3.3 Lymph: composition and dynamics

3.4 Heart: Origin and conduction of cardiac impulse, ECG and cardiac cycle

**Unit-2** (Credit – 0.5) **10 Lectures**

**4. Respiration**

4.1 Mechanism & regulation of breathing

4.2 Haemoglobin, Transport of gases & Gaseous exchange

4.3 Hypoxia and oxygen therapy

**5. Excretion**

5.1 Structure of metanephric kidney

5.2 Urine formation and regulation

5.3 Renal function tests

**Unit-3** (Credit – 0.25) **5 Lectures**

**6. Muscle**

6.1 Muscle proteins

6.2 Mechanism of contraction

6.3 Muscular dystrophy

**7. Nerve conduction & neurotransmitters**

**Section B: Vertebrate Endocrinology**

**Unit-4** (Credit – 1.0) **17 Lectures**

**1. Hypothalamo-hypophysial system**

1.1 Hypothalamus & neurosecretion

1.2 Pituitary gland: Structure, cell types & hormones

**2. Pineal organ: structure and function**

**3. Thyroid gland**

3.1 Role in metamorphosis of amphibian

3.2 Biosynthesis of thyroxin

**4. Adrenal gland**

4.1 Structure

4.2 Role of Cortical hormones & Catecholamine

**Unit-5** (Credit - 0.5) **10 Lectures**

**5. Gonads**

5.1 Structure of testis and ovary

5.2 Steroid hormones and their functions

**6. Mechanism of hormone action**

6.1 Protein hormones: G-proteins, Cyclic AMP signaling cascade, PKC signaling pathway

6.2 Steroid hormones

**7. Gastrointestinal hormones: secretin, gastrin and cholecystinin**

### ***BOOKS RECOMMENDED***

1. Eckert and Randell: Animal Physiology: Mechanisms & Adaptations (2<sup>nd</sup> ed 2005, CBS Publishers)
2. Berry: Textbook of Animal Physiology (11<sup>th</sup> ed 2008, Emkay Publications)
3. Ganong: Review of Medical Physiology (22<sup>nd</sup> ed 2005, Lang Medical Publications)
4. Guyton and Hall: Text Book of Medical Physiology (11<sup>th</sup> ed 2006, W.B. Saunders)
5. Srivastava, Agrawal and Kumar: Animal Physiology (2011, S.Chand & co. Ltd.)
6. Chaudhuri: Concise Medical Physiology (2<sup>nd</sup> ed 1993, New Central Book Agency Ltd.)
7. Wright: Applied physiology (7<sup>th</sup> ed 1943, Oxford University Press, H. Milford)
8. Bentley: Comparative Vertebrate Endocrinology (1998, Cambridge University Press)
9. Gorbman et al: Comparative Endocrinology (1983, John Wiley & Sons)
10. Norris: Vertebrate Endocrinology (4<sup>th</sup> ed 2007, Elsevier)
11. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
12. Turner and Bagnara: General Endocrinology (1984, Saunders)
13. Larson: Williams Textbook of Endocrinology (10<sup>th</sup> ed 2002, Saunders)

**M.Sc. – Semester II**  
**Zoology (THIRD PAPER)**  
**ZOO507: Developmental Biology & Animal Behaviour**

**Section A: Developmental Biology**

- Unit-1** (Credit - 0.5) **9 Lectures**
- 1. Introduction and basic concepts**
    - 1.1 The origin of developmental biology- cell theory
    - 1.2 Mosaic and regulative development
    - 1.3 Role of nucleus, cytoplasm & yolk
  - 2. Fertilization in mammals**
    - 2.1 Gametogenesis
    - 2.2 Acrosomal reaction
    - 2.3 Prevention of polyspermy and gamete fusion
    - 2.4 Parthenogenesis
- Unit-2** (Credit – 1.25) **20 Lectures**
- 3. Embryonic development**
    - 3.1 Egg type, ooplasmic segregation
    - 3.2 Cleavage: patterns
    - 3.3 Blastulation in amphibians
    - 3.4 Gastrulation
      - a. Fate maps
      - b. Morphogenetic cell movements and formation of germ layers in sea urchin, amphibians and birds
    - 3.5 Embryonic Induction
      - a. Primary & secondary inducer
      - b. Competence, Differentiation
      - c. Heterogeneous induction
    - 3.6 Neuralation in vertebrates
  - 4. Placentation in mammals**
- Unit-3** (Credit - 0.25) **5 Lectures**
- 5. Growth (concept, mechanism, curves) & Aging, homeobox**
  - 6. Stem cells and their applications**
  - 7. Standard techniques & methods in experimental embryology**
    - 7.1 Vital dyeing, Extirpation, Isolation
    - 7.2 Transplantation & grafting

**Section B: Animal Behaviour**

- Unit-4** (Credit - 0.5) **10 Lectures**
- 1. Introduction to Animal Behavior:** Ethology and Animal Behavior
  - 2. Concept of behavior:** Instincts and Fixed action patterns
  - 3. Methods of studying of animal behavior in the wild**
  - 4. Methods of studying of animal behavior in the in the lab adopting different approaches:**
    - 4.1 Neuro-anatomical
    - 4.2 Neurophysiological
    - 4.3 Neurochemical
  - 5. Mechanism of behavior:** Neural and endocrine regulation
- Unit-5** (Credit - 0.5) **10 Lectures**
- 6. Animal signals and communication**
    - 6.1 Kinds of stimuli, stimulus filtering
    - 6.2 Evolution of language in Primates
  - 7. Social behaviour**
    - 7.1 Social organization in insects
    - 7.2 Group selection, kin selection, Altruism

**8. Learning & memory:** Forms of learning, neural mechanism of learning and memory

**9. Sexual behaviour:** Sexual selection, courtship behaviour

***BOOKS RECOMMENDED***

1. Gilbert: Developmental Biology (2006, Sinauer Publications)
2. Kalthoff: Analysis of Biological Development (1996, McGraw Hill)
3. Monk: Mammalian Development – A Practical Approach (1987, IRL Pub.)
4. O’Rahilly and Muller: Human Embryology and Teratology (1992, Wiley)
5. Rana: Human Embryology Made Easy (1998, CRC Press)
6. Balinsky: An Introduction to Embryology (5<sup>th</sup> ed 1981, Saunders College Pub.)
7. Alcock : Animal Behaviour: An Evolutionary Approach (7th ed 2005, Sinaur)
8. Bolhuis & Giraldeau: The Behavior of Animals: mechanisms, function, and evolution (2005, Blackwell)
9. Drickamer, Vessey & Jakob: Animal Behavior: Mechanisms, Ecology, Evolution (2007, McGraw-Hill)
10. Grier: Biology of Animal Behaviour (1984, Mosby)
11. Manning & Dawkins: An introduction to Animal Behaviour (5th ed 1998, Cambridge Univ. Press)
12. Mathur Reena: Animal Behaviour (2010, Rastogi Pub.)

