

**DEPARTMENT OF ZOOLOGY**

M.Sc. Zoology

# M.Sc. Zoology

**Course Contents & Syllabi**

(w.e.f. 2020)



**Hemvati Nandan Bahuguna Garhwal University**

(A Central University)

Srinagar (Garhwal), Uttarakhand

## M.Sc. Zoology

### M.Sc. 1<sup>st</sup> Semester (July to November)

Code	Course	L	T	P	C	MM
SOLS/Zool/C 001	Animal Diversity I – (Lower Non-Chordata)	3	0	0	3	100
SOLS/Zool/C 002	Cell Biology & Molecular Biology	3	0	0	3	100
SOLS/Zool/C 003	Genetics, Evolution & Taxonomy	3	0	0	3	100
SOLS/Zool/C 004	Developmental Biology & Parasitology	3	0	0	3	100
SOLS/Zool/C 005	Lab Course I Based on C001 & C002	0	0	3	3	100
SOLS/Zool/C 006	Lab Course II Based on C003 & C004	0	0	3	3	100
<b>Core Credits = 18</b>						<b>600</b>

### M.Sc. 2<sup>nd</sup> Semester (December to April)

Code	Course	L	T	P	C	MM
SOLS/Zool/C 007	Animal Diversity-II (Higher Non-Chordata)	3	0	0	3	100
SOLS/Zool/C 008	Animal Physiology	3	0	0	3	100
SOLS/Zool/C 009	Instrumentation, Computer Application and Biostatistics	3	0	0	3	100
SOLS/Zool/C 010	Elementary Biotechnology & Microbiology	3	0	0	3	100
SOLS/Zool/C 011	Lab Course I Based C007 & C008	0	0	3	3	100
SOLS/Zool/C 012	Lab Course II Based C009 & C010	0	0	3	3	100
<b>Total</b>						<b>600</b>
SOLS/Zool/SS01	Basic Bioinformatics	0	0	0	3	100
SOLS/Zool/SS02	Human Population Genetics	0	0	0	3	100
<b>Core Credits = 18</b>						

### M.Sc. 3<sup>rd</sup> Semester (July to November)

Code	Course	L	T	P	C	MM
SOLS/Zool/C 013	Animal Diversity (Chordata)	3	0	0	3	100
SOLS/Zool/C 014	Ecology & Wildlife	3	0	0	3	100
SOLS/Zool/C 015	Lab Course Based on C013 & C014	0	0	3	3	100
SOLS/Zool/E 01a	Fish Biology I	3	0	0	3	100
SOLS/Zool/E 01b	Entomology I					
SOLS/Zool/E 01c	Environmental Biology I					
SOLS/Zool/E 01d	Reproductive Biology I					
SOLS/Zool/E 02a	Fish Biology II	3	0	0	3	100
SOLS/Zool/E 02b	Entomology II					
SOLS/Zool/E 02c	Environmental Biology II					
SOLS/Zool/E 02d	Reproductive Biology II					
SOLS/Zool/E 03	Lab Course Based on E001a/b/c/d & E002 a/b/c/d	0	0	0	3	100
<b>Total</b>						<b>600</b>
SOLS/Zool/SS03	Biological & Radiotracer Techniques	0	0	0	3	100
SOLS/Zool/SS04	Aquatic Biodiversity	0	0	0	3	100
<b>Core Credits 09 + Elective Credits 09; Total Credits = 18</b>						

### M.Sc. 4<sup>th</sup> Semester (December to April)

Code	Course	L	T	P	C	MM
SOLS/Zool/C 016	Endocrinology & Animal Behaviour	3	0	0	3	100
SOLS/Zool/C 017	Biochemistry & Immunology	3	0	0	3	100
SOLS/Zool/C 018	Lab Course Based on C016 & C017	0	0	3	3	100
SOLS/Zool/E 04a	Fisheries Science	3	0	0	3	100
SOLS/Zool/E 04b	Applied Entomology					
SOLS/Zool/E 04c	Applied Environmental Biology					
SOLS/Zool/E 04d	Applied Reproductive Biology					
SOLS/Zool/E 05a	Methodology in Fishery Science	3	0	0	3	100
SOLS/Zool/E 05b	Methodology in Entomology					
SOLS/Zool/E 05c	Methodology in Environmental Biology					
SOLS/Zool/E 05d	Methodology in Reproductive Biology					
SOLS/Zool/E 06	Lab Course Based E004 a/b/c/d & E005 a/b/c/d	0	0	3	3	100
SOLS/Zool/E 07	Dissertation*	0	0	6	6	100
<b>Total</b>						<b>500/600*</b>
SOLS/Zool/E 008	Report based on Field work/Excursion –organized by the Department	0	0	3	3	100
SOLS/Zool/SS05	Cold Water Fisheries	0	0	0	3	100
SOLS/Zool/SS06	Environmental Biotechnology	0	0	0	3	100

\*Students securing Minimum 70% marks in I & II Semester together can opt for dissertation

**Total: 54 (Core Credits) + 18 (Elective Credits) = 72 Credits**

**Max. Marks for each paper: 100 [40 (Sessional Tests) + (60 End Term Test)]**

**Sessional (Mid Term Test, Assignment, Classroom Seminar & Laboratory Work, Internship, Industrial/Institutional visits, Winter/Summer Training based report Writing & Presentation, Report based on field trips, excursion organized by Department etc.)**

All 2-year Master's Programs will have the following components, viz.

(i) Core Course (C) - Minimum 54 credits; (ii) Electives (E) - Minimum 18 credits; (iii) Self Study Course (SS) - Maximum 09 credits (one minimum 03 credits course shall be mandatory but not to be included while calculating the grades)

\*M.Sc. 4<sup>th</sup> Semester – Core Course 3 (2 Theory +1 Lab Courses of 3 credits each), Elective Courses 3 (2 Theory + 1 Lab Courses of 3 credits each) / 1 Theory of 3 Credits + 1 Dissertation of 6 Credits, Dissertation be allotted in the beginning of 3<sup>rd</sup> semester to the students securing more than 70% in the First & Second Semester together).

**Note: Corrigendum in syllabus of M.Sc. Zoology Syllabus (3rd Semester) Core Course SOLS/Zool/C014 Ecology & Wildlife approved by Board of Studies (BoS) in the 21<sup>st</sup> meeting held on 30.10.2021.**

**SOLS/Zool/C001 Animal Diversity I (Lower Non-Chordata)**

No. of Credits = 3

**UNIT I**

Major and minor Invertebrate phyla: General characters, organization, classification up to order and their types. Origin and evolution of lower and higher invertebrates. Overview of economic importance of invertebrates.

**UNIT II**

Protozoa: Comparative morphology of all classes. Locomotor organelles and locomotion. Nutrition: holophytic, holozoic, saprozoic, myxotrophic and parasitic. Reproduction: A sexual and asexual reproduction, parthenogenesis, regeneration.

**UNIT III**

Porifera: Comparative morphology of all classes. Types of canal system. Reproduction: Asexual, sexual reproduction and regeneration in sponges.

**UNIT IV**

Coelenterata: Comparative morphology of all classes. Polymorphism, Coral reefs & formation, Affinities of Ctenophora.

Helminthes: Comparative external and internal morphology of platyhelminthes and Aschelminthes.

**Recommended Books:**

1. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington: Invertebrate Structure and function, Nelson, 1987.
3. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
4. Hickman, Roberts & Hickman: Integrated principles of Zoology (7th ed) Times-Mirror, Mosby, 1984.
5. Kotpal, Agrawal & Khetrapal: Modern Text-book of Zoology, Invertebrates. Rastogi, 1976.
6. Marshall & William: Text book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillan, 1972.

**SOLS/Zool/C002 Cell Biology & Molecular Biology**

No. of Credits = 3

**Cell Biology**

**UNIT I**

Ultrastructure of pro- and eukaryotic cells.

Plasma membrane: Structure - organisation, lipid bilayer, proteins & glycoconjugates, liposomes. Function- Ionic transport, transporter proteins, types of transport (symport, antiport, active & passive, endocytosis, exocytosis). Endomembrane system: Intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathways.

Cytoskeleton: Components & functions & derived organelles (cilium, flagellum).

Mitochondria: Structure function & genetic organisation. Ribosome: Biosynthesis & formation in nucleolus.

**UNIT II**

Signal Transductions

Cell signaling-types of signaling. Cell surface receptor mediated signaling.

Cell cycle: Molecular events during interphase, genetic regulation of cell cycle (including yeast as model system).

Cellular transformation and malignancy. Retroviruses, Apoptosis and causes of cancer.

**Molecular Biology**

**UNIT III**

The central Dogma of Molecular Biology.

DNA: Structure and conformation, supercoiling, packing of DNA into chromosomes. Structural polymorphism of DNA & RNA. Three-dimensional structure of t-RNA.

**UNIT IV**

DNA replication. Genetic code.

Transcription and translation in prokaryotes and eukaryotes. RNA processing. Mutations & DNA repair systems.

**Recommended Books:**

1. Mayr: Animal species and Evolution Belknap Press, 1966.
2. Moody: Introduction to evolution (Indian Edition) Kalyani Publ., 1978.
3. Strickberger: Evolution, (Indian Edition). CBS Publ., 1994.
4. Richard Swann Lull: Organic Evolution Seema Publications, 1976
5. Simpson G.G.: Principles of Animal Taxonomy, Columbia Univ. Press, 1961.
6. Mayr, E. Systematics and the Origin of Species, Columbia Univ. Press, 1942.
7. Blackwelder RE: Guide to the Taxonomic Literature of Vertebrates, Iowa State Univ. Press, 1972.

**M.Sc. Zoology 1<sup>st</sup> Semester****SOLS/Zool/C003 Genetics, Evolution & Taxonomy**

No. of Credits = 3

**Genetics****UNIT I**

Monohybrid and Dihybrid crosses with molecular explanations. Incomplete and Co dominance, Gene interaction, Lethal Alleles, Multiple Alleles, Pedigrees.

