

NEHRU GRAM BHARATI VISHWAVIDYALAYA

KOTWA- JAMUNIPUR- DUBAWAL

ALLAHABAD (UTTAR PRADESH)

[From Academic Session 2017-18 onwards]



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

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

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
Total	20

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 obtain minimum credit i.e. 2.5, he/she will be considered 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 a candidate fails to clear his/her semester after 2 attempts 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

Unit-1 (Credit – 0.25)	5 Lectures		
1. Protozoa			
1.1 Locomotory organs			
1.2 Nucleus and reproduction			
2. Porifera			
2.1 Canal system			
2.2 Skeletal system			
Unit-2 (Credit - 0.5)	10 Lectures		
3. Cnidaria			
3.1 Nematocysts			
3.2 Polymorphism			
3.3 Metagenesis in <i>Obelia</i>			
3.4 Coral reef			
4. Helminths (Platyhelminthes, Aschelminthes): Parasitic adaptation & host-parasite relationship			
Unit-3 (Credit –1.0)	18 Lectures		
5. Annelida			
5.1 Coelom			
5.2 Trochophore larva: structure and significance			
5.3 Metamerism			
6. Mollusca			
6.1 Nervous system in Cephalopoda			
6.2 Modifications of foot			
6.3 Sense organs			
Unit-4 (Credit – 0.75)	13 Lectures		
7. Arthropoda			
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			
8. Echinodermata: larval forms and their significance			
Unit-5 (Credit - 0.5)	8 Lectures		
9. Salient features and affinities of following minor phyla			
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 & Biostatistics

Section A: Evolution & Animal Distribution

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

- 1. The geological time scale of Evolution**
- 2. Origin and early history of life**
- 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

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

- 2.1 Modes of speciation,
- 2.2 Isolating mechanisms
- 2.3 Molecular Evolution

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

- 1. Geological and geographical distribution of animals**
- 2. Continental drift**
- 3. Zoo-geographical regions**
- 4. Barriers influence animal distribution**

Section B: Biostatistics

Unit-4 (Credit - 0.75) **14 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. 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: Biodiversity and Wild life

Section A: Biodiversity

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

1. Introduction to Biodiversity

- 1.1 Definition, Concepts, Scope and Significance
- 1.2 Levels of Biodiversity- Genetic, Species and Ecosystem
- 1.3 Hotspots- (Western Ghats and Indo- Burma Border)

Unit II (Credit - 0.5) **12 Lectures**

2. Biodiversity measurement

- 2.1 Richness, Evenness
- 2.2 Biodiversity index- types; simpson, Shannon Wiener
- 2.3 Threats - Habitat loss and Man-Wildlife conflict

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

3. Biodiversity conservation and management

- 3.1 Conservation strategies: *in situ*, ex-situ
- 3.2 National parks, Sanctuaries
- 3.3 National Biodiversity Action Plan, 2002

Section B: Wild life

Unit IV (Credit - 0.5) **12 Lectures**

1. Scope of Wildlife Biology

- 1.1 Physiological Basis of; Hibernation, aestivation, Migration
- 1.2 Animal adaptations to water, temperature, predation
- 1.3 Orientation & navigation in animals

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

2. Wild life and Society

- 2.1 Indian Wildlife (Protection) Act, 1972
- 2.2 Convention for International Trade of endangered species
- 2.3 Wildlife diseases and their control Ecosystem people

BOOKS RECOMMENDED

1. Odum and Baret: Fundamentals of Ecology (5th ed 2005 EWP)
2. Cunningham and Saigo: Environmental Science (5th Ed. 1999, McGraw Hill)
3. Willimer, Stone and Johnston: Environmental Physiology (2000, Blackwell Sci. Oxford 4K)
4. Sharma PD: Environmental Biology and toxicology (2nd ed 2010, Rastogi Publication)
5. Aaron, N.M. Wildlife ecology W.H. Freeman Co. San Francisco, U.S.A. 1973
6. Ali, Salim, The Book of Indian Birds Oxford University Press, Mumbai 1997
7. Anthony R.E. Sinclair, John M. Fryxell and Graeme Caughly Wildlife Ecology, Conservation and Management Blackwell Publishing, U.S.A. 2006
8. Arora B.M. and Bipul Chakraborty Colorful Atlas on Indian Wildlife Diseases and Disorders IBDC, Lucknow. 20089. Arora B. M. (Editor) Indian Wildlife Yearbook AIZ & WV, Bareilly, 2002