**M.Sc. – Semester II**  
**Zoology (FOURTH PAPER)**  
**ZOO508: Ecology & Biostatistics**

**Section A: Ecology**

- Unit-1** (Credit – 1.0) **18 Lectures**  
1. Introduction to ecology, environmental concepts – laws and limiting factors  
2. **Population ecology**  
2.1 Characteristics of population  
2.2 Logistic and exponential population growth, limits of population growth  
2.3 Population dynamics, fertility rate and age structure.  
3. **Ecological Niche**  
3.1 Concept of Niche, niche parameters, niche overlap  
4. **Competition and coexistence**  
4.1 Intra-specific and inter-specific interactions and their models  
4.2 Mutualism and commensalism, prey-predator interactions.
- Unit-2** (Credit – 0.75) **12 Lectures**  
5. **Ecosystem**  
5.1 Nature of ecosystem, ecosystem management  
5.2 Food webs, energy flow through ecosystem, ecological energetics, ecological pyramids  
5.3 Biogeochemical cycles (N, S and P cycles)  
5.4 The biosphere, biomes and impact of climate on biomes.  
6. **Biodiversity**  
6.1 Types, pattern, assessment, conservation and management  
6.2 Biodiversity act and related international conventions.  
6.3 Sustainable development, human-made biodiversity crisis
- Unit-3** (Credit - 0.5) **8 Lectures**  
7. **Environmental Stress**  
7.1 Environmental Stresses and their management  
7.2 Global climatic pattern, global warming, acid rain, ozone depletion  
8. **Ecotoxicants**  
8.1 Major classes, Uptake, biotransformation, detoxification, elimination and accumulation of toxicants.  
8.2 Biodegradation and bioremediation of chemicals.  
9. **Bioindicators and biomarkers of environmental health**  
10. **Practical application of ecology, remote sensing, molecular ecology**

**Section B: Biostatistics**

- Unit-4** (Credit - 0.25) **6 Lectures**  
1. **Sampling & Data presentation**  
1.1 Population sample, random sample  
1.2 Data presentation in form of tables & graphs (bar graph, histogram, line chart, pie chart)  
2. **Distribution**  
2.1 Binomial, Poisson and normal distribution  
2.2 Probability distribution & its properties  
3. **Measures of central tendency: Mean, Median, Mode**
- Unit-5** (Credit - 0.5) **10 Lectures**  
4. **Measures of dispersion: ranges, variance, standard deviation, standard error**  
5. **Correlation**  
6. **Test of significance: t-test, chi-square test**  
7. **Analysis of variance**  
8. **Introduction to statistical softwares**

### ***BOOKS RECOMMENDED***

1. Odum: Fundamental of Ecology (1971, W.B. Saunders)
2. Odum and Baret: Fundamentals of Ecology (5<sup>th</sup> ed 2005 EWP)
4. Cunningham and Saigo: Environmental Science (5th Ed. 1999, McGraw Hill)
5. Willimer, Stone and Johnston: Environmental Physiology (2000, Blackwell Sci. Oxford 4K)
6. Turk and Turk: Environmental Science (4th Ed. 1993, Saunders)
7. Sharma PD: Environmental Biology and toxicology (2<sup>nd</sup> ed 2010, Rastogi Publication)
8. Snedecor and Cochran: Statistical Methods (1994, Affiliated East-West Press, New Delhi)
9. Arora & Malhan: Biostatistics (2005, Himalaya Publishing House)
10. Prasad SG: Elements of Biostatistics (1<sup>st</sup> ed 2010, Rastogi Publication)

**M.Sc. – Semester II**  
**Zoology**  
**ZOO533+ZOO534: PRACTICAL EXAM**

**Total marks: 100 (Internal Assessment: 20 marks + Practical: 80 marks)**

**Internal Assessment: 20 marks (Based in internal practical assessment in practical class)**

**External Practical Examination**

Sl. No.	Content	Marks
1	Chordata (Display)/Model	15
2	Chordata (Permanent slide preparation)	5
3	Mammalian physiology	5
4	Developmental biology	5
5	Ecology	10
6	Biostatistics	5
7	Spotting (1-10)	10
8	Animal Behaviour (mini project)	5
9	Viva voce	5
10	Class record & Attendance	10
11	Seminar	5
	<b>Total</b>	<b>80</b>

**Chordata**

- **Permanent preparation**
  1. Study of external features of *Amphioxus* and permanent preparation of its oral hood and velum
  2. Permanent preparation of test and spicules of *Herdmania*
- **Display:** Demonstration of internal ear of *Scoliodon*, nervous system of catfish
- **Spotting**
  - Study of museum specimens
  - Study of prepared slides
  - **Osteology**
    1. Study of endoskeleton of bony fish, amphibian, reptiles, birds and mammals
    2. Reptilian skull, palate in birds
- Different types of feathers in birds

**Mammalian Physiology**

- Differential leucocytes counting (DLC) in human blood
- Determination of blood groups (ABO and Rh)
- Studies on frog skeletal muscle (gastrocnemius muscle preparation) contraction, and to observe the effects of increasing voltage, frequency of stimulus and load
- Studies on frog heart beat *in situ*, and to observe the effects of temperature

**Developmental Biology**

- Collection of frog spawns and observation of different developmental stages
- Study of embryonic development in chick through slides

- Window preparation to study chick embryo development

### **Animal Behaviour:**

- Descriptive writing on specific behavior of selected animals (Defensive behaviour, Aggressive behaviour, Social behavior, foraging behaviour, courtship behaviour)
- Mini-project on behaviour of any animal model (objective with type of behaviour, introduction, hypothesis, observation, result & discussion) by self observation