Modification of Dihybrid Ratios and their biochemical basis. Fine structure of Gene. Statistical Applications in Genetics (Probability and Significance Testing).

**UNIT II**

Linkage and Crossing over, Genetic mapping techniques. Sex Linked inheritance and genetic disorders. Mutations and Chromosomal Aberrations.

Operon hypothesis, Lac operon (positive and negative control). Regulation of gene expression in eukaryotes.

Population Genetics: Hardy Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic Drift.

**Evolution****UNIT III**

Natural Selection: Types of Selection and Selection coefficient. Role of Mutation in Evolution, (Gene mutation, Mutation Rates, Mutation and selection, Genetic Polymorphism).

Speciation: Isolating mechanism, Modes of Speciation (Allopatric, Sympatric, Parapatric).

Micro and Macroevolution.

Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna). Island Biogeography theory. Fossils and fossilization.

**Taxonomy****UNIT IV**

Theories of biological classification, Linnaean hierarchy.

Stages in taxonomy, Importance of Taxonomy.

Nomenclature: ICZN, Taxon, Rank and Categories. Important rules of Nomenclature, Latin words and abbreviations.

Biological Species Concepts (Polytypic and monotypic species, Subspecies).

Taxonomic characters and taxonomic keys. Preservation of collected material and curating

**Recommended Books:**

1. Gardner, Gimmons and Snustad: Principles of Genetics, John Wiley & Sons.
2. Robert, H. Tamarin: Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
3. Daniel L. Hartl and M. Ruvolo: Genetics Analysis of Genes and Genomes, Jones and Bartlett India Pvt. Ltd.
4. William S. Klung Cummings, Spencer and Pallidino: Concepts of Genetics, Pearson Education, Pearson Benjamin Cummings.
5. Benjamin A. Peirce: Genetics A conceptual Approach, W.H. Freeman and Company
6. TA Brown: Gene Cloning and DNA Analysis and Introduction, Wiley-Blackwell.
7. Allendorf, Luikart, Aitken: Conservation and the Genetics of Populations, Wiley-Blackwell.
8. Strickberger: Evolution, Jones and Bartlett Publishers.
9. Species Evolution: Role of Chromosomal Change, Cambridge University Press.
10. Ernst Mayr and Ashlock: Principles of Systematic Zoology, McGraw-Hill.
11. Ashok Verma: Principles of animal Taxonomy, Alpha Science International Ltd.
12. Judith E. Winston: Describing Species Practical and Taxonomic procedure for biologists, Columbia University Press.
13. V.C. Kapoor: Theory and Practice of Animal Taxonomy, Oxford and IBH Publishing Co. Pvt. Ltd.

**SOLS/Zool/C004 Developmental Biology & Parasitology**

No. of Credits = 3

**Developmental Biology**

**UNIT I**

Development and differentiation of sperm and oocytes, capacitation, vitellogenesis.  
Mechanism of fertilization acrosomal reaction, cortical reaction and fertilization membrane.  
Blocks to polyspermy, Parthenogenesis.  
Cellular differentiation (transcriptional regulation of gene expression, differential RNA processing and translation).  
Concept of organiser and embryonic inductions: primary, secondary & tertiary cellular interactions.  
Eye morphogenesis.

**UNIT II**

Development in Drosophila: Cleavage, gastrulation; Molecular basis of development, maternal-effect genes, segmentation genes and homeotic selector genes.  
Metaplasia & trans differentiation.  
Lymphocyte differentiation and genomic alterations.  
Limb morphogenesis. Regeneration, Teratogens.  
Metamorphosis: Insect, Amphibian metamorphosis.

**Parasitology**

**UNIT III**

Parasitism and evolution of parasitism.  
Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Entamoeba histolytica*, Trypanosomes, *Leishmania donovani*, *Trichomonas vaginalis*, *Giardia intestinalis* & *Plasmodium*).

**UNIT IV**

Parasitic adaptations in Platyhelminthes and Aschelminthes. Common trematode, cestode and nematode parasites. Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris*, *Schistosoma*, *Fasciola*, *Wuchereria*, *Taenia*)  
Introduction to arthropods and vectors of human diseases (mosquitoes, lice, flies & ticks).  
Parasitism in Crustacea

**Recommended Books:**

1. Gilbert: Developmental Biology. Sinauers Associates Publ. Massachusetts, 1997.
2. Balinsky: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London.
3. Berill: Development Biology. Tata McGraw Hill Publishing Co. Ltd
4. Casselman: Histochemical techniques, John Wiley, 1959.
5. Smyth (1994): Introduction to Animal Parasitology Cambridge University Press
6. Chatterjee: Parasitology, Chatterjee Medical Publisher, 1981.
7. Read: Animal Parasites, Prentice Hall, 1977.
8. Schmidt & Roberts 1989 Wiliam & Wilkins Foundations of Parasitology (IVth ed.)

**SOLS/Zool/C 005 Lab Course Based on C001 & C002**

**SOLS/Zool/C 006 Lab Course Based on C003 & C004**

**SOLS/Zool/C007 Animal Diversity II (Higher Non-Chordata)**

No. of Credits = 3

**UNIT I**

Minor Group: Classifications to order level, Characters and Affinities of Phoronida and Rotifera.

**UNIT II**

Annelida: Classification to order level, Comparative morphology of all classes, Coelom, Segmental organs.

Arthropoda: Classification to order level, Appendages & Mouth parts in insects, Larval forms in Crustacea, Arachnida.

Organization and Affinities of Onychophora.

**UNIT III**

Mollusca: Classification to order level, Comparative morphology of all classes, Major features of the Respiratory and Reproductive Systems, Larval forms, Torsion, Pearl formation.

**UNIT IV**

Echinodermata: Classification to order level, Water vascular system, Larval forms and affinities.

**Recommended Books:**

1. Kotpal R.L: Modern Text Book of Zoology: Invertebrates, Rastogi Publications.
2. Nigam H C: Biology of Non-Chordates, Nagin Chand, 1985.
3. Parker TJ & Haswell WA: A Text book of Zoology Vol I & II, McMillan
4. Hyman L: Invertebrate Series, Academic Press
5. Starr et al: Biology, The Unity and Diversity of Life
6. Twenhofel et al: Principles of Invertebrate Palaeontology
7. Doyle P: Understanding Fossils Invertebrate Palaeontology

**SOLS/Zool/C008 Animal Physiology**

No. of Credits = 3

**UNIT I**

Physiology of respiration: Exchange of respiratory gases at the pulmonary surface. Transport of respiratory gases by blood. Factors affecting oxyhaemoglobin dissociation. Neural and chemical control of respiration.

Physiology of digestion & absorption: Functional anatomy of the gastrointestinal tract. Gastrointestinal motility and its regulation. Secretions of the gastrointestinal tract. Liver and biliary system.

Digestion and absorption of proteins, fats and carbohydrates.

Physiology of excretion: Formation of urine: Functional anatomy of the kidney. Glomerular filtration and its control. Reabsorptions & secretions in the tubules. Mechanisms of active transport. Excretion and control of urea, sodium, potassium and other ions.

Functions of aldosterone, antidiuretic hormone and renin-angiotensin system in renal physiology. Osmoregulatory mechanisms.

**UNIT II**

Physiology of cardiovascular system: Characteristics of vertebrate cardiac muscle. Initiation, conduction and regulation of heart beat. Cardiac cycle and cardiac output.

Regulation of cardiac amplitude and frequency. ECG and myocardial infarction. Blood pressure and its regulation.

Circulation (open and closed, blood composition and function). Blood groups.

The cascade of biochemical reactions involved in coagulation of blood. Blood groups. Lymphatic systems.

**UNIT III**

Nervous system: Neuron - the basic functional unit, the sensory & motor divisions.

Ionic basis of resting and action potentials of neurons, significance of myelinated nerve fibers and velocity of conduction. Physiologic anatomy of the synapse.

Mechanism of synaptic transmission, transmitters (acetylcholine, norepinephrine, histamine, GABA). Reflexes and types of reflexes.

Neuromuscular physiology: Structural proteins of muscle cells, actin myosin complex and source of energy for contraction. Sliding filament theory of muscle contraction. Excitation-contraction coupling.

#### UNIT IV

Sensory physiology: The eye and visual processes - Functional anatomy of the structural elements of the retina. Photochemistry of vision. Extraretinal photoreception. Visual adaptations in vertebrates.

The ear and auditory processes - Tympanic membrane and the ossicular system. Conduction of sound from tympanum to cochlea. Functional anatomy of cochlea. Sound transmission in cochlea.

Mechanism of thermoregulation in poikilotherms, homeotherms and heterotherms. Aestivation and hibernation.

#### Recommended Books:

1. Knut Schmidt-Nielsen. Animal physiology-Adaptation and Environment. Cambridge University Press (1979)
2. Lauralee Sherwood, Hillar Klandorf, and Paul Yancey. Animal Physiology: From Genes to Organisms. Cengage Learning (2012)
3. . Richard W. Hill, Gordon A. Wyse, Margaret Anderson - Animal Physiology, 3rd Ed-Sinauer Associates, Inc. (2012)
4. Srivastava A K. Animal Physiology and Biochemistry S. Chand Publications (1986)
5. Singh H. R and Kumar N. Animal Physiology and Biochemistry. Vishal Publishing Co.

### M.Sc. Zoology 2<sup>nd</sup> Semester

#### SOLS/Zool/C009 Instrumentation, Computer Application and Biostatistics

No. of Credits = 3

#### Instrumentation

##### UNIT I

Principles and applications of Microscopy: Light, phase contrast, transmission electron microscopy (TEM & SEM). Colorimeter, Spectrophotometer.

