

# **M.Sc. Zoology Syllabus**

**I, II, III & IV Semesters**



**2021 - 2022**

**DEPARTMENT OF ZOOLOGY & AQUACULTURE**

**ACHARYA NAGARJUNA UNIVERSITY  
NAGARJUNANAGAR – 522510, GUNTUR,  
ANDHRA PRADESH, INDIA**

# M.Sc. Zoology

## Programme details:

The Master of Science in Zoology programme is a two-year course divided into four semesters. A student is required to earn/obtain 100 credits for the completion of programme and the award of degree.

### 1. Programme Structure - M.Sc. Zoology – Choice Based Credit System (CBCS)

(to be implemented from 2019-20 admitted batch) Exam Time: 3 hours

Credits	Marks	
<b>I SEMESTER - THEORY</b>	<b>(70Ext+ 30 Int)</b>	
Paper-I (Z 1.1): Structure and Function of Invertebrates and Vertebrates	100	04
Paper-II (Z 1.2): Biodiversity and Systematics	100	04
Paper-III (Z 1.3): Developmental Biology	100	04
Paper IV (Z 1.4): Molecular Cell Biology	100	04
<b>PRACTICALS</b>		
Practical-I (ZP 1): Invertebrates, Vertebrates and Biodiversity	100	04
Practical-II (ZP 2): Developmental Biology and Molecular Biology	100	04
<b>II SEMESTER - THEORY</b>		
Paper-V (Z 2.1): Genetics and Evolution	100	04
Paper-VI (Z 2.2): Comparative Animal Physiology	100	04
Paper-VII (Z 2.3): Principles of Ecology	100	04
Paper-VIII (Z 2.4): Tools and Techniques in Biology	100	04
<b>PRACTICALS</b>		
Practical-III (ZP 3): Genetics and Animal Physiology	100	04
Practical-IV (ZP 4): Ecology and Tools & Techniques in Biology	100	04
<b>III SEMESTER - THEORY</b>		
Paper-IX (Z 3.1): Animal Biotechnology and Microbiology	100	04
Paper-X (Z 3.2): Ichthyology	100	04
Paper-XI (Z 3.3): Limnology	100	04
Paper-XII (Z 3.4): Aquatic Toxicology	100	04
<b>PRACTICALS</b>		
Practical-V (ZP 5): Biotechnology, Microbiology and Ichthyology	100	04
Practical-VI (ZP 6): Limnology and Toxicology	100	04
<b>IV SEMESTER - THEORY</b>		
Paper-XIII (Z 4.1): Fish Pathology	100	04
Paper-XIV (Z 4.2): Immunology	100	04
Paper-XV (Z 4.3): Aquaculture	100	04
Paper-XVI (Z 4.4): Aquaculture Management	100	04
<b>PRACTICALS</b>		
Practical-VII (ZP 7): Fish Pathology and Immunology	100	04
Practical-VIII (ZP 8): Aquaculture and Aquaculture Management	100	04
<b>Project Work, Field Training and Viva-voce</b>	100	04
<b>Total:</b>	<b>2500</b>	<b>100</b>
<b>MOOCs:</b>		
1. One MOOC - II Semester	100	02
2. One MOOC - III Semester	100	02

**ACHARYA NAGARJUNA UNIVERSITY**  
**M.Sc ZOOLOGY I<sup>st</sup> SEMESTER**  
**PAPER - I: STRUCTURE AND FUNCTION OF INVERTEBRATES AND VERTEBRATES**  
**CODE No. Z 1.1**

**UNIT – I**

1. **Invertebrates:** General characters of invertebrates; Coelom - Origin and functions, acoelomates, pseudocoelomates and coelomates (Protostomia and Deuterostomia).
2. **Nutrition and Digestion:** Patterns of feeding and digestion in Cnidarians; filter feeding in Polychaeta, Mollusca and Echinodermata.
3. **Respiration:** Structure and function of respiratory organs in Annelida, Arthropoda and Moluccas - gills, lungs and tracheae.

**UNIT – II**

1. **Invertebrate Larvae:** Larval forms of free-living invertebrates;
2. Larval forms of parasites.
3. **Minor Phyla:** Organization and general characters of Rotifera, Phoronida and Chetognatha

**UNIT – III**

1. **Parasites:** Life cycle and biology of *Trypanosoma gambiense*, *Leishmania donovani*, *Wuchereria bancrofti* and *Schistosoma haematobium*.
2. **Insects:** Insects and diseases;
3. Economic importance of insects.