### **Ecology**

- Study of biotic components of a pond/river ecosystem and description of morphological adaptations of the collected organisms
- Determination of soil type
- Determination of pH, total hardness, free CO<sub>2</sub>
- Measurement of dissolved oxygen by Winkler's method
- Estimation of Nitrate & chloride content of water

### **Biostatistics**

- Presentation of data in form of frequency table
- Measurement of central tendencies (arithmetic mean, median & mode)
- Problems based on chi-square test & correlation

### **1. Museum Speciation**

<b>Protochordata</b>	:	<i>Herdmania, Amphioxus</i>
<b>Cyclostomes</b>	:	<i>Petromyzon, Ammocoete larva, Myxine</i>
<b>Pisces</b>	:	<i>Trygon, Pristis, Torpedo, Protopterus, Hilsa, Labeo, Wallago, Exocoetus, Hippocampus, Anabas, Chimera, Diodon, Synaptura, Echeneis, Tetradon, Amia, Holocephali, Ecipensor</i>
<b>Amphibia</b>	:	<i>Ichthyophis, Ambystoma, Axolotal larva, Salamendra, Amphiuma, Proteus, Siren, Alytes, Pipa</i>
<b>Reptilia</b>	:	<i>Chelone, Testudo, Sphenodon, Chaemeleon, Phrynosoma, Draco, Iguana, Haloderma, Typhlops, Python, Bangarus, Naja, Hydrophis, Viper, Natrix, Crotalus</i>
	:	
<b>Aves</b>	:	Pigeon, Fowl
<b>Mammals</b>	:	<i>Hedgehog, Manis, Hystrix, Bat</i>

### **2. Permanent Slides**

<b>Protochordata</b>	:	W.M. <i>Salpa, Doliolum</i> , T.S. of <i>Amphioxus</i> , Spicules of <i>Herdmania</i>
<b>Amphibia</b>	:	V.S. of Skin, T.S. through alimentary canal, C.S. of Liver, C.S. of Lung, T.S. of Kidney, T.S. of gonads
<b>Aves</b>	:	W.M. of filoplumes, W.M. of down feather
<b>Mammals</b>	:	V.L.S. through Skin, T.S. of Liver, T.S. of Lung, T.S. of Kidney, T.S. of Gonads

### ***BOOKS RECOMMENDED***

- P.S. Verma: Vertebrate Practical (2012, S. Chand & Co.)
- S.S. Lal: Vertebrate Practical (2009, Rastogi publications)
- Asthana, Agrawal and Jindal: Vertebrate Zoology (2012, Pragati Prakashan)
- Robert William Hegner: Practical Zoology (1922, The Macmillon company)

**M.Sc. – Semester III**  
**Zoology (FIRST PAPER)**  
**ZOO509: Biotechnology & Immunology**

**Section A: Biotechnology**

**Unit-1** (Credit – 0.75) **13 Lectures**

- 1. Scope & importance of biotechnology**
- 2. Recombinant DNA technology**
  - 2.1 Introduction
  - 2.2 Enzymes used in DNA technology: Restriction endonucleases, Exonucleases, Polymerases, Ligase, kinases, phosphatases
- 3. Cloning vectors:** Plasmids, Phages, Cosmids, Artificial chromosomes, Expression vectors
- 4. Construction of genomic and cDNA libraries**

**Unit-2** (Credit – 0.75) **13 Lectures**

- 4. Screening and characterization of clones**
  - 4.1 Gene probes: Properties and application
  - 4.2 Principles of hybridizations and hybridization based techniques: colony, plaque, Southern, Northern and in situ hybridizations
- 5. Basic principles and applications of the following techniques**
  - 5.1 DNA sequencing, Polymerase Chain Reaction, Microarray
  - 5.3 DNA fingerprinting. Biosensors & biochips
- 6. Site directed mutagenesis**

**Unit-3** (Credit – 0.75) **12 Lectures**

- 7. Gene transfer techniques**
  - 7.1 Electroporation and microinjection
  - 7.2 Embryonic cell transfer, Animal cloning
- 8. Animal Tissue culture**
  - 8.1 Cell culture, organ culture and culture media
  - 8.2 Hybridoma technology & monoclonal antibodies
- 9. Applications of Recombinant DNA Technology**
  - 9.1 Biosynthesis of insulin
  - 9.2 DNA drugs and vaccines, Sewage treatment
- 10. Introduction and scope of bioinformatics**

**Section B: Immunology**

**Unit-4** (Credit - 0.5) **10 Lectures**

- 1. Immune system**
  - 1.1 Innate and adaptive immunity
  - 1.2 Immune organs: Primary & secondary
  - 1.3 Immune cells: types, production and function, Complement system
- 2. Humoral immunity**
  - 2.1 Antigen and haptens, Primary and secondary response
  - 2.2 Antibody: Types, structure and functions
  - 2.3 Generation of antibody diversity, Class switching

**Unit-5** (Credit - 0.25) **6 Lectures**

- 3. Cell mediated immunity**
  - 3.1 T-cell receptors, HC complexes
  - 3.3 Antigen: processing and presentation
  - 3.4 T helper cell and lymphocyte activation

3.5 Cytokines, interferon

**4. Concept of vaccination**

**5. Transplantation immunology**

**6. Immune disorders:** Immunodeficiency syndrome, autoimmune disorders

***BOOKS RECOMMENDED***

1. Ausubel et al.: Short Protocols in Molecular Biology. (2002, Wiley Pub.)
2. Glick and Pasternak: Molecular Biotechnology. (2003, ASM Press)
3. Kracher: Molecular Biology - A Practical Approach (1995, Academic Press)
4. Krenzer and Massey: Recombinant DNA and Biotechnology (2000, ASM Press)
5. Meyers (Ed.). Molecular biology and biotechnology. (1995, VCH Publishers)
6. Smith: Biotechnology (5<sup>th</sup> ed 2009, Cambridge University Press)
7. Abbas et al: Cellular and Molecular Immunology (2007, Saunders)
8. Barrett: Text Book of Immunology (1988, Mosloy)
- 13 Benjamin et al: Immunology – A Short Course (2003, Wiley-Liss)
- 14 Kuby: Immunology (2006, Freeman)
- 15 Roitt: Essential Immunology (2003, Blackwell)

**M.Sc. – Semester III**  
**Zoology (SECOND PAPER)**  
**ZOO510: Molecular Biology & Cytogenetics**

**Section A: Molecular Biology**

**Unit-1** (Credit – 0.5) **10 Lectures**

**1. DNA Replication**

- 1.1 Replication in Prokaryotic and Eukaryotic Cell
- 1.2 The replicons, origin, primosome and replisomes
- 1.3 DNA polymerases

**Unit-2** (Credit – 0.75) **12 Lectures**

**2. Mechanism of Transcription**

- 2.1 Prokaryotic transcription: Promoters, bacterial RNA polymerase; initiation, elongation and termination.
- 2.2 Eukaryotic transcription: Promoters, enhancers, factors & properties of RNA polymerase I, II, III.
- 2.3 Reverse transcription
- 2.4 Inhibitors of transcription

**3. Post transcriptional Processing**

- 3.1 Maturation of rRNA, mRNA and tRNA
- 3.2 RNA splicing, introns and exons, consensus sequence function. 3' Poly A tail, 5' capping.