##### UNIT II

Centrifugation. Clinical, high-speed and ultracentrifuges.  
Chromatography: Paper, thin layer chromatography, GLC.  
Electrophoresis: Agarose, Polyacrylamide, two-dimensional gel electrophoresis

#### Computer Application

##### UNIT III

Introduction to Computers: Mini, micro, mainframe and super computers; Components of a computer system (CPU, I/O units). Data storage device, Memory concepts.  
Software and types of software.  
Computer applications in biology and information communications (databases, e-mail and local networks).

#### Biostatistics

##### UNIT IV

Biostatistics: Importance of statistics in biological research. Introduction to some distributions of random variables: Binomial, Poisson, normal. Basic/Descriptive statistics: Measures of central tendency and measures of dispersion.

Skewness & kurtosis. Simple correlation and linear regression (scatter diagram, regression coefficients, regression lines).

Elementary idea of random variables. Students-t, chi-square and F-Tests of Significance testing and their purpose: Introduction to Statistical softwares. MS Excel and their purpose.

#### Recommended Books:

1. Hoel, P.G.: Elementary Statistics. John Wiley & Sons, Inc. New York.
2. Mahajan: Methods in Biostatistics, (4th ed.). Jaypee Bros. 1984.
3. Milton & Tsokos: Statistical Methods in Biological and Health Sciences, McGraw Hill, 1983.
4. Sokal & Rohlf: Introduction to Biostatistics. Freeman, Toppan, 1973.
5. D. Rajaraman & V. Rajaraman: Computer Primer (2nd ed.). Prentice Hall of India, New Delhi.
6. Roger Hunt & John Shelley: Computer and Commonsense. Prentice Hall of India, New Delhi.
7. Peter Norton's: Introduction to Computers with CD-ROM, 2<sup>nd</sup> ed. Tata McGraw Hill.
8. Zar JH: Biostatistical Analysis. Pearson.
9. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill

**SOLS/Zool/C010 Elementary Biotechnology & Microbiology**

No. of Credits = 3

**Biotechnology**

**UNIT I**

Biotechnology: History, definition & Scope.

General steps of Gene cloning-cutting, ligation, transformation and analysis of clones, genomic & C-DNA library.

A general idea of cloning vectors based on plasmid & phages, blotting techniques, DNA-sequencing, polymerase chain reaction.

**UNIT II**

Gene therapy, DNA finger printing, Transgenic animals and plants. Potential hazards of recombinant DNA technology.

Products of recombinant DNA technology, Human genome project and its applications.

**Microbiology**

**UNIT III**

Microbiology: Bacteria - classification, staining techniques, pathological significance.

Physiology, genetics & reproduction of viruses of plants and animals, Bacteriophage, lysogenic & lytic cycle, Bacterial genetics.

Microbial culture techniques & media enrichment techniques.

Microbial fermentation: Microbes in decomposition and recycling processes.

Microbes as pathological agents in plants, animals and man.

**UNIT IV**

Laboratory facilities, culture media for animal cell culture, Primary culture, cell lines and cloning, Tissue and organ culture, Transfection methods & transgenic animals. Molecular markers CRFLPs, RAPDs, minisatellites, microsatellites. Application of animal cell culture.

**Recommended Books:**

1. Pelczar: Microbiology, Tata McGraw Hill, 1993
2. Davis: Microbiology (3rd ed.) Harper & Row, Publ. Inc., 1980
3. Dubey and Maheshwari: An Introduction to Microbiology, S Chand Publications, New Delhi

**SOLS/Zool/C 011 Lab Course Based on C007 & C008**

**SOLS/Zool/C 012 Lab Course Based on C009 & C010**

**Self Study Course**

**SOLS/Zool/SS01 Basic Bioinformatics**

No. of Credits = 3

**UNIT I**

Biology & IT, Computers in biology & medicine, Introduction to Genomics, Proteomics, Drug Design, etc.

Introduction to networking. Networking protocols. LAN, MAN, WAN, Internet (www), FTP.

**UNIT II**

Biological sequence data banks (GENBANK, EMBL, PDB, SWISSPROT).

Sequence alignments (Global & Local), Algorithms used (Dynamic & Heuristic) –

Needleman Wunsch, Smith Waterman, BLAST, FASTA; Substitution matrices.

**UNIT III**

Sequence analysis using s/w tools (DNASIS, GENESCAN).



Introduction to Phylogenetic trees, Algorithms for construction of phylogenetic trees.

#### UNIT IV

Molecular structure prediction, RNA secondary structure prediction and algorithm used.

Introduction to Human genome project.

Introduction to Bio Perl.

#### Recommended Books

1. Attwood & Smith: Introduction to Bioinformatics, Pearson Education Pt. Ltd., 2004.
2. Arsthur M. Lest: Introduction to Bioinformatics, Oxford University Press, 2002.
3. Bioinformatics-Sequence, structure and Databanks, 4<sup>th</sup> ed. Oxford University Press, 2006.
4. Lacroix and Critchlow: Bioinformatics-Managing Scientific Data, 1<sup>st</sup> ed., Margan Kaufmann Publishers, 2003.
5. Misener and Krawetz: Bioinformatics-Methods & Protocol, Vol. 132, Human Press, New Jersey, 2003.

### M.Sc. Zoology 2<sup>nd</sup> Semester

#### SOLS/Zool/SS02 Human Population Genetics

No. of Credits = 3

##### UNIT I

Definition, aim and scope of population genetics, Mendelian principles of inheritance and their relevance to human populations. The Mendelian population, gene pool.

##### UNIT II

Mutations in Man- Determining the human mutation rate, selection, Fitness, Balance. Hardy – Weinberg Law and its applications in human populations genetics.  
Population distance – Genetic Distance, Morphological distance and population heterogeneity.

##### UNIT III

Genetic polymorphism – Concept, Balanced and transient stages models explaining maintenance of genetic polymorphism.  
Heterozygans selection, Intra uterine selection, fitness as a function of gene frequency.

##### UNIT IV

Genetic isolates – Formation and disintegration, genetic consequences of isolate formation with special reference to genetic drift.  
Genetic and variability of (i) Skin pigmentation (normal & induced) (ii) dermal ridge patterns (iii) serological traits (ABO, MN, Rh & secreted factors).

#### Recommended Books

1. Caualli-Sforza, L.L.: The genetic of Human Population Crow.
2. Kimura, M: An Introduction to Population Genetic Theory, Harrison and Boyce.
3. Stern, Curt: Principles of Human Genetics.
4. Vogel, F. & Matulsky A.G.: Human Genetics: Problems & Approaches.

### M.Sc. Zoology 3<sup>rd</sup> Semester

#### SOLS/Zool/C 013 Animal Diversity (Chordata)

No. of Credits = 3

##### UNIT I

General Characters, classification, development of Urochordata and Cephalochordata.  
Affinities of Hemichordata, Urochordata & Cephalochordata.

##### UNIT II

General Characters, Classification and affinities of Cyclostomata  
Salient features of different groups of fishes; comparison between Chondrichthyes and Osteichthyes; Dipnoi.  
Origin and evolution of Amphibia  
Parental care in Amphibia

### UNIT III

General characters and classification of Reptilia and Aves.  
Origin of Reptilia and adaptive radiation in Reptilia.  
Characters and affinities of Chelonia and Rhynchocephalia  
Origin and ancestry of birds, Characters and affinities of Ratitae  
Origin and mechanism of flight in birds.  
Palate in birds.  
Migration in birds.

### UNIT IV

General characters and classification of mammals.  
Origin of mammals.  
Characters and affinities of Prototheria and Metatheria  
Dentition in mammals  
Aquatic and flying adaptations in mammals  
Adaptive radiation in mammals.

#### Recommended Books:

1. Parker T.J. & Haswell W.A.: A Text Book of Zoology, Vol II, ed. 7<sup>th</sup>, Macmillan & Co. Ltd, London, 1962.
2. Young J.Z.: The Life of Vertebrates, Oxford, 1950.
3. Kotpal, R.L. Modern Text Book of Zoology, Vertebrates. Rastogi Publication, Meerut.

## M.Sc. Zoology 3<sup>rd</sup> Semester

### SOLS/Zool/C014 Ecology & Wildlife

No. of Credits = 3

#### Unit I

**Limiting Factors:** Liebig's law of minimum, Shelford's law of tolerance. Combined concept of limiting factors, Factor interaction.

**Biogeochemical cycle:** Concept & types of biogeochemical cycle (nitrogen, phosphorus, carbon & water cycle)

**Ecosystem:** Concept & types of ecosystems. Energy flow, food chain & ecological pyramids

**Habitat Ecology:** Concept of habitats & niche. Ecotone & Edge effect, Habitat fragmentation, Habitat Management; Use of Toposheets and GIS Imageries.

#### Unit II

**Population:** Concepts & attributes; Biotic potential; Density, Natality, Mortality and reproductive rates; Intrinsic rate of natural increase; Survivorship curves.

**Population Growth & Regulation:** Logistic theory, Stochastic models. Carrying capacity; Population regulation (density dependent & density independent); Cycles & fluctuations.

**Community:** Concept & characteristics (stratification, density, dominance & diversity); Ecological succession (concept & models), keystone species.

#### Unit III

**Biodiversity:** Concept & importance. Genetic, species and ecosystem diversity; Factors influencing biodiversity; Endemism, Hot spots of biodiversity.

**Environmental Pollution:** Definition and types of pollution. Sources and effects of pollution (air, water, solid waste, radioactive).

**Environmental Impact Assessment (EIA):** Concept, process & importance; Hydropower projects, E flows, ecosystem services, decommissioning of dams.

**Physiography of India:** Biogeographic zones their characteristics and faunal composition.

**Himalayan Region:** Habitat types and distribution of endangered fauna.

#### Unit IV

**Wildlife population estimation techniques:** Transects, Drive counts, Aerial Counts, Point counts, Quadrates.

**Population indices:** Camera traps, natural marking, pug marks, cells, dung, pellets, scats, tags & rings.

**Capturing, Handling and Immobilization of Wildlife:** Types of Traps & trap setting; Methods for capturing (Fish, Reptiles, Birds and Mammals); Darts and guns, drugs and antagonists used.