**UNIT – IV**

- Vertebrates:** Important characters, nature of vertebrate morphology.
1. **Respiratory system:** Comparative account of respiratory organs in vertebrates.
  2. **Circulatory system:** Evolution of heart among vertebrates; Evolution of aortic arches and portal systems among vertebrates.

**UNIT – V**

1. **Nervous system:** Comparative anatomy and function of brain and cranial nerves in vertebrates. Comparative anatomy of spinal cord, spinal nerves and autonomous nervous system in vertebrates.
2. **Urogenital system:** Evolution of urogenital systems among vertebrates.
3. **Sensory organs:** Olfactory and taste organs in vertebrate series; Lateral line system in fishes.

**REFERENCE BOOKS**

1. Barrington EJW. *Invertebrate Structure and Function*. 1976. Thomas Nelson and Sons Ltd. London.
2. Hyman LH. *The Invertebrates*. 1955. Vol.1 to 8, McGraw Hill Co., New York.
3. Parker TJ and Haswell WA. 1972. *Text Book of Zoology*. Vol. 2, Vertebrates (Eds.), AJ. Marshall, ELPS and MacMillan.
4. Read CP. 1972. *Animal Parasitism*. Prentice Hall, Inc. New Jersey.
5. Ruppert EE, Fox RS & Barnes RD. 2004. *Invertebrates Zoology*, 7<sup>th</sup> edition, Thomson, Brooks/Cole.
6. Young JZ. *The Life of Vertebrates*. 1962. Marion Nixon from Amazon.com
7. Young JZ. 1966. *The Life of Mammals*, Clarendon Press.

**M.Sc. ZOOLOGY**  
**I- SEMESTER**  
**PAPER- II: BIODIVERSITY AND SYSTEMATICS**  
**CODE No. Z 1.2**

**UNIT –I**

1. **Biodiversity:** Definition and significance; biodiversity at global, national and local levels; magnitude and distribution of biodiversity.
2. **Patterns of biodiversity:** Latitudinal and altitudinal gradients; species area relationship
3. **Biogeographic realms** of the world.
4. Biogeographic zones of India and faunal diversity; Hotspots in the world and in India.

**UNIT – II**

1. **Hierarchical components** of biodiversity: Species diversity, genetic diversity and ecosystem diversity.
2. **Biodiversity values:** Direct values and indirect values.
3. **Biodiversity in peril:** Causes of biodiversity losses and extinction; anthropogenic impact on biodiversity.

**UNIT – III**

1. **Systematics:** Species concept. Taxonomy and its components—classification and phylogeny, Cladistic classification.
2. **Identification:** Keys, biodiversity documentation, species identification and identification tools.
3. **Nomenclature:** International Code of Zoological Nomenclature (ICZN); Types: Holotype, Paratype, Neotype, Lectotype, Syntype, Homonymy and Synonymy.

**UNIT – IV**

**Biodiversity management and conservation**

1. IUCN classification of wildlife.
2. Biodiversity threats; *In-situ* conservation and *Ex-situ* conservation.
3. Gene banks; conservation of genetic resource; cryopreservation.
4. Wildlife protection acts; organizations involved in protection of Biodiversity.

**UNIT- V**

1. **Biodiversity and biotechnology:** DNA based wildlife forensics; genetically modified organisms (GMOs) and Bioremediation.
2. **Molecular taxonomy:** DNA fingerprinting.
3. Satellite Remote Sensing and GIS programmes; Environmental Impact Assessment (EIA).

**REFERENCE BOOKS**

1. Agarwal KC. 1998. *Biodiversity*. India.
2. *International Code of Zoological Nomenclature*. 1985. Third edition adopted by XX General assembly of the International Union of Biological Sciences, University of California Press, Berkeley and Los Angeles Edition.
3. Kormondy EJ. 1996. *Concepts of Ecology*. Eastern Economy Edition.
4. Oliver S&OwenMc. *Natural Resource Conservation: An Ecological Approach*. Macmillan Publ. Co. New York.
5. Peggy I. Fieldler and Perer M. Kareiva. 1997. *Conservation Biology*.
6. Prabodh K. Maiti and Paulami Maiti. 2011. *Biodiversity: Perception, Peril and Preservation*.
7. Saharia VV. 1982. *Wildlife in India*. Natraco Publishers, Dehradun.
8. Tandon RK. 1999. *Biodiversity, Taxonomy & Ecology*. Prithipalsingh Scientific Publishers, Jodhpur.