**Unit-3** (Credit – 0.75) **12 Lectures**

**4. Translation**

- 4.1 Formation of initiation complex, chain elongation, translocation & termination
- 4.2 Inhibitors of protein biosynthesis.
- 4.3 Comparison of protein biosynthesis in prokaryotes with eukaryotes.
- 4.4 Post Translational processing, chaperones and protein folding

**5. Regulation of Transcription and Translation**

- 5.1 Positive and negative control, Repressor & Inducer
- 5.2 Concept of operon, lac-, trp-operons

**Section B: Cytogenetics**

**Unit-4** (Credit – 0.5) **10 Lectures**

**1. Organization of Eukaryotic chromatin and chromosome**

**2. Centromere, kinetochore and telomere**

**3. Chromosomal aberrations**

- 3.1 Structural & numerical chromosomal aberrations
- 3.2 Meiotic consequences of inversion & translocation

**Unit-5** (Credit – 0.5) **10 Lectures**

**6. Human cytogenetics**

- 6.1 Karyotype and nomenclature of metaphase chromosome bands
- 6.2 Common syndromes caused by chromosomal aberrations (aneuploidy, deletion and duplication)
- 6.3 Chromosomal anomalies in cancer
- 6.4 Sex determination in human

**7. Techniques in cytogenetics:** Banding techniques, genotoxicity assays, FIS

**BOOKS RECOMMENDED**

- 1. Alberts et al: Essential Cell Biology (1998, Garland)
- 2. Alberts et al: Molecular Biology of the Cell (2002, Garland)
- 3. Bostock & Sumner: Eukaryotic Chromosome (1987, North-Holland)
- 4. Brooker: Genetics: Analysis and Principles (1999, Addison-Wesley)
- 5. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
- 7. Griffith et al: Modern Genetic Analysis (2002, Freeman)
- 8. Hartl & Jones: Essential Genetics: A Genomic Perspective (2002, Jones & Bartlet)
- 9. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)

**M.Sc. – Semester III**  
**Zoology (THIRD PAPER)**

**ZOO511C1: Elective Paper I - Cell Biology**  
**Cell morphology and organelles**

*Section A: Cell morphology*

**Unit-1** (Credit – 0.75) **12 Lectures**

**1. Prokaryotes**

- 1.1 Viruses: structure and replication
  - a. Bacteriophage (Lambda phage,  $\phi$  x 174)
  - b. Retroviruses (HIV)
- 1.2 Bacteria: Structure and reproduction of *E. coli*

**Unit-2** (Credit – 0.5) **10 Lectures**

**2. Plasma Membrane**

- 2.1 Architecture
- 2.2 Function: transport across membrane

**Unit-3** (Credit – 0.5) **10 Lectures**

**3. Cytoskeleton**

- 3.1. Microfilaments: Structural organization and function
- 3.2. Microtubule: Structural and functional organization, cilia, flagella, centriole
- 3.3. Intermediate filaments

*Section B: Cell organelles*

**Unit-4** (Credit – 0.75)

**4. Ribosomes and Endoplasmic reticulum**

**12 Lectures**

- 4.1 Ribosomes in prokaryotes & eukaryotes: Structure and function
- 4.2 Endomembrane system: Structure and function of cell
- 4.3 Protein sorting and secretion
- 4.4 Mechanism of intracellular digestion

**Unit-5** (Credit – 0.50) **10 Lectures**

**5. Mitochondria**

- 5.1 Ultrastructure and function
- 5.2 Mitochondrial born diseases

**BOOKS RECOMMENDED**

1. Alberts et al: Essential Cell Biology (1998, Garland)
2. Alberts et al: Molecular Biology of the Cell (2002, Garland)
3. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
4. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
5. Lodish et al: Molecular Cell Biology (2000, Freeman)
6. Pollard & Earnshaw: Cell Biology (2002, Saunders)
7. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
9. Karp: Molecular Cell Biology (2002, John Wiley & Sons)
10. Sheeler & Bianchi: Cell and Molecular Biology (3<sup>rd</sup> ed 2006, John Wiley & Sons)
11. Gupta: Gupta P K: Cytology (2009, Global media publications)

**M.Sc. – Semester III**  
**Zoology (FOURTH PAPER)**  
**ZOO512C2: Elective Paper II - Cell Biology**  
**Karyology, Cell division and Ageing**

*Section A: Karyology*

**Unit 1**(Credit – 0.5)

**1. Nucleus**

- 1.1 Ultrastructure
- 1.2 Function
- 1.3 Chemical composition and its significance

**10 Lectures**

**Unit-2** (Credit – 0.75)

**2.0 Giant chromosomes: Structure and function**

- 2.1 Polytene chromosome
- 2.2 Lamp-brush chromosome

**12 Lectures**

**Unit-3** (Credit - 0.5)

**3. Cell-Cell Interactions**

- 3.1 Cellular junctions
- 3.2 Extracellular matrix
- 3.3 Desmosomes

**10 Lectures**

*Section B: Cell division & ageing*

**Unit-4** (Credit – 0.5)

**4. Cell cycle**

- 4.1 Interphase
- 4.2 Cell division: 1) Mitosis, 2) Meiosis
- 4.3 Regulation of cell cycle