M.Sc. – Semester I
Zoology (FOURTH PAPER)
ZOO504: Ecology

Unit-1 (Credit – 0.75)	12 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	
Unit-2 (Credit – 0.75)	14 Lectures
4. Competition and coexistence	
4.1 Intra-specific and inter-specific interactions and their models	
4.2 Mutualism and commensalism, prey-predator interactions.	
5. Ecosystem	
5.1 Ecosystem type	
5.2 Food webs, energy flow through ecosystem,	
5.3 Ecological energetics, ecological pyramids	
5.3 Biogeochemical cycles (N, S and P cycles)	
5.4 The biosphere, biome.	
Unit-3 (Credit – 0.5)	10 Lectures
6. Environmental biodegradation	
6.1 Environmental degradation: natural and manmade	
6.2 Pollution: types, sources	
6.3 Major pollutants: air, water, soil and noise and control	
6.4 Global warming, Ozone depletion	
Unit-4 (Credit - 0.25)	6 Lectures
7. Ecotoxicants	
7.1 Major classes, Uptake,	
7.2 Biotransformation, detoxification	
7.3 Elimination and accumulation of toxicants	
Unit-5 (Credit - 0.75)	12 Lectures
8. Bioindicators	
9. Biomarkers of environmental health	
10. Practical application of ecology,	
11. Remote sensing, molecular ecology	

BOOKS RECOMMENDED

1. Odum: Fundamental of Ecology (1971, W.B. Saunders)
2. Odum and Barrett: Fundamentals of Ecology (5th 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 (2nd ed 2010, Rastogi Publication)

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	Biodiversity	10
4	Wild life	5
5	Biostatistics	5
6	Ecology	10
7	Spotting (1-10)	10
8	Viva voce	5
9	Class record & Attendance	10
10	Seminar	5
	Total	80

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

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 CO₂
- 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

Wildlife

- Wild life exercise based photographs, models,

Biodiversity

- Practical based on biodiversity and wild life

List of museum specimens & slides

1. Museum Specimens:

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

2. Permanent Slides:

Protozoa	:	<i>Euglina, Paramecium</i> W.M. Binary Fission, Conjugation in <i>Paramecium, Monocystis, Plasmodium, Opalina, Balantidium, Entamoeba, Leishmania</i>
Porifera	:	Spongin fibres, gemmule, spicules, L.S. & T.S. of <i>Sycon</i>
Cnidaria	:	T.S. of Hydra through gonads, <i>Obelia</i> W.M., <i>Obelia</i> medusae, Ephydra Larva
Helminthes	:	Gravid proglottid of <i>Taenia</i> , Miracidium, Redia, Cercaria, Metacercaria, Cysticercus larva.
Annelida	:	T.S. <i>Nereis</i> , parapodium of nereis and heteronereis, trochophore larva,
Arthropoda	:	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.
Echinodermata	:	T.S. of arm of starfish, pedicellaria, bipinnaria larva.
Hemichordata	:	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