**Radiotelemetry:** Concept & use; Radio collars, antenna and receivers, satellite collars.

**Conservation:** IUCN categories for conservation; Indian Wildlife Protection Act, CITES, WWF.

**Use of Biotechnology in Conservation:** Collection, extraction and preservation of DNA samples from Wild, Amplification, Sequencing and Molecular markers. Ancient DNA.

## Recommended Books:

1. Bookhout, A. Theodore: Research and Management Techniques for Wildlife Habitats. The Wildlife Society, Bethesda, 1996
2. Krebs, C.J.: Ecology (6th ed.) Harper Collins College Publisher, 2016
3. Majupuria T C: Wildlife Wealth of India, Tecpress Service, Bangkok, 1990
4. Menon, Vivek: Indian Mammals: A Field Guide. Hachette Book Publishing India Pvt. Ltd.
5. Odum: Fundamentals of Ecology, Saunders Co. Publ., 1993 Indian ed.
6. Prater, S.H.: The Book of Indian Animals, BNHS, Oxford University Press 1993.
7. Richard D. Teague: A Manual of Wildlife Conservation, Nataraj Publishers, 1989.
8. Ricklef, R.E.: Ecology, Newton Mass, Chiron Press, 1973
9. Robert H. Giles: Wildlife Management Techniques (3rd ed.) Natraj Publishers, Dehradun, 1981
10. Smith RL: Ecology and Field Biology, Harper Collins Publ. 1996.
11. Sutherland, William J.: Ecological Census Techniques. Cambridge University Press, 2006

## SOLS/Zool/C 015 Lab Course Based on C013 & C014

### M.Sc. Zoology 3<sup>rd</sup> Semester

#### SOLS/Zool/E 01a Fish Biology I

No. of Credits = 3

#### UNIT I

##### Systematics and Phylogeny

Introduction and History of Ichthyology. Zoogeographical distribution, Origin, evolution, and phylogeny of fishes. Schemes of classification of fossil and recent fishes. General Characters of Teleost and Elasmobranch fishes.

#### UNIT II

Agnatha: Characters, basic biology and affinities of Cyclostomes and Ostracoderms.

Placoderms: General characters and affinities.

Holocephali: Salient features external and internal morphology and affinities.

Dipnoi: Salient features and affinities.

#### UNIT III

##### Comparative Morphology of Telesosts and Elasmobranchs

Integuments (Teleosts and Elasmobranchs), colouration and its significance, mechanism of colour change.

Exoskeleton: Structure and development of placoid and nonplacoid scales. Fins and their origin.

Skeletal system: Skull. Vertebrae, Girdles, Opercular bones, Pharyngeal bones in teleosts and elasmobranch.

#### UNIT IV

##### Comparative morphology of following organs in teleosts and elasmobranchs.

Alimentary canal and associated glands. Modifications based on different feeding behaviour.

Structure of heart, afferent and efferent branchial arteries.

Structure of a Gill and Pseudobranch.

Brain and cranial nerves.

Urinogenital system.

## Recommended Books:

1. Khanna, S.S. and Singh, H.R. A Text Book of Fish Biology and Fisheries. Narendra Publishing House, Delhi- 110 006
2. Gupta, S.K. and Gupta, P.C. General and Applied Ichthyology (Fish and Fisheries). S Chand Publications, New Delhi- 110055

**SOLS/Zool/E 01b Entomology I**

No. of Credits = 3

**UNIT I**

Introduction to external morphology: body wall, segmentation. The head: structure of head; appendages, and antennae. The thorax: pro, meso and metathorax; legs. The wings: origin, structure and articulation. The abdomen: structure, appendages; external female and male genitalia.

**UNIT II**

Classification of insect with special reference to that of different orders. General characters, habits, habitats, importance of the insect orders-Collembola, Protura, Diplura, Thysanura, Ephemerida, Placoptera, Odonata. General characters, habits, habitats, importance of the insect orders-Embioptera, Orthoptera, Phasmida, Dermaptera, Blattaria, Menteodea, Isoptera, Zoraptera.

**UNIT III**

General characters, habits, habitats, importance of the insect orders-Psocoptera, Thysanoptera, Heteroptera, Homoptera, Anoplura, Neuroptera, Megaloptera, Trichoptera.

**UNIT IV**

General characters, habits, habitats, importance of the insect orders-Coleoptera, Strepsiptera, Hymenoptera, Lepidoptera, Diptera.

**Recommended Books:**

1. Metcal & Flint: Destruction and useful Insects, Tata McGraw-Hill, 1979
2. Ayyar, TVR: Hand Book of Economic Entomology for South India, International Book & Periodical Supply Service, 1984.
3. Pruthi HS: Text Book on Agricultural Entomology, ICAR Publication, 1969.
4. Fernald HT, HH Shepard: Applied Entomology, McGraw-Hill, 1955
5. Frost SW: Insect life and insect Natural History, Dover Publication, New York, 1959.
6. Mehta PR & Varma BK: Plant Protection, Directorate of Extention, Ministry of Food, Community development & Co – operation, New Delhi, 1968.
7. Ananthakrishnan TR: Applied Entomology
8. Evans JW: Insect Pests and Their Control, Periodical Expert Book Agency, 1984.
9. Bhutani DK & Jotwani MG: Insects in Vegetables, Periodical Expert Book Agency

**SOLS/Zool/E 01c Environmental Biology I**

No. of Credits = 3

**UNIT I**

Introduction to Environmental biology, its multidisciplinary nature and scope. Components of Environment: atmosphere, lithosphere & hydrosphere. Climate (micro, regional and global); Hydrological cycle; Soil profile. Changing interactions between man and environment (cultural, political, ecological).

**UNIT II**

Terrestrial biomes of the world their characteristics and major biota (Grassland, Desert, Forest, Tundra). Aquatic biomes (lotic, lentic, marine, estuaries, coral reef), their status. Wetlands of India. Environmental adaptations: Aquatic, Aerial, Desert, Arboreal, Fossorial, Defensive.

**UNIT III**

Island biogeography theory. Habitat fragmentation, Habitat selection, Corridors, Community patterns (gradients and Continuum), Community indices. Ecological niche. Population cycles and fluctuations; Dispersal. Intra & Inter specific relationship. Models of succession; Pioneer & climax concept.

**UNIT IV**

Concept of biological indicators; biological monitoring; Indicator organisms. Invasive species and its impact. Biological control: Biomagnification, Bioassimilation & Bioaccumulation. Elementary Toxicology, Xenobiotics: Carcinogenic (heavy metals, radioactive substances and pesticides) their chemical nature.

**SOLS/Zool/E 01d Reproductive Biology I**

No. of Credits = 3

**UNIT I**

**Sex Genetics:** Sex determination, Gonadal Differentiation and development.  
Role of Y chromosomes (mammals) and autosomes and sex hormones.  
Sex hormones and differentiation of brain and reproductive behaviour.

**UNIT II**

**Hormones of Reproduction:** Gonadotropins, Chemistry and Synthesis.  
**Sex steroids:** Synthesis ( $\Delta 4$  and  $\Delta 5$  pathways) & excretion of steroids.  
**Mechanism of action:** GnRH, androgens, estradiol and progesterone.

**UNIT III**

**Endocrine control of male reproduction (rat/man).**  
Hormonal control of spermatogenesis, Androgen binding protein (ABP), Inhibin.  
Neuroendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epithelium, LH-effects on Leydig cells, negative feedback regulation).

**UNIT IV**

**Endocrine control of female reproduction (rat/man)**  
Hormonal control of ovulation. The ovary and the reproductive tract. The ovarian cycle.  
Folliculogenesis, Ovulation, formation & degeneration of corpus luteum. Neuroendocrine control of ovarian function. (GnRH secretion, FSH LH-effects on developing follicles, ovulation, corpus luteum formation & function, cellular effects of LH, FSH in hormone production). Foetoplacental Unit and Feedback mechanisms.  
Estrus & menstrual cycles.  
The Role of CNS, Hypothalamus and Pineal in Reproduction. Reproduction in wild animals.  
Timing of reproduction phenomenon of seasonality. The Biological clock.

M.Sc. Zoology 3<sup>rd</sup> Semester

**SOLS/Zool/E 02a Fish Biology II**

No. of Credits = 3

**UNIT I**

**Specialized Characters**  
Accessory Respiratory organs in fishes.  
Swim Bladder and its modifications, Blood supply of Air bladder, Gas secreting complex, Functions  
Weberian ossicles: Structure and arrangement, Working mechanism and functions.  
Electric organs: Structure, Mechanism of electric discharge, Functions.  
Bioluminescence: Luminiscent organs, Mechanism of light emission, Significance.  
Sound production in fishes

**UNIT II**

**Fish Behaviour**  
Fish behavior: Social, ecological, reproductive, migratory, foraging behavior. Parental care in fishes.  
Receptor organs: Eye, Acoustico-Lateralis system, olfactory organs and Taste buds  
Migration in fishes: Pattern, Causes and Factors influencing.  
Parental care and viviparity in fishes.  
Pheromones and their role in sexual behavior of fish.

**UNIT III**

**Fish Physiology and Embryology**  
Fertilization and development of fish egg (Teleost). Cleavage, Blastulation, Gastrulation and fate map.  
Hatching and post-embryonic development.  
Respiration: Functional organization of Gill lamellae, Blood supply of gill, Mechanism of gas exchange, Counter current mechanism.  
Physiology of excretion and osmo-regulation, Mechanism of water- salt balance in freshwater, marine and estuarine fishes.  
Reproductive physiology: Spawning patterns and stimulating factors, Follicular atresia.  
Haemopoiesis: Composition of Blood, haemopoietic tissues, synthesis of Haemoglobin.  
Physiology of Thermo-regulation in fishes.