**10 Lectures**

**Unit -5** (Credit – 0.75)

**5. Cell aging & death**

- 5.1 Theories: Modern concept
- 5.2 Apoptosis and necrosis

**12 Lectures**

**BOOKS RECOMMENDED**

1. Alberts et al: Essential Cell Biology (1998, Garland)
2. Alberts et al: Molecular Biology of the Cell (2002, Garland)
3. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
4. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
5. Lodish et al: Molecular Cell Biology (2000, Freeman)
6. Pollard & Earnshaw: Cell Biology (2002, Saunders)
7. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
9. Karp: Molecular Cell Biology (2002, John Wiley & Sons)
10. Sheeler & Bianchi: Cell and Molecular Biology (3<sup>rd</sup> ed 2006, John Wiley & Sons)
11. Gupta: Gupta P K: Cytology (2009, Global media publications)

## M.Sc. (Zoology) III<sup>rd</sup> Semester

### Elective Paper: Environmental Biology

#### ZOO511E1: Basics of Environmental Biology, Tools & Chemistry

Section A: *Basics of Environmental Biology, Tools*

**Unit-I** (Credit – 0.5)

**10 Lectures**

**1. Fundamentals of Ecology & Tools**

- 1.1. Fundamentals of Ecology, definition and types
- 1.2. Habitat Ecology
- 1.3. Community Ecology
- 1.4. Environmental tools & techniques

**Unit-II** (Credit – 0.5)

**10 Lectures**

**2. Fundamentals of Ecosystem**

- 2.1. Definition and types
- 2.2. Terrestrial ecosystem
- 2.3. Aquatic ecosystem
- 2.4. River Continuum Concept (RCC)

**Unit-III** (Credit – 0.75)

**12 Lectures**

**3. Types of Ecosystem**

- 3.1 Freshwater lotic & lentic ecosystem
- 3.2 Terrestrial ecosystem: Grassland, Forest, Mangrove, Mountain, Desert
- 3.3 Marine ecosystem, type: Coastal and open sea environment
- 3.4 Continental shelf, continental zone, EEZ

Section B: *Environmental Chemistry*

**Unit-IV** (Credit – 0.75)

**12 Lectures**

**4. Environmental Chemistry**

- 4.1 Concept, Scope & importance (lithosphere, hydrosphere atmosphere)
- 4.2 Basic concepts: Gibb's energy, Chemical Equilibrium, Acid-base reaction
- 4.3 Chemistry of Water (pH, conductivity, DO, total hardness, total alkalinity, Chloride) & Soil Nitrate, Phosphorus, Silicate
- 4.4 Chemistry of Air

**Unit-V** (Credit – 0.5)

**10 Lectures**

**5. Environmental Toxicology**

- 5.1 Concept, Scope & importance
- 5.2 Type and sources of toxic substances: rural and urban area
- 5.3 Factors affecting environmental toxicity
- 5.4 Man and environmental toxins

#### **BOOKS RECOMMENDED**

1. Odum: Ecology
2. Welch: Limnology Vols. I-II
3. Bouhey: Ecology of populations
4. Arora: Fundamentals of environmental biology
5. APHA (2000): American Public Health Association
6. J. W. Moore and E. A. Moore: Environmental Chemistry
7. Environmental Chemistry: B.K. Sharma, and H. Kaur
8. H.V. Jadhav Elements of Environmental Chemistry

## M.Sc. (Zoology) III<sup>rd</sup> Semester

### Elective Paper: Environmental Biology

#### ZOO512E2: Biodiversity, Natural resources and conservations

##### Section A: Biodiversity

**Unit-I** (Credit – 0.75) **12 Lectures**

**1. Biodiversity**

- 1.1 Biodiversity: Definition, type
- 1.2 Threats & Factors governing biodiversity: Historical & Proximate
- 1.3 Measurement of biodiversity: diversity indices, similarity indices
- 1.4 Hotspots of Biodiversity

**Unit-II** (Credit –0.75) **12 Lectures**

**2. Aquatic Biodiversity**

- 2.1 Planktons
- 2.2 Nektons
- 2.3 Benthos
- 2.4 Factors governing the distribution of Plankton, Nekton, and Benthos

**Unit-III** (Credit – 0.5) **10 Lectures**

**3. Habitat Diversity**

- 3.1 Wetlands; types & ecological importance
- 3.2 Wastelands, types & ecological importance
- 3.3 Mangroves, types & ecological importance
- 3.4 Forest; types & ecological importance

##### Section B: Natural resources and conservations

**Unit-IV** (Credit – 0.5) **10 Lectures**

**4. Natural Resources**

- 4.1 Definition, type: Conventional and non-conventional
- 4.2 Natural energy resources: Air, water, Solar
- 4.3 Alternate energy resources :Atomic, Thermal and Hydro- energy
- 4.4 Conservation of natural resources

**Unit-V** (Credit – 0.5) **10 Lectures**

**5. Conservation**

- 5.1 Definition, Concept & Types
- 5.2 *In-situ* and *ex-situ* Conservation
- 5.3 Endemic & Endangered Species, Vulnerable Species, Red Data Book,
- 5.4 Earth Summit, Environmental Action Plan (EAP), National Biodiversity ACT, Biodiversity Registers

##### **BOOKS RECOMMENDED**

1. Declaration of: The Stockholm Conference, Rio, Rio+5 and Rio+10.
2. Anti – Pollution Acts (3) and Commentaries published thereon.
3. Constitution of India [Referred articles from Part-III, Part-IV and Part-IV-A].
4. Pares Distn. Environmental Laws in India (Deep. Deep, Latest edn.)
5. P. Leelakrishnan, Environmental and the law (Bullorthworths, Latest edn.).
6. Basic environmental technology: Jerry; A. Nathanson.

**M.Sc. – Semester III**  
**Zoology (THIRD PAPER)**  
**ZOO511F1: Elective Paper I- Fishery Science**  
**Taxonomy and Evolution**

*Section A: Taxonomy*

**Unit-I** (Credit –0.5) **10 Lectures**

- 1.1 General characters and classification of fishes
- 1.2 Modern classification of fishes
- 1.3 General characters and classification of Elasmobranch

**Unit –II** (Credit- 0.5) **10 Lectures**

- 2.1 General characters and classification of Osteochthys
- 2.2 Affinities of Actinopterygians.
- 2.3 Affinities of lung fishes

*Section B: Evolution*

**Unit III** (Credit- 0.75) **12 Lectures**

- 3.1 Origin and evolution of major groups of fishes
- 3.2 Evolutionary strategies
- 3.3 Gene and genome duplication

**Unit IV** (Credit- 0.5) **10 Lectures**

- 4.1 Fossil record of fishes
- 4.2 Shark like fishes, Bony fishes
- 4.3 Development of jaws and limbs in fishes

**UNIT V** (Credit- 0.75) **12 Lectures**

- 5.1 Zoo-geographical realms
- 5.2 Distribution of fresh water and marine fishes
- 5.3 Chimaeras and Dipnoans
- 5.4 Fish migration.