Unit-1 (Credit – 0.75)	12 Lectures
1. Origin of Chordata	
2. Characteristic features and affinities of the following lower chordates	
2.1 Hemichordata	
2.2 Protochordata	
a. Urochordata	
b. Cephalochordata	
2.3 Cyclostomes	
Unit-2 (Credit – 0.75)	12 Lectures
3. Origin of Gnathostomes	
4. Pisces	
4.1 Peculiar features of Lung fishes (Dipnoi)	
4.2 Lateral line system	
4.3 Electric organs	
5. Amphibia: Origin & evolution of Tetrapodes	
Unit-3 (Credit -0. 25)	10 Lectures
6. Reptile	
6.1 Origin of reptiles	
6.2 Skulls in reptiles	
6.3 Mesozoic reptiles	
Unit-4 (Credit – 0.25)	8 Lectures
7. Aves	
7.1 Origin of birds	
7.2 Flightless birds	
7.3 Modification of beak, feet and palate in birds	
Unit-5 (Credit – 1.0)	12 Lectures
8. Mammal	
8.1 Origin of mammals	
8.2 Characteristic features of monotremes, marsupials & placentals	
8.3 Adaptive radiation in placental	

BOOKS RECOMMENDED

1. Prasad & Kashyap: A Textbook of Vertebrate Zoology (14th 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: Animal Physiology, Endocrinology & Biochemistry

Section A: Animal Physiology, Endocrinology

Unit-1 (Credit – 0.50) **10 Lectures**

1. Digestion and nutrition

- 2.1 Absorption of macronutrients and their regulation
- 2.2 Obesity and starvation

2. Respiration

- 4.1 Mechanism & regulation of breathing
- 4.2 Transport of gases & Gaseous exchange
- 4.3 Hypoxia and oxygen therapy

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

3. Circulation

- 3.1 Types, Blood and Lymph composition & function,
- 3.2 Heart: Origin and conduction of cardiac impulse, ECG and cardiac cycle

4. Excretion

- 5.1 Structure and function of Kidney
- 5.2 Urine formation and regulation

6. Neuromuscular system

- 6.1 Types, Mechanism of contraction, Muscular dystrophy
- 6.2 Nerve conduction & neurotransmitters

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

1. Mechanism of hormone action

Cyclic AMP signaling cascade, PKC signaling pathway

Hypothalamo-hypophysial system

- 1.1 Hypothalamus & neurosecretion
- 1.2 Pituitary gland: Structure, cell types & hormones

2. Endocrine glands

- 2.1 Structure and function: Pineal, Thyroid, Adrenal, gastrin and cholecystokinin
- 2.2 2.3 Biosynthesis of thyroxin and Gonadial Hormones

Section B: Biochemistry

Unit-4 (Credit – 0.75) **14 Lectures**

1. Carbohydrates

- 1.1 Chemistry, Metabolism: Glycolysis, Krebs's Cycle, Oxidative phosphorylation, Peptidoglycan

2. Protein structure

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

3. Enzymes

- 3.1 Enzyme kinetics: Michaelis-Menten equation
- 3.2 Mechanism of action, Inhibition: types & mechanism
- 3.3 Allosteric enzymes, isoenzymes & ribozymes

4. Vitamins & Coenzyme: Structure & Function

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

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

6. Buffers

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

BOOKS RECOMMENDED

1. Eckert and Randell: Animal Physiology: Mechanisms & Adaptations (2nd ed 2005, CBS Publishers)
2. Berry: Textbook of Animal Physiology (11th ed 2008, Emkay Publications)
3. Guyton and Hall: Text Book of Medical Physiology (11th ed 2006, W.B. Saunders)
4. Srivastava, Agrawal and Kumar: Animal Physiology (2011, S.Chand & co. ltd.)
5. Chaudhuri: Concise Medical Physiology (2nd ed 1993, New Central Book Agency Ltd.)
6. Bentley: Comparative Vertebrate Endocrinology (1998, Cambridge University Press)
7. Norris: Vertebrate Endocrinology (4th ed 2007, Elsevier)
8. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
9. Turner and Bagnara: General Endocrinology (1984, Saunders)
10. Larson: Williams Textbook of Endocrinology (10th ed 2002, Saunders)
11. Berg et al: Biochemistry (5th ed 2001, Freeman)
12. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2004, Pearson)
13. Harper's Review of Biochemistry (22nd ed 1991, Lange Medical Books)
14. Stryer L.: Biochemistry (5th ed 2002, Freeman)
15. Rawn: Biochemistry (2nd ed 1989, Neil Patterson)