**UNIT IV**

**Endocrine and Biochemistry**  
Pituitary gland: Micro-anatomy, Hormones of Pituitary and their physiological actions.  
Thyroid gland: Structure and function  
Structure and functions of Pancreatic islets in fishes.  
Location and functions of Corpuscles of Stannius, Pineal and Urophysis in fishes.

**Recommended Books:**

1. Kyle: The Biology of Fishes, 2007.
2. Singh H.R.: Advances in Fish Biology, Hindustan Publishing Corp., 1994.
3. Munshi J.D. & Munshi J.S.D.: Fundamental of Freshwater Biology, Narendra Publ. House, 1995.
4. Khanna S. S. & Singh H.R. : A Text Book of Fish Biology & Fisheries, Narendra Publ. House, 2014
5. Srivastava C.B.L.: Fish Biology, Narendra Publication House, 2008.
6. Ojha J.: Biology of Hill Stream Fish, Narendra Publication House, 2002.

**M.Sc. Zoology 3<sup>rd</sup> Semester****SOLS/Zool/E 02b Entomology II**

No. of Credits = 3

**UNIT I**

Digestive system: Structure, physiology of digestion and absorption of different types of food.

Structure of circulatory system: Haemolymph its composition and function.

Physiology of respiration: The tracheal system, spiracles, respiration in aquatic insects.

Nervous system: Structural basis

Excretion: Structure and physiology of malpighian tubules and its secondary functions. Reproduction: male and female gonads.

**UNIT II**

Structure of compound eye, mosaic vision; Production and reception of sound; Light producing organs.

Hormones: Neurosecretion and co-ordination, Metamorphosis: types, hormonal control of metamorphosis, Pheromones.

**UNIT III**

Structure of the insect egg, maturation, cleavage, formation of blastoderm, gastrulation, blastokinesis, germ layers, Various types of larvae and pupae, moulting, diapauses, Oviparity, viviparity, ovo-viviparity in insects.

**UNIT IV**

Abiotic factors: effect of temperature, light and humidity on growth of insect population; biotic potential, Malthusian principle and dynamics of population fluctuation, hibernation, aestivation. Biotic factors: parasitism, predation and social life in insects, phase theory of locust, parental care.

**Recommended Books:**

1. Mani MS: An Introduction to Entomology, National Book Trust, 1971.
2. Mani MS, Introduction to High Entomology, Mathuen & Coy. Ltd. 1962.
3. Snodgrass RE: Arthropod Anatomy, Comstock Publ. Associates, NY, 1952.
4. Wigglesworth VB: Insect Physiology, Cambridge University Press, 1954.
5. Essig EO: College Entomology, Satish Book Enterprise, Agra, 1982.
6. Fox RM & Fox JW: Introduction to Comparative Entomology. Affiliated East-West Press Pvt. Ltd. New Delhi, 1968.
7. Little VA: General & Applied Entomology, Oxford & IBH Publ. Copy, 1963.
8. Imms AD: Insect Natural History, Collinns St. James's Place London, 1947.
9. Elzinga RJ: Fundamentals of Entomology, Prentice Hall of India Pvt. Ltd., 1978.
10. Comstock JH: An Introduction to Entomology, Comstock Publ. Coy. INC., 1950.
11. Richard DW and Davies RG: A General Text Book of Entomology, Mathuen & Coy., Ltd.

**M.Sc. Zoology 3<sup>rd</sup> Semester****SOLS/Zool/E 02c Environmental Biology II**

No. of Credits = 3

**UNIT I**

Natural Resources: Management & conservation; Renewable & non-renewable resources;

Concept and currencies of Sustainable development.

Biodiversity & its conservation. Environment Protection laws. Earth Summit, Rio+20.

**UNIT II**

Concept of Protected areas: Sanctuary, National Parks & Biosphere Reserves. IUCN. Categories Biodiversity hot spots, conventions on biodiversity.

International efforts in biodiversity conservation (UNFP, IUCN, WWF); CITES; UNESCO's World heritage mission; Convention on Biological Diversity (CBD).

### UNIT III

Global Environmental Problems: Climate change, Green house effect; Acid rain; Ozone layer depletion; Deforestation; Desertification; Marine pollution; Urbanization.

#### Elementary Toxicology:

Exposure to Toxicants: Routes & sites of exposure (inhalation, injection & through food or intestinal).

Duration & frequency of exposure: Acute, subacute, chronic & subchronic.

Chemical nature of toxicants.

Mechanism of action: Receptors (Proteins), mechanism of action of DDT, Lead (Pb) & UV rays.

### UNIT IV

Environmental Problems/Hazards in Hills: Earthquake; Land slide; Soil erosion; Sedimentation; Cloud burst; Flash floods; Glacial retreat.

Application of Remote sensing & Geographical Information Systems (GIS) in environment management.

Disasters, their types and management.

#### Recommended Books:

1. D.E. Hathway: Molecularly aspects of Toxicology: The Royal Society of Chemistry, Burlington House, London.
2. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.
3. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bunglow Road, Delhi Ecology and Environment
4. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
5. Joshi, P C and Joshi, N. Ecology and Environment. Himalayan Publishing House, Delhi, 2005

### M.Sc. Zoology 3<sup>rd</sup> Semester

#### SOLS/Zool/E 02d Reproductive Biology II

No. of Credits = 3

##### UNIT I

Abiotic & Biotic factors influencing life. Zoogeographical regions of the world.

Physiographic diversity of Indian main land. Biogeography of India. Himalayan Biogeography.

Forest types of India. Representative fauna from different biogeographic zones.

Biological diversity: Genetic diversity. Taxonomic diversity, Functional diversity, Measurement of biodiversity (morphological & karyotypic variation, protein & DNA markers).

Evolution of diversity (e.g. birds). Species and speciation, Variation within species.

##### UNIT II

**Population Ecology:** Density, Dispersion, Age Structure, Sex ratio, Mortality, (Survivorship & Mortality curves). Natality. Population growth & regulation: Population growth (Exponential, Logistic) & Fecundity. Prey predator relationship. Interspecific and intraspecific competition: Territoriality and Home range. Resource partitioning and utilization.

##### UNIT III

Population Genetics: Genetic variation and evolution, Genetic heterozygosity (genotypes, phenotypes, sources of variation, Hardy-Weinberg equilibrium, nuclear and Mt DNA).

Gene flow, Inbreeding depression, Coefficients, Genetic drift, Minimal viable population.

##### UNIT IV

Reproductive patterns (mating, sexual selection, resource-based, genes based, Lek behaviour).

Reproductive isolation, ecological isolation. Reproductive efforts (Parental care, parental investment, parental energy budget). r selection, k selection.

Endangered species: Cheetah, Project Elephant, Gir Lions, Tiger project, Musk deer. Sanctuaries and National parks of India.

Wildlife Trade. Role of NGO's, IBWL, WWF, IUCN, CITES. Wetlands, Wildlife Protection Act.

#### SOLS/Zool/E 03 Lab Course Based on E 01 a/b/c/d & E 02 a/b/c/d

**Self Study Course****SOLS/Zool/SS 03 Biological & Radiotracer Techniques**

No. of Credits = 3

**UNIT I**

Analytical separation methods:

Chromatography - General principle and application

Adsorption chromatography, Partition chromatography, Gas chromatography, liquid chromatography, Paper chromatography, Thin layer chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, HPLC (High Performance/Pressure Liquid chromatography).

**UNIT II**

Electrophoresis - General principle and application

Paper electrophoresis, Moving boundary method, Gel electrophoresis (Native, Denaturing &amp; Reducing), Disc Gel electrophoresis, Slab Gel electrophoresis, Isoelectrofocussing (IEF), Isotachopheresis.

**UNIT III**

Centrifugation: Basic principles. Common centrifuges used in laboratory (clinical, high speed &amp; ultra centrifuges). Sedimentation rate, Sedimentation coefficient, Zonal centrifugation, Equilibrium density gradient centrifugation

Types of rotors (fixed angle, swing bucket), Types of centrifugation: Preparative, differential &amp; density gradient.

Microscopy: Light, phase contrast, Fluorescence and Confocal microscopy, Scanning and Transmission Electron microscopy.

**UNIT IV**

Biosensors: Introduction &amp; principles. First, second &amp; third generation instruments, cell based biosensors, enzyme immunosensors.

Spectroscopic methods: principle and applications of UV-visible, IR, NMR, ESR Spectroscopy. Principle &amp; application of X-ray crystallography.

Application of radioisotopes in biology. Properties and units of radioactivity.

Radioactive isotopes and half life.

Measurement of radioactivity: GM Counter, gamma counter, liquid scintillation counter.

Tracer techniques of Autoradiography, Radioimmunoassay.

Safety rules in handling of radioisotopes and hazardous chemicals.

**Recommended Books:**

1. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill, 1991.
2. Alberts et al.: Molecular Biology of the cell (2nd ed.), Garland, 1989.
3. Biochemical Technique: Theory & Practical J.F. Robyt & B.J. White Waveland Press, Inc.
4. Wilson & Walker: Practical Biochemistry (4th ed) University of Hertfordshire Cambridge University Press
5. Jayraman: Laboratory Manual in Biochemistry
6. Arnold L. Demain & Julian E. Davies: Manual of Industrial Microbiology & Biotechnology 2<sup>nd</sup> ed.

**SOLS/Zool/SS 04 Aquatic Biodiversity**

No. of Credits = 3

**UNIT I**

Biodiversity: Definition, Concept, Scope and measurement of biodiversity.

Types of Biodiversity: Species, Genetic, Community, Ecosystem.

Factors governing biodiversity: Historical &amp; Proximate

Endemic species: Definition, Concept, Scope, Hot spots

**UNIT II**

Types of aquatic ecosystem &amp; biomes and their characteristics.