**BOOKS RECOMMENDED**

1. Dutta Munshi, J.S. and M.P. Srivastava Natural History of Fishes and Systematics of Fresh water Fishes of India, 2006 Narendra Publishing House, New Delhi.
2. Gupta S.K. and Gupta P.C. General and applied Ichthyology.
3. Day, F. 1958. The fishes of India: being a natural history of the fishes known to inhabit the seas and freshwater of India, Burma and Ceylon. William Dawson, London
4. Jayaram, K.C. 2002. The freshwater fishes of the Indian region. Narendra Publishing House, Delhi, pp 551.
5. Talwar, P. K. And Jhingran, A. G. 1991. Inland fishes of India and adjacent countries Vol. 1&2. Oxford & IBH Publishing, New Delhi, pp 1062.
6. Srivastava C.B.L. A text book of Fishery Science and Indian Fishries
7. Lagler et al Ichthyology
8. Norman J.R. A History of Fishes.
9. S.S. Khanna An Introduction of fishes

**M.Sc. – Semester III**  
**Zoology (FOURTH PAPER)**  
**ZOO512F2: Elective Paper II- Fishery Science**

**Fish Morphology, Physiology and Behavior**

*Section A: Morphology, Physiology*

**Unit-I** (Credit –0.25) **6 Lectures**

- 1.1 Definition, scope and importance
- 1.2 General structure of fish and terminology
- 1.3 Length-weight

**Unit-II** (Credit –0.75) **20 Lectures**

- 1.1 Integumentary system; scale, type
- 1.2 Digestive system: Food and feeding, gut analysis
- 1.3 Structure and function of kidney
- 1.4 Respiratory system: structure and function
- 1.5 Swim bladder, Accessory respiratory organ

**Unit –III** (Credit 1.0) **18 Lectures**

- 3.1 Circulatory system: structure and function of Heart
- 3.2 Reproduction, breeding biology
- 3.3 Excretion of nitrogenous wastes, water and ion balance
- 3.4 Endocrine glands

*Section B: Fish Behavior*

**Unit –IV** (Credit – 0.25) **5 Lectures**

- 2.1 Introduction to behavior
- 2.2 Patterns of behavior
- 2.3 Methods of studying patterns of behavior in fishes

**Unit-5** (Credit – 0.25) **5 Lectures**

- 2.1 Osmoregulation in fishes
- 2.2 Swimming mechanism, Buoyancy regulation-propulsive system
- 2.3 Pigmentary behavior in fish

**BOOKS RECOMMENDED**

1. Dutta Munshi, J.S. and M.P. Srivastava Natural History of Fishes and Systematics of Fresh water Fishes of India, 2006 Narendra Publishing House, New Delhi
2. Gupta S.K. and Gupta P.C. General and applied Ichthyology
3. Srivastava C.B.L. A text book of Fishery Science and Indian Fisheries
4. Lagler et al. Ichthyology
5. Norman J.R. A History of Fishes.
6. Kyle, HMA Biology of Fishes
7. S.S. Khanna An Introduction of fishes

**M.Sc. – Semester IV**  
**Zoology (FIRST PAPER)**  
**ZOO513: Skill Development (Vermitechnology)**

**Unit 1** (Credit 1.0) **18 Lectures**

1. Introduction about vermitechnology
2. Vermicomposting
3. Requirements of Vermicomposting and vermiculture
4. Choice of species, Composting species

**Unit 2** (Credit 0.5) **10 Lectures**

1. Species for Solid waste management
2. Physical factors: Temperature and moisture, shelter Aeration,
3. Chemical factors; Hydrogen Ion Concentration (pH)

**Unit 3** (Credit 0.5) **10 Lectures**

1. Feed and feeding materials for Vermiculture
2. Mineralization and Humification
3. Vermitechnology methods
4. Vermiwash technology

***BOOKS RECOMMENDED***

1. Charls Darwin s Plough Tools for vermitechnology by Madhab Chandra Das
2. Vermitechnology: From Soil Health to Human Health 2006 by L.S. Ranganathan, 139 pp.

**M.Sc. – Semester IV**  
**Zoology (SECOND PAPER)**  
**ZOO514C3: Elective Paper III - Cell Biology**  
**Cellular Techniques and Histochemistry**

*Section A: Cellular Techniques*

**Unit-1** (Credit – 0.5)

**10 Lectures**

**1. Fixation and tissue processing**

- 1.1 Types of fixatives
- 1.2 Chemistry of fixation
- 1.3 Choice of fixatives, Fixatives used in electron microscopy
- 1.4 Dehydration, Clearing and embedding

**Unit-2** (Credit – 0.5)

**10 Lectures**

**2. Microtomy**

- 2.1 Principle
- 2.2 Types of microtomes
- 2.3 Sectioning of paraffin blocks
- 2.4 Principle and methods of staining of paraffin sections

**Unit-3** (Credit – 0.50)

**4. Staining**

**12 Lectures**

- 3.1 General lipids by Sudan black B method, Neutral lipids by Sudan III and Sudan IV methods
- 3.2 Nucleic acid; Methyl green pyronin-Y for DNA and RNA, Feulgen reaction for DNA
- 3.3 Enzyme Acid and alkaline phosphatases by metal precipitation and azo dye methods

*Section B: Histochemistry*

**Unit-4** (Credit – 1.0)

**20 Lectures**

- 4.1 **Histological stains:** haematoxylin and eosin, vital stains, chromogens
- 4.2 **Principles and methods of histochemical localization and identification;**  
**Carbohydrate: a)** Glycogen and glycoproteins with oxidizable vicinal diols by periodic acid Schiff method, **b)** Glycoproteins with carboxyl groups and/or *O*-sulphate esters by alcian blue methods
- 4.3 **Protein: a)** General protein localization by bromophenol blue method, **b)** –NH<sub>2</sub> groups by ninhydrin-Schiff method, **c)** –SS- groups by performic acid –Schiff and performic acid- alcian blue methods