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
 - 2. Fertilization in mammals**
 - 2.1 Gametogenesis, Acrosomal reaction
 - 2.3 Prevention of polyspermy and gamete fusion
 - 2.4 Parthenogenesis
- Unit-2** (Credit – 1.0) **18 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
 - 4. Placentation in mammals**
- Unit-3** (Credit - 0.5) **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, Isolation
 - 7.2 Transplantation & grafting

Section B Animal Behavior

- 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) **12 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 (5th 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: Cytology & Instrumentation

Section B: Cytology

Unit-1 (Credit – 0.75) **14 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

Unit-2 (Credit – 0.25) **5 Lectures**

3. ATP production in Mitochondria

- 3.1 Structure: assemblies of respiratory chain and Fo- F₁ ATPase
- 3.2 Oxidative phosphorylation: mechanism and chemiosmotic concept

4. Cell signaling

5. Apoptosis: mechanism and significance

Unit-3 (Credit – 0.5) **10 Lectures**

1. Organization of Eukaryotic chromatin and chromosome

2. Centromere, kinetochore and telomere

3. Chromosomal aberrations

6. Human cytogenetics

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

Section B: Instrumentation

Unit-4 (Credit – 0.75) **15 Lectures**

1. Centrifugation

Basic principles, Types of rotors, Ultracentrifuge

2. Spectrophotometry

Types of spectrophotometer, Absorption spectrum, Principles of UV- Vis spectrophotometry

3. Electrophoresis

Principles, Agarose- and polyacrylamide gel
Isoelectrofocussing, Two-dimensional gel electrophoresis

4. Chromatography

Principles, Paper and thin layer chromatography, Column chromatography: Gel filtration, Ion exchange & Affinity, Introduction to HPLC

7. Microtomy

Paraffin, Freezing

Unit-5 (Credit – 0.75) **10 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

BOOKS RECOMMENDED

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
2. Karp: Cell and Molecular Biology (2007, Wiley)
3. Lodish et al: Molecular Cell Biology (2007, Freeman)
4. DeRobertes & DeRobertes: Cell & Molecular Biology (1987, Lee & Febiger)
5. Karp: Cell & Molecular Cell Biology (2002, John Wiley & Sons)
6. Gupta P K: Cytology (2009, Global media publications)
7. Rana: Bio-techniques: Theory & Practice (2007, Rastogi publications)

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	Biochemistry	10
6	Cytology	5
7	Spotting (1-10)	10
8	Animal Behaviour (mini project)	5
9	Viva voce	5
10	Class record & Attendance	10
11	Seminar	5
	Total	80

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

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

1. Museum Speciation

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

2. Permanent Slides

Protochordata	:	W.M. <i>Salpa, Doliolum</i> , T.S. of <i>Amphioxus</i> , Spicules of <i>Herdmania</i>
Amphibia	:	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
Aves	:	W.M. of filoplumes, W.M. of down feather
Mammals	:	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

Unit-1 (Credit – 0.5)	10 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	
Unit-2 (Credit – 0.75)	14 Lectures
3. Cloning vectors: Plasmids, Phages, Cosmids, Artificial chromosomes, Expression vectors	
4. Construction of genomic and cDNA libraries	
5. 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	
Unit-3 (Credit – 0.5)	10 Lectures
6. Basic principles and applications of the following techniques	
5.1 DNA sequencing, Polymerase Chain Reaction, Microarray	
5.3 DNA fingerprinting. Biosensors & biochips	
7. Site directed mutagenesis	
Unit-4 (Credit – 0.75)	12 Lectures
8. Gene transfer techniques	
8.1 Electroporation and microinjection	
8.2 Embryonic cell transfer, Animal cloning	
9. Animal Tissue culture	
9.1 Cell culture, organ culture and culture media	
9.2 Hybridoma technology & monoclonal antibodies	
Unit-5 (Credit – 0.5)	8 Lectures
10. Applications of Recombinant DNA Technology	
10.1 Biosynthesis of insulin	
10.2 DNA drugs and vaccines, Sewage treatment	
11. Introduction and scope of bioinformatics	