Freshwater biodiversity.

Marine biodiversity.

Biodiversity data bases of CMFRI, CIFRI, NBFGR.

**UNIT III**

Threats to habitats and Biological diversity in Freshwater and marine ecosystems.

Endangered species: Definition, Concept, Scope.

Conservation; Definition, Concept, Scope.

Physical and chemical characteristics of freshwater rivers, lakes, reservoirs and wetlands.

Over view of freshwater biodiversity in important Rivers, Lakes Reservoirs and Wetlands of India with emphasis on Himalaya.



#### UNIT IV

Impact of Hydroelectric Projects (HEP) on aquatic biodiversity.

Environmental Impact Assessment (EIA): Case studies.

Environmental flows: Importance for the aquatic flora & fauna.

Environmental flows assessment methodology: Hydrological, hydraulics rating, habitat simulation & holistic.

#### Recommended Books:

1. KJ Gaston & JI Spicer: Biodiversity: An Introduction
2. WT Edmondson: Freshwater Biology
3. VG Jhingran: Fish & Fisheries of India
4. EP Odum: Ecology
5. HBN Hynes: Freshwater Ecology
6. WK Dodds: Freshwater Ecology
7. Rivers for Life: Managing water for people and nature, Sandra Postel, Brain D. Richter
8. Nautiyal P & Singh H R Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009
9. Nautiyal et al. Ecology & Diversity of Freshwater Environments. Transmedia, Srinagar Garhwal, 2005

#### M.Sc. Zoology 4<sup>th</sup> Semester

#### SOLS/Zool/C016 Endocrinology & Animal Behaviour

No. of Credits = 3

#### Endocrinology

##### UNIT I

Endocrine messengers: hormones, neurohormones, hormone like substances (neuronal peptides, autocooids, pheromones, neurosecretion).

Hormones and Physiological actions of the following endocrine glands in vertebrates: Thyroid, Parathyroid, Pancreas, Gastro-intestinal tract, Adrenal cortex and Medulla, Thymus & Pineal.

Hormone biosynthesis: Protein peptide hormones (gonadotrophins, thyrotrophin, corticotrophin, Steroids and catecholamines).

Mechanism of action of Protein hormones and Catecholamines: membrane bound receptors, G-protein and control of adenylyl cyclase, Cyclic nucleotide cascade.

##### UNIT II

Organisation & physiological actions of the Testis: Androgen binding protein (ABP), Inhibin. Neuroendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epithelium, LH-effects on Leydig cells, negative feed back regulation).

Organisation & physiological actions of the Ovary: Folliculogenesis, Ovulation, Luteinization, Ovarian cycles; Seasonal reproductive cycles; sexual dysfunctions in man.

#### Animal Behaviour

##### UNIT III

The science of behaviour: History, scope and terminology. Proximate and ultimate causes of behaviour.

Instinct: Definition and characteristics (sign stimuli and Fixed Action Pattern).

Learning behaviour: Definition. Spatial learning. Associative learning, classical conditioning, operant conditioning, language learning. Imprinting. Kin recognition. Instinct versus learning behaviour.

Timing of behaviour: Biological rhythms. The Biological Clock. Circadian rhythms and their synchronisation seasonal rhythms. Photoperiodism.

##### UNIT IV

Communication: Visual, olfactory, acoustic. Bird songs. Amphibian calls. Communication in bats. (echolocation in bats, electrolocation in fish)

Chemoreception: Chemicals (pheromones) as signals in insects, fish and mammals. Role of olfaction in communication behaviour (territorial, sex recognition, feeding etc) in fish and mammals.

Neural control of behavior:

Components of brain involved in various behaviours. Neural control of drinking, learning, eating, activity & rest, sleep, aggression, sexual behaviour.

Hormonal Control of behaviour. Hormone brain relationships. Sexual behaviour in mammals (eg. rat).

Sociobiology: Elements of sociality and social grouping in animals.

#### Recommended Books:

1. Alcock: Animal behaviour Sinaur Associates, Inc. 1989.
2. Goodenough et al.: Perspectives on animal behaviour. Wiley & Sons, New York. 1993.
3. Grier: Biology of animal behaviour, Mosby 1984.
4. Krebs & Davies: An introduction to behavioural ecology (3rd ed.) Blackwell 1993.
5. Lehner: Handbook of ethological methods, Garland STPM Press, New York, 1979.
6. Halliday, T.R.: Animal Behaviour Vol. 1 & 2 Communication, 1983.
7. Saunders: Insect Clocks Pergamon Press. 1982.
8. Palmer: An Introduction to Biological Rhythms Academic Press New York. 1976

9. Ross & Salisbury: Plant Physiology, Indian ed. (FOR BIOLOGICAL RHYTHMS)
10. Mac E. Hadley: Endocrinology, Prentice-Hall International ed. 1988/1992.
11. G J Goldsworthy et al: Endocrinology, Blackie, 1981.
12. Maurice Goodman: Basic and Medical Endocrinology, Raven Press.
13. F.S. Greenspan & P.H. Forsham: Basic and Clinical Endocrinology Maruzen Asian Ed. Lange Medical Publ. USA, Singapore
14. Chester-Jones: Fundamentals of Comparative Vertebrate Endocrinology Plenum Press, New York & London, 1987.
15. P.J Bentley: Comparative Vertebrate Endocrinology S. Chand & Company Ltd, Ram Nagar New Delhi, 1980
16. Wilson Foster: Williams Textbook of Endocrinology, Seventh ed. Saunders International ed. London, 1985.

## M.Sc. Zoology 4<sup>th</sup> Semester

### SOLS/Zool/C017 Biochemistry and Immunology

No. of Credits = 3

#### UNIT I

Enzymes: Classification (rationale, overview and specific example) Zymogens and their activation (protease and Prothrombin).

Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Lock and Key Hypothesis, Induced –Fit Hypothesis, Michaelis- Menten equation and its derivation, Different plots for the determination of Km and Vmax.

Carbohydrate Metabolism I: Pathway and regulation of Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis.

Carbohydrate Metabolism II: Citric acid cycle and its regulation, electron transport chain and oxidative phosphorylation, pentose phosphate pathway and its regulation.

#### UNIT II

Amino Acid Metabolism: Overview of Amino acid degradation, Urea cycle (conversion of ammonia into urea, linkage between urea cycle and citric acid cycle) and its regulation.

Conversion of nitrogen to ammonia by microorganisms, overview of amino-acid biosynthesis.

Fatty Acid Metabolism: Fatty Acid Oxidation and regulation  $\beta$ -oxidation, Oxidation of unsaturated fatty acids and odd chain fatty acids.  $\beta$ -oxidation in peroxisomes, ketone bodies and their overproduction.

Fatty Acid Biosynthesis and Regulation. Reactions of fatty acid synthase, synthesis of triglycerols, membrane phospholipids & prostaglandins.

Cholesterol biosynthesis and regulation.

#### UNIT III

Nucleic Acid Metabolism: Purine biosynthesis and its regulation, pyrimidine biosynthesis and its regulation. Formation of deoxyribonucleotides.

Salvage pathway for purine & pyrimid in nucleotides, Degradation of purines and pyrimidines into uric acid and urea. Integration of Metabolism.

Overview of the Immune System. Cells and Organs of the Immune System. Antigens, Antigenicity versus Immunogenicity. Haptens & Epitopes

Immunoglobulins: Structure and Function. Major Histocompatibility Complex. Antigen processing and presentation. Structure and functions of BCR & TCR.

#### UNIT IV

Cytokines. The Complement System. Cell mediated cytotoxicity: Mechanism of T cell & NK cell mediated lysis. Ab-dependent cell mediated cytotoxicity (ADCC)

Overview of Hypersensitivity and Autoimmunity. Introduction to Transplantation.

Vaccines: Active and Passive Immunization

Introduction to Monoclonal Antibodies and Hybridoma technology.

Antigen-Antibody Interactions: Precipitation Reaction, Agglutination Reactions, RIA, ELISA, Western Blotting, Immuno precipitation, Immuno-fluorescence.

#### Recommended Books:

1. Lehninger: Principles of Biochemistry, 4<sup>th</sup> ed., Nelson & Cox, WH Freeman and Company, 2007
2. Voet & Voet: Biochemistry, 2<sup>nd</sup> ed., Wiley & Sons.
3. Berg, Tymoczko, Stryer: Biochemistry, 5<sup>th</sup> ed., WH Freeman and Company, 2003.
4. Garrett & Grisham: Biochemistry, 4<sup>th</sup> ed., Brooks/Cole Cengage learning, 2010.
5. Murray, Granner, Rodwell: Harper's Illustrated Biochemistry, 27<sup>th</sup> ed. McGraw Hill, 2006
6. Conn & Stumpf: Outlines of Biochemistry, 5<sup>th</sup> ed., Willey India, 2007.
7. Kuby: Immunology (4<sup>th</sup> ed.).
8. Roitt, Male & Brostoff : Immunology (3<sup>rd</sup> ed).
9. Elgert & Elgert : Immunology.
10. Wilson & Walker: Practical Biochemistry (4<sup>th</sup> ed.).

### SOLS/Zool/C 018 Lab Course Based on C016 & C017

**UNIT I****Aquaculture:**

Scope, importance and present status.

Concept of different culture systems: Extensive and intensive fish culture, Fish culture in ponds and reservoirs. Culture in rice fields, bheries, Cage culture, Pen culture, Monoculture and polyculture.

Preparation and maintenance of fish farm: Fertility and pH maintenance. Role of fertilizers, required water quality and its maintenance. Control of aquatic weeds, insects and predatory fishes.

Fish nutrition: Development of natural food and supplementary feeding.

Culture techniques Procurement of stocking material from natural sources, Induced breeding and use of new generation drugs, ovaprim, different hatching techniques, Transport of fish seed.