**Unit-5** (Credit – 0.5)

**5. Immuno-histochemistry**

**10 Lectures**

- 5.1 Basic principles of immune-histochemistry and their application
- 5.2 Detection of HRP-TMB reaction product
- 5.3 Techniques in cell biology: Autoradiography, cathode ray oscilloscope, perfusion, Camera lucida

**BOOKS RECOMMENDED**

1. Alberts et al: Essential Cell Biology (1998, Garland)
2. Alberts et al: Molecular Biology of the Cell (2002, Garland)
3. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
4. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
5. Lodish et al: Molecular Cell Biology (2000, Freeman)
6. Pollard & Earnshaw: Cell Biology (2002, Saunders)
7. Gupta: Gupta P K: Cytology (2009, Global media publications)
8. Sheeler & Bianchi: Cell and Molecular Biology (3<sup>rd</sup> ed 2006, John Wiley & Sons)
9. Karp: Molecular Cell Biology (2002, John Wiley & Sons).

**M.Sc. – Semester IV**  
**Zoology (THIRD PAPER)**  
**ZOO515C4: Elective Paper IV - Cell Biology**  
**Cell Signalling, Neuron and Bioenergetics**

*Section A: Cell Signalling*

**Unit-1** (Credit – 0.75) **12 Lectures**

**1. Signal transduction**

- 1.1. Intracellular receptor and cell surface receptors
- 1.2. Signalling via G-protein linked receptors (PKA, PKC, CaM kinase)
- 1.3. Enzyme linked receptor signaling pathways
- 1.4. Network and cross-talk between different signal mechanisms

**Unit-2** (Credit – 0.75) **12 Lectures**

**2. Biology of cancer**

- 2.1 Cytological characteristics of transformed cell
- 2.2 Metastasis
- 2.3 Tumor suppressor gene and oncogene
- 2.4 Carcinogens

**Unit-3** (Credit -0.5) **10 Lectures**

**3. Special cell functions**

- 3.1 Ghost cell preparation & application
- 3.2 Production & maturation of RBC
- 3.3 Immunocompetent cells: Differentiation of B & T lymphocytes and their immune response

*Section B: Neuron & Bioenergetics*

**Unit-4** (Credit – 0.5) **10 Lectures**

**4. Neuron**

- 4.1 Types, structure
- 4.2 Signal conduction: Action potential, synaptic transmission
- 4.3 Na<sup>+</sup> - K<sup>+</sup> ATPase pump

**Unit-5** (Credit – 0.5) **10 Lectures**

**5. Bioenergetics:** Law of energy changes, Redox couples

**6. Photomicrography:** Principles, softwares

**7. Knowledge of Image analysis softwares:** Adobe Photoshop, Coral draw, Image J

***BOOKS RECOMMENDED***

1. Alberts et al: Essential Cell Biology (1998, Garland)
2. Alberts et al: Molecular Biology of the Cell (2002, Garland)
3. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
4. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
5. Lodish et al: Molecular Cell Biology (2000, Freeman)
6. Pollard & Earnshaw: Cell Biology (2002, Saunders)
7. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
9. Karp: Molecular Cell Biology (2002, John Wiley & Sons)
10. Sheeler & Bianchi: Cell and Molecular Biology (3<sup>rd</sup> ed 2006, John Wiley & Sons)
11. Gupta: Gupta P K: Cytology (2009, Global media publications)

**M.Sc. (Zoology) IV<sup>th</sup> Semester**  
**Elective Paper: Environmental Biology**

**ZOO514E3: Environmental Pollution and Management**

*Section A: Environmental Pollution*

**Unit-I** (Credit – 0.75) **12 Lectures**

**1. Pollution**

- 1.1 Pollution: Definition, types and sources
- 1.2 Nature of the pollutants: Physical, Chemical and Biological
- 1.3 Biogeochemical cycle of Pesticides
- 1.4 Biogeochemical cycle of Heavy metals;

**Unit-II** (Credit – 0.5) **10 Lectures**

**2. Pollution Type**

- 2.1 Air pollution
- 2.2 Water pollution & Solid waste pollution
- 2.3 Radioactive and thermal pollution.
- 2.4 Noise pollution

**Unit-III** (Credit – 0.5) **10 Lectures**

**3. Pollution Effects**

- 3.1 Global warming
- 3.2 Acid rains
- 3.3 Ozone depletion
- 3.4 Natural Disaster: floods, droughts, earthquake, landslides, Tsunami, volcanos, cyclones & Storms

*Section A: Environmental Management*

**Unit-IV** (Credit – 0.75) **12 Lectures**

**4. Environmental Management**

- 4.1 Definition, type and technique
- 4.2 Monitoring of soil and its management
- 4.3 Monitoring of water and its management
- 4.4 Treatment of municipal and industrial waste

**Unit-V** (Credit – 0.5) **10 Lectures**

**5. Rural Pollution and management**

- 5.1 Domestic and agricultural pollution
- 5.2 Control and measures
- 5.3 Effect on Pollutants on society

**BOOKS RECOMMENDED**

1. Environmental radioactivity – M. Eisendbud, Academic press.
2. Essentials of nuclear chemistry – II, T. Arnikar, Wiley easter.
3. Nuclear chemistry through problems – II, T. Arnikar & N. S. Rajurkar,
4. New age Int. (P) Ltd.
5. Environmental Science – A study of Inter relationships, E. D. Enger, B. E.
6. Smith, 5th ed., W C B publication

**M.Sc. (Zoology) IV<sup>th</sup> Semester**  
**Elective Paper: Environmental Biology**

**ZOO515E4: Application, management & Legal Environmental Biology**

*Section A: Application & Management of Environmental Biology*

**Unit-I** Credit – 0.75) **12 Lectures**

**1. Environmental Flow**

- 1.1 Environmental flows: Importance for the aquatic flora & fauna
- 1.2 Methodology of Environmental flows assessment
- 1.3 Studies on Hydrology, geology and water chemistry
- 1.4 Build Block Methodology (BBM)

**Unit-II** (Credit – 1.0) **18 Lectures**

**2. Environmental Management**

- 2.1 Environmental management Programme (EMP): Urban & Rural
- 2.2 Hydroelectric Projects (HEP)
- 2.3 Environmental Impact Assessment (EIA),
- 2.4 Trend and purpose of Environmental monitoring

**Unit-III** (Credit – 0.5) **9 Lectures**

**3. Environmental Management**

- 3.1 Global agreements and national concerns.
- 3.2 RAMSAR sites,
- 3.3 Quarantine Regulations, National Forest Policy,
- 3.4 Biodiversity Act., Wild-life Protection Act

*Section A: Legal Environmental Biology & Computer*

**Unit-IV** (Credit – 0.5) **9 Lectures**

**4. Environmental Policies, Acts and Rules**

- 4.1 Environmental laws in India
- 4.2 Factories Act, Motor Vehicle Act,
- 4.3 Hazardous Waste legislation for pollution
- 4.4 Anti-Pollution Acts: The water Act. 1974.