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 (5th ed 2009, Cambridge University Press)

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

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: 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. 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)
6. Griffith et al: Modern Genetic Analysis (2002, Freeman)
7. Hartl & Jones: Essential Genetics: A Genomic Perspective (2002, Jones & Bartlet)
8. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
9. Abbas et al: Cellular and Molecular Immunology (2007, Saunders)
10. Barrett: Text Book of Immunology (1988, Mosloy)
- 11 Benjamin et al: Immunology – A Short Course (2003, Wiley-Liss)
- 12 Kuby: Immunology (2006, Freeman)
- 13 Roitt: Essential Immunology (2003, Blackwell)

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, ϕ 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 (3rd 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

10 Lectures

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

Unit-2 (Credit – 0.75)

12 Lectures

2.0 Giant chromosomes: Structure and function

- 2.1 Polytene chromosome
- 2.2 Lamp-brush chromosome

Unit-3 (Credit - 0.5)

10 Lectures

3. Cell-Cell Interactions

- 3.1 Cellular junctions
- 3.2 Extracellular matrix
- 3.3 Desmosomes

Section B: Cell division & ageing

Unit-4 (Credit – 0.5)

10 Lectures

4. Cell cycle

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

Unit -5 (Credit – 0.75)

12 Lectures

5. Cell aging & death

- 5.1 Theories: Modern concept
- 5.2 Apoptosis and necrosis

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 (3rd ed 2006, John Wiley & Sons)
11. Gupta: Gupta P K: Cytology (2009, Global media publications)

M.Sc. (Zoology) IIIrd 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 – 0.75)

12 Lectures

2. Fundamentals of Ecosystem

- 2.1 . Definition and types: lotic & lentic
- 2.2 . Lotic: Stream, river, spring, rill, fall
- 2.3 Lentic; Pool, reservoir, lake
- 2.4 . River Continuum Concept (RCC)

Unit-III (Credit – 0.75)

12 Lectures

3. Types of Ecosystem

- 3.1 Freshwater ecosystem: Ganga, Yamuna, Sone, Ken
- 3.2 Terrestrial ecosystem: Forest, Mangrove, Mountain
- 3.3 Marine ecosystem: Continental shelf, continental zone, EEZ

Section B: Environmental Chemistry

Unit-IV (Credit – 0.5)

10 Lectures

4. Environmental Chemistry

- 4.1 Concept, Scope & importance
- 4.2 Chemistry of Water: pH, conductivity, DO, Total Hardness,
- 4.3 Total alkalinity, & Soil Nitrate, Phosphorus, Silicate

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

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) IIIrd 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 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 (Bulloughworths, 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)** –NH₂ 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 (3rd 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⁺ - K⁺ 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 (3rd ed 2006, John Wiley & Sons)
11. Gupta: Gupta P K: Cytology (2009, Global media publications)

M.Sc. (Zoology) IVth 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, Ozone depletion
- 3.3 Natural Disaster: floods, droughts, landslides, Tsunami, volcanos, cyclones

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) IVth Semester
Elective Paper: Environmental Biology

ZOO515E4: Application, management & Legal Environmental Biology

Section A: Application & Management of Environmental Biology

Unit-I Credit – 0.5) **11 Lectures**

1. Environmental Flow

- 1.1 Environmental flows: Importance for the aquatic flora & fauna
- 1.2 Methodology of Environmental flows assessment
- 1.3 Build Block Methodology (BBM)

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

2. Environmental Management

- 2.1 Environmental management Programme (EMP): Urban & Rural
- 2.2 Hydroelectric Projects (HEP)
- 2.3 Environmental Impact Assessment (EIA),

Unit-III (Credit – 0.75) **12 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 – 0.5) **9 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.
7. Canter, L. W. Environmental Impact Assessment, Mc. Graw Hill Publication, New York.

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 Costal 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. 2nd 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.