**UNIT II****Culture Practices:**

Culture of Common carp and Exotic Trouts

Prawn culture

Sewage – fed Fisheries and Integrated fish farming

Common fish diseases and their control

Mahseer and Schizothoracid fishery. Current status, problems and perspectives

Culture of Larvicidal fishes. Characters and importance

**UNIT III****Harvesting and Post harvesting**

Fishing gears used in inland waters and seas.

Fish preservation and processing techniques.

Fish by-products and their uses.

Fish spoilage: Causes of rigor mortis, precautions to control rancidity, microbial spoilage.

Nutritive value of fish, biochemistry of fish flesh of Indian major carps.

Storage, transportation and marketing.

**UNIT IV****Capture and Ornamental Fishery:**

Rivers, Lakes, Dams / Reservoir fishery- Problems and perspectives in Capture fisheries.

Estuarine fishery. Characteristics and species dynamics.

Marine fishery: Coastal, off shore and deep sea fishery. Exclusive Economic Zone.

(Hilsa, Oil sardine, mackerel, Bombay duck, Sole, Ribbon, Shark and Rays).

Recreational fishery and Cooperative movements. Fish Farmers Development Agencies (FFDA). Climate change and fishery.

Major, Marine and freshwater ornamental fishes, their food & breeding needs.

Health management of ornamental fishes. Specific diseases and their cure.

Setting and maintenance of aquaria.

**Recommended Books**

1. S.K. Gupta, P.C. Gupta: General and Applied Ichthyology, S. Chand & Comp., 2006.
2. Vadapalli Satyanarayana: Fish Culture, Narendra Publ. House, 2002.
3. R.K. Rath: Freshwater Aquaculture, 2<sup>nd</sup> ed., Scientific Publishers, 2000.
4. Singh & Mittal: Dictionary of Aquaculture, Daya Publishing House, 1963.
5. Tor G. Heggberget: The Role of Aquaculture in World Fisheries, Oxford University Press, 1996.
6. Jhingran V G: Fish and Fisheries of India. Hindustan Publication Corp.
7. Nautiyal, P., Bhatt, J P, Gusain, O P and Dobriyal A.K. (Ed): Biological Diversity in Freshwater Environments, Transmedia, Media House, Srinagar Garhwal, 2005
8. Bahuguna, P. and Dobriyal, A K . Biology of the Ornamental Fish *Puntius conchoni* (Ham. Buch.), Narendra Publishing House, Delhi, 2019

**SOLS/Zool/E 04b Applied Entomology**

No. of Credits = 3

**UNIT I**

Insects in relation to man: sericulture, apiculture and lac culture and its parasites, predators and diseases. Insect of veterinary importance; sand fly, horse fly, sucking louse, fleas.

**UNIT II**

Brief knowledge of important household, vegetable, store grain and fruit pests with special reference to distribution, habits, habitat, nature of damage, life history and control.

Cut worm (*Agrotis ipsilon*)

Cabbage caterpillar (*Pieris brassicae*)

Rice weevil (*Sitophilus oryzae*)

Mustard aphid (*Lipaphis erysimi*)

Red cotton bug (*Dysdercus cingulatus*)

Woolly apply aphid (*Eriosoma lanigerum*)

Termite: Important termites of Fam. Termitidae (*Odontotermis sp.*)

**UNIT III**

Origin of pests, Insect pest control; mechanical, physical, culture, biological. Genetic control: chemosterilants, radiation.

**UNIT IV**

Integrated Pest Management (IPM), Role of pheromones and hormones in insect pest management. Legislative control of insect pests and quarantine law.

Nomenclature and classification of insecticides on the basis of mode of action, chemical nature. Environmental factors influencing effectiveness of insecticides, persistence, biodegradability, hazards of insecticides, precaution and antidotes.

**SOLS/Zool/E 04c Applied Environmental Biology**

No. of Credits = 3

**UNIT I**

Air: Air pollutants (chemistry, sources & control); Air Quality standards, carbon credits, carbon footprint, Thermal pollution sources and effect.

Water: Biochemical aspects of water pollutants (domestic, industrial & agricultural waste). Waste water treatment (Aerobic & anaerobic treatment processes); Water quality standards.

Case study-Ganga Action Plan.

Noise Pollution: Effects of noise and its control.

**UNIT II**

Radioactive fallouts its effects & safe disposal.

Solid waste management: Sources & control methods (composting, Vermi Culture, Biogas).

Hazardous waste & their management.

Bioremediation (herbicides, pesticides, hydrocarbons, oil spills).

Ecological Restoration: wasteland & its reclamation & restoration.

**UNIT III**

Environmental Impact Assessment (EIA): Case study of River valley projects & Mining.

Bioassay: Dose-response relationships; Frequency; Response & cumulative response; statistical concepts (LD50-potency v/s Toxicity).

Concept of hyper & hypo sensitivity factors affecting Toxicity.

**UNIT IV**

Ecological experimentation & models: Theories & hypothesis; experimentation; Inductive & deductive methods.

Models: Analytical & simulation models; Validation & verification.

Biological pest control: Use of predators; Parasites, parasitoids & pathogens; Integrated Pest Management.

**Recommended Books:**

1. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
2. Joshi, P C and Joshi, N. Ecology and Environment. Himalayan Publishing House, Delhi, 2005
3. Dey, S and Nasrin, B. Ecology of Aquatic Systems, MEDTECH, 2016

**SOLS/Zool/E 04d Applied Reproductive Biology**

No. of Credits = 3

**UNIT I**

Wildlife Maps: Toposheet (use and interpretation), Satellite Imageries, Habitat mapping, Food, shelter and cover).

Interpretation of Satellite data, GIS and GPS systems. Computers, softwares used for interpretation.

Wildlife Habitat Studies: Understanding forest types, quality and age. Vegetation structure and storeys.

Techniques for the assessment of wildlife Habitat and vegetation cover (Quadrat, Transects, PCQ etc.).

**UNIT II**

Wildlife Census: Indirect signs of wildlife (Pallets, pug marks, hoof marks, scratches, dens, Burrows etc).

Estimating Wildlife Populations: Transects in different habitats, landscapes. Transects for different groups of animals.

Estimating wildlife in Himalayan Ecosystem.

Camera traps in wildlife census and behavioural studies. Animal body signs and population estimation. Wildlife photography.

**UNIT III**

Capturing and Handling Wildlife: Types of traps and trap setting. Methods for Capturing carnivores, large and small mammals, birds, reptiles, ungulates, rodents, fishes.

Types of Darts and guns used in capturing wildlife. Drugs used for immobilizing wildlife. Antagonists used.

Handling and care of captured wildlife animals.

Radio telemetry and collaring: Types of collars, radio tags (insects to large mammals).

Transmitters, radio receivers, antenna.

**UNIT IV**

Collection and preservation of samples (pallets, dung, scats) from wild. Analyzing food contents.

Application of biotechnology to Wildlife Conservation: Sample Collection and preservation. DNA extraction procedures and amplification. Ancient DNA extraction.

Molecular marks used in amplification. Sequencing.

Instruments used for setting up Conservation genetics laboratory.

M.Sc. Zoology 4<sup>th</sup> Semester**SOLS/Zool/E 05a Methodology in Fishery Science**

No. of Credits = 3

**UNIT I****Habitat Ecology (Abiotic characteristics)**

Physiography of pond, lake, streams, river, reservoir. Substrate conditions, hard and soft substrate, particle size sampling for determining abiotic conditions; sample type sampling frequency, sampling and preservation of water for laboratory analysis.

Methods for determining physical environment: Air and water temperature, current velocity, turbidity, transparency.

Methods for estimation of chemical environment, pH conductivity DO, Free CO<sub>2</sub>, Alkalinity, Hardness, Chlorides, Phosphate and Nitrate.

**UNIT II****Habitat Ecology (Biological characteristic)**

Qualitative analysis, Inventory of floral and faunal elements in aquatic ecosystems to class/order level.

Collection and quantitative analysis of biotic communities (density, % composition) plankton and benthic communities (periphyton, macro invertebrates). Multivariate analysis for comparing communities at different locations.

Computation of indices; species richness, species diversity, Margalef diversity index. Similarity index-

Identification of fish fauna (carps, catfish); use of keys, monographs.

**UNIT III****Life history traits**

History of Fisheries Science, Fish stocks; concept, test of homogeneity using morphometric and meristic analysis, truss analysis, molecular techniques.

Length-weight relationship, Relative Condition Factor, Quantitative estimation of dietary components;

Numerical, volumetric, gravimetric, Points method.

Determining category of food (basic, secondary etc) and dietary habits (herb-omni, carnivore), feeding intensity (Gastrosomatic index, Kn).

Determining stages of sexual maturity (macroscopic and microscopic methods), size at first maturity, spawning season and frequency (Gonado-Somatic index) fecundity.

**UNIT IV**

Determination of age and growth in fishes by hard parts (Scale, otolith and operculum), Length frequency method.

Identification of annuli, Growth rate, back calculation method.

Estimation of harvestable size of fish.

Fishery biology of snow trout and Golden mahseer.

Stock assessment, growth parameters, mortality exploitation rate and ratio. FiSAT software.

Fishing gears, Catch per Unit Effort (CPUE).