**Unit-V** (Credit – 0.25) **6 Lectures**

**5. Computer applications**

- 5.1 Basic knowledge of Microsoft office: Word, Excel, Power Point
- 5.2 Knowledge of various soft were: OMNIDIA, Statistica, SPSS
- 5.3 Truss and CANOCO soft water

**BOOKS RECOMMENDED**

1. Declaration of: The Stockholm Conference, Rio, Rio+5 and Rio+10.
2. Anti – Pollution Acts (3) and Commentaries published theorem.
3. Constitution of India [Referred articles from Part-III, Part-IV and Part-IV-A].
4. Pares Distn. Environmental Lows in India (Deep. Deep, Lated edn.)
5. P. Leelakrishnan, Environmental and the last (Bullorthworths, Latold, edn.).
6. Basic environmental technology: Jerry; A. Nathanson.

**M.Sc. – Semester IV**  
**Zoology (SECOND PAPER)**  
**ZOO514F3: Elective Paper II- Fishery Science**  
**Capture Fishery**

*Section A: Freshwater Fishery*

**Unit I:** (Credit 0.75) **12 Lectures**

- 1.1 Fishery resources in different river System: Ganga & Yamuna
- 1.2 Regulation, exploitation and improvement of fish stocks
- 1.3 Present and future prospects of riverine fishery in India

**Unit II** (Credit 0.75) **12 Lectures**

- 2.1 Dams and their effect on fishery
- 2.2 Cold water fishery and its resources
- 2.3 Fisheries management in cold water
- 2.4 Present and future prospects of Cold water fishery in India

**Unit III** (Credit 0.5) **10 Lectures**

- 3.1 Estuarine fisheries and resources
- 3.2 Problems confronting brackish-water capture fisheries
- 3.3 Present and future prospects of estuarine fishery in India

*Section B: Marine Fishery*

**Unit IV** (Credit 0.5) **10 Lectures**

- 4.1 Marine fishery in India
- 4.2 Coastal fishery resources of India
- 4.3 Inshore fishery & off shore fishery
- 4.4 Deep sea fishery

**Unit V** (Credit 0.5) **10 Lectures**

- 5.1 Oceanography in relation to fishery
- 5.2 Exclusive economic zone (EEZ)
- 5.3 Present and future prospects of marine fishery in India

***BOOKS RECOMMENDED***

1. Jhingran V.G. Fish and Fisheries of India
2. Beavan, C.R. Handbook of Freshwater fishes of India
3. Bal and Rao. marine Fisheries
4. Gupta S.K. and Gupta P.C. General and applied Ichthyology.
5. Srivastava C.B.L. A text book of Fishery Science and Indian Fishries
6. S.S. Khanna An Introduction of fishes

**M.Sc. – Semester IV**  
**Zoology (THIRD PAPER)**  
**ZOO515F4: Elective Paper III- Fishery Science**  
**Culture Fishery**

*Section A: Aquaculture*

**Unit I:** (Credit -1.0) **18 Lectures**

**1. Aquaculture**

- 1.1 Aquaculture: Principal, definition, types and resources
- 1.2 Pond preparation: physic-chemical characteristics feature
- 1.3 Brooder, nursery, rearing and stocking ponds
- 1.4 Present and future prospects of aquaculture in India

**Unit II:** (Credit -0.75) **12 Lectures**

**2. Pond Management**

- 2.1 Pond management: use of fertiliser, aquatic vegetation and control
- 2.2 Eradication of weed and predator (insects & fishes)
- 2.3 Supplementary feeding,
- 2.4 Biological factors, control of algal blooms

**Unit III:** (Credit -0.5) **10 Lectures**

**3. Composite Fish culture**

- 3.1 Inland culture: methods on culture
- 3.2 Composite fish culture, air breathing fish culture
- 3.3 Integrated fish farming, cage, pen, raceway & tank culture
- 3.4 Trout, Prawn and Pearl culture

*Section B: Spawning & Computer Application*

**Unit IV:** (Credit -0.5) **10 Lectures**

**4. Spawning**

- 4.1 Natural spawning and seed collection
- 4.2 Techniques breeding: Natural and induced
- 4.3 Fish disease and their control

**Unit V** (Credit-0.25) **5 Lectures**

**5. Computer Application**

- 5.4 Basic knowledge of Microsoft office: Word, Excel, Power Point
- 5.5 Truss and CANOCO soft water
- 5.6 Fish stock assessment: FISAT sotware

**BOOKS RECOMMENDED**

1. Agarwal SC 2008. A handbook of Fish farming. 2<sup>nd</sup> Ed. Narendra Publishing House, New Delhi
2. Balugut, E.A.1989. Aquaculture system and practices. A selected review publishing House, New Delhi.
3. Dash, M.C. and Patnik, P.N.1994. Brackish water culture. Palani Paramount publications, Palani.
4. Michael, B.N. and Singholka, B. 1985. Freshwater Prawn Farming. A manual of culture of *Macrobrachium rosenbergii*. Daya Publishing House, New Delhi.
5. Paul Raj, S. 1996. Aquaculture for 2000 A.D. Palani Paramount Publications, Palani.
6. Pillay, T.V.R. 1990 Aquaculture Principles and Practices. Blackwell Scientific Publications Ltd.
7. Sinha, V.R.P. and Srinivastava, H.C. 1991. Aquaculture Productivity. Oxford and IBH Publications Co., Ltd., New Delhi.
8. Noga E.J. 1996. Fish Disease diagnosis and treatment. Mosby –Yearbook, Inc. St. Louis. M.O.
9. Venugopal S. 2005. Aquaculture. Pointer Publication. Welcomme R.L. 2001. Inland Fisheris Ecology and Management. Fishing News Books.