## Recommended Books

1. Talwar, P.K. and Jhingran, A.G. Inland fishes. Oxford and IBH Publishing Co., New Delhi
2. Nautiyal P: Methods in fisheries Science & Aquatic Ecology. Bishen Singh Mahendra Pal Singh, Dehradun 2019
3. Carlander: Handbook of Freshwater Fishery Biology, vol. 2, Iowa State Univ. Press, 1977.
4. Nautiyal P: The Golden Mahseer (A Threatened Fish of Himalaya). Lambert Academic Publishing, Amazon Distribution GmbH, Leipzig, 2012
5. Nautiyal P: (Compiled & Edited) Mahseer – The Game Fish [Natural History, Status and Conservation practices in India and Nepal] Jagdamba Prakashan, Dehradun 1994
6. Bahuguna, P. and Dobriyal, A K . Biology of the Ornamental Fish *Puntius conchonius* (Ham. Buch.), Narendra Publishing House, Delhi, 2019
7. Agarwal, N K and Singh, G. The Ganga in the Himalayas (Fish Diversity and Environment). NPH, Delhi, 2020

## M.Sc. Zoology 4<sup>th</sup> Semester

### SOLS/Zool/E 05b Methodology in Entomology

No. of Credits = 3

#### UNIT I

##### Introductory Entomology

Research methodology in entomology in introduction. Role of entomology in agriculture (Beneficial and Harmful insects).

Medical entomology: Disease vectors (Mosquito, Sand fly, tsetse fly, pathogens, lifecycle and diseases).

Veterinary entomology: Vector insect (Ticks, Mites, Flies, pathogens, lifecycle and diseases). Forensic.

Entomology: Principle, Forensic entomological flies, use of human lice in forensic entomology, Importance.

#### UNIT II

##### Entomological techniques-I

Type of sampling survey, Different Collection Methods, Collection of wild flies and Domestic insects.

Collecting Insect in the wild area-Tools and Equipments, Preparing and using baits, Collecting from natural substances, Collection permission from govt. agency like forest department State Biodiversity Board (SBB),

National Biodiversity Authority (NAB), Transporting live adults or larvae.

#### UNIT III

Preservation of insects, classification of insects up to the level of families with hands-on experience in identifying the families of insects and Catalogues.

Insect Laboratory and rearing equipment, Experimental designs in field and Laboratory Observation techniques and Molecular techniques in insect taxonomy.

Mortality correction, Bioassay: Principles, Importance, Factor affecting, Procedures apparatus used.

#### UNIT IV

##### Entomological Techniques-II

Trophic relationships.

Use of ecological data, insect diversity: Indices, richness, rarity.

Population estimates.

Coexistence and Competition.

Distribution patterns.

Study of terrestrial/aquatic insect biodiversity, physico-chemical parameters of water (turbidity/transparency, velocity, pH, temperature, estimation of CO<sub>2</sub>, O<sub>2</sub> hardness).

## M.Sc. Zoology 4<sup>th</sup> Semester

### SOLS/Zool/E 05c Methodology in Environmental Biology

No. of Credits = 3

#### UNIT I

Importance and need of environmental research. Problem identification, objectives, significance, scope and limitations.

Literature survey. Importance and designing of the problem to be undertaken.

Field survey: Site selection, source selection for data acquisition.

Sampling strategies, Sample size, Frequency, Bias, Error. Project Report Preparation.

#### UNIT II

Measurement of solar radiation, wind velocity, air quality monitoring, measurement of oxides of nitrogen, carbon, sulphur, lead, tropospheric ozone, methane, aerosol, pesticide.

Stack sampling, sample collection for particulate matters (Dustfall collection, High volume sampler), indoor air pollutants (radon) measurement.

#### UNIT III

Water quality analysis: Measurement of water temperature, velocity, depth, transparency, dissolved oxygen, free carbon dioxide, pH, turbidity, hardness, alkalinity, BOD, COD, dissolved nutrients (Nitrates, phosphates, sodium, potassium, chloride, etc.), heavy metals. Sampling methods for terrestrial flora and fauna (quadrant method).

#### UNIT IV

Sampling methods for aquatic fauna and flora (plankton, periphyton, micro and macroinvertebrates, nekton, etc.). Soil types, measurement of soil pH, water holding capacity, organic matter, soil nutrients (nitrate, nitrite, calcium and magnesium), Sampling of soil fauna. Sampling of soil for microbial diversity.

Application of statistical Descriptive and regression analysis in Environmental Science: Parametric and Nonparametric Tests, Hypothesis testing, t-test, Z-test, F-test, multivariate test chi square test, Kruskal Wallis test.

Statistical Softwares: Excel, Statistica, SPSS, etc.

#### Recommended Books:

1. Welch, P.S. Limnological methods, Mc Graw Hill Book Co. NY.
2. APHA. Standard Methods for Examination of Water and Wastewater. 22nd Edn., APHA, AWWA, WPCF, Washington DC, USA; 2012.
3. Edmondson TH. (ed). Freshwater biology, Ward. H B and Whipple, G H, John Wiley and Sons, NY; 1992.
4. Gupta, S.L. & Gupta, H. Research methodology (Text and cases with SPSS application). IBH Pvt Ltd, 2011

#### M.Sc. Zoology 4<sup>th</sup> Semester

#### SOLS/Zool/E 05d Methodology in Reproductive Biology

No. of Credits = 3

##### UNIT I

Collection and cryopreservation of gametes and embryos; Assessment of sperm function; Capacitation. In vitro fertilization.

Multiple ovulation & Embryo transfer technology for farm animals, artificial insemination.

Recovery and maturation of oocyte.

Assessment of reproductive cycles of wildlife in captive and natural conditions.

Reproductive Cycles of some endangered species.(musk deer, elephant, tiger, pheasants) and farm animals (cattle, sheep, goat and Pig). Real-time ultrasonic scanning.

Hormones of Pregnancy. Pregnancy tests.

##### UNIT II

Principles and methods of fertility control (rhythm method, diaphragm, condom, IUD, oral contraceptives, surgical intervention, pregnancy termination).

Immunoendocrinology, immunoreproduction and immunocontraception – basic principles;

candidate vaccines; Gamete antigens and their immuno contraceptive potential. Male and female infertility (causes and diagnosis). Hysterosalpingeography, Laproscopy.

##### UNIT III

Captive breeding programs. Role of CZA in Conserving endangered wildlife. Techniques for improving reproductive efficiency. Superovulatory response and associated factors.

Infrastructure required to setup laboratory.

##### UNIT IV

Gene cloning and reproduction. Cloning of animals by nuclear transfer. Impact of artificial insemination technology. Embryo transfer and associate techniques. Factors influencing cloning techniques. Production and applications of transgenic animals and knock outs.

Bioethics

#### SOLS/Zool/E 06 Lab Course Based on E 04 a/b/c/d & E 05 a/b/c/d

#### M.Sc. Zoology 4<sup>th</sup> Semester

#### Self Study Course

#### SOLS/Zool/SS 05 Cold Water Fisheries

No. of Credits = 3

##### UNIT I

Coldwater fisheries in India: Concept and scope.

Natural and man-made coldwater fishery resources, their distribution and extent in various states of India (Himalaya and Peninsular India).

Coldwater fish fauna in India and Nepal Himalaya and their threat status.

##### UNIT II

Source (glacier and spring fed) based classification of fluvial resources.

Origin based classification of lacustrine resources.

The physical and chemical environment of fluvial and lacustrine resources their characteristic biota and communities.

##### UNIT III

Coldwater capture fisheries in lotic and lentic ecosystems.

Coldwater culture fishery, history in India, cultivable fishes fundamentals of coldwater fish culture, fish farm for trout and mahseer.

Mahseer and trout culture techniques.

#### UNIT IV

Fish stocks, concept and importance in capture fishery.  
Morphometric and meristic analysis for determining the homogeneity of stocks.  
Life history traits of barils, mahseer, snow trout and exotic carps (common grass, silver).  
Stock assessment features: growth parameters mortality, ratio and rate of exploitation.  
Statistical techniques in fishery science.

#### Recommended Books

1. Singh H R & Lakra W S: Cold Water Aquaculture and Fisheries, Narendra Publication House, 2000.
2. Carlander: Handbook of Freshwater Fishery Biology, vol. 2, Iowa State Univ. Press, 1977.
3. Nautiyal P: The Golden Mahseer (A Threatened Fish of Himalaya). Lambert Academic Publishing, Amazon Distribution GmbH, Leipzig, 2012
4. Nautiyal P: (Compiled & Edited) Mahseer – The Game Fish [Natural History, Status and Conservation practices in India and Nepal] Jagdamba Prakashan, Dehradun 1994
5. Bahuguna, P. and Dobriyal, A K. Biology of the Ornamental Fish *Puntius conchoni* (Ham. Buch.), Narendra Publishing House, Delhi, 2019

#### M.Sc. Zoology 4<sup>th</sup> Semester

#### SOLS/Zool/SS 06 Environmental Biotechnology

No. of Credits = 3

#### UNIT I

Environmental Biotechnology: Concept.  
Air pollution and its control through Biotechnology (deodorization, reduction in CO<sub>2</sub> emission, bioscrubbers, biobeds, biofilters etc).  
Water pollution and its controls: Sources of water pollution, waste water treatment-physical, chemical and biological processes (aerobic & anaerobic processes)  
Solid waste: Sources and management (composting, vermiculture and biogas production)

#### UNIT II

Xenobiotics in Environment: Xenobiotic compounds, Recalcitrance, Bioleaching and Biomining.  
Bioremediation: Types, in situ and ex situ bioremediation; Bioremediation for herbicides, Pesticides, hydrocarbons and oil spills  
Hospital wastes, hazardous waste and their management.  
Biopesticides in integrated pest management.  
Biofertilizers.

#### UNIT III

Global Environmental Problems: Ozone depletion, UV-B, green-house effect and acid rain, their impact and biotechnological approaches for management.  
Restoration of waste land/degraded ecosystem.  
Industrial pollution and its control: Pulp & Paper, Tannery, Dairy and Petroleum.  
Basic concepts of Environmental Impact Assessment (EIA)  
Environment Management: Concept & Approaches

#### UNIT IV

Introduction to fermentation processes and types of fermentation  
Microbial Growth Kinetics; Isolation, Preservation and Improvement of industrially important microorganisms  
Production of solvents (Ethanol, Butanol), Antibiotics (Penicillin, Tetracycline) and Alcoholic beverages by fermentation.