**I - SEMESTER**  
**PAPER- III: DEVELOPMENTAL BIOLOGY**  
**CODE No. Z 1.3**

**UNIT – I:**

1. Origin and migration of primordial germ cells (PGCs) to the genital ridges, differentiation of gonads in mammals.
2. Spermatogenesis: Sperm – formation, structure and types; Leydig cells – endocrine regulation of spermatogenesis.
3. Oogenesis: Formation and maturation of ovum, previtellogenesis, vitellogenesis, formation of yolk, functions of egg and types of eggs.

**UNIT – II:**

1. Fertilization: Cell surface molecules in sperm-egg recognition in animals, mechanism of fertilization, molecular events during fertilization and post fertilization.
2. Early Development: Zygote formation, cleavage, blastulation, gastrulation and formation of germ layers in animals; Fate maps and cell lineage.

**UNIT – III:**

1. Cell aggregation and differentiation; axes and pattern formation in *Drosophila*, amphibian and chick.
2. Differentiation of neurons, post embryonic development.
3. Larval formation, metamorphosis in insects and amphibians.

**UNIT – IV:**

1. Programmed cell death: Incidence of apoptosis, apoptosis during animal development; apoptosis during limb development.
2. Aging and senescence; Dietary restriction and anti-aging action; Age related diseases.

**UNIT – V:**

1. Potency, commitment, Specification, Induction, Competence, Determination and differentiation.
2. Hormonal regulation of Meta morphosis in insects and amphibians.

**REFERENCE BOOKS:**

1. Austen CR and Short RV. 1980. Reproduction in Mammals. Cambridge University Press.
2. Gilbert SF. 2006. Developmental Biology, 8 thEdition. Sinauer Associates Inc., Publishers, Sunderland, USA.
3. Longo FJ. 1987. Fertilization. Chapman & Hall, London.
4. Rastogi VB and Jayaraj MS. 1989. Developmental Biology. Kedara Nath Ram Nath Publishers, Meerut, Uttar Pradesh.
5. Schatten H and Schatten G. 1989. Molecular Biology of Fertilization. Academic Press, New York.
6. Sreekrishna V. 2005. Biotechnology –I, Cell Biology and Genetics. New Age International Publ. New Delhi, India.
7. Subramonian T. 2008. Molecular Developmental Biology. Narosa Publishing House.

**M.Sc. ZOOLOGY**  
**I - SEMESTER**  
**PAPER - IV: MOLECULAR CELL BIOLOGY**  
**CODE No. Z 1.4**

**UNIT – I**

1. Composition, Structure and Functions of Carbohydrates and Proteins.
2. Composition, Structure and Functions of Lipids and Nucleic Acids.

**UNIT – II**

1. Membrane Structure and Function: Phospholipid Bilayer and Membrane Proteins, Diffusion, Osmosis, Active Transport, Ion channels, Ion pumps, Electrical Properties of Membrane.
2. Bioenergetics, Glycolysis, Oxidative Phosphorylation.

**UNIT – III**

1. **RNA Synthesis and Processing:** Transcription Factors and Machinery, Formation of Initiation Complex, Transcription Activators and Repressors, RNA Polymerases, Capping, Elongation and Termination (RNA Processing, RNA Editing, Splicing and Polyadenylation), RNA transport.
2. **Protein Synthesis and Processing:** Translation, Ribosome, Formation of Initiation Complex, Initiation Factors and their Regulation, Elongation and Elongation Factors, Termination, Aminoacylation of tRNA, Aminoacyl tRNA Synthetase and Translational Proofreading, Translational Inhibitors: Antibiotics, Post-translational Modification of Proteins.

**UNIT – IV**

1. Control of Gene Expression at Transcription and Translation Level: Prokaryotic and Eukaryotic Gene Expression.
2. Regulation of Expression of Viral and Phage Genes, Role of Chromatin in Gene Expression, Gene Silencing.

**UNIT – V**

1. Organization of Gene and Chromosome: Structure of Gene and Chromosomes, Unique and Repetitive DNA, Heterochromatin vs. Euchromatin, Operon Concept, Interrupted Genes, Gene Families, Transposons.
2. Cell Cycle and Cell Division: Steps in Cell Cycle, Control of Cell Cycle, Mitosis and Meiosis,

**REFERENCE BOOKS**

1. Bourne GH. 1970. *Division of Labour in Cells*. Academic Press, New York.
2. De Robertis RMF and Saez RDP. 1970. *Cell Biology*. Academic Press, New York.
3. Gilman M, Witkowski JA and Watson MZJD. 1992. *Recombinant DNA*. 2<sup>nd</sup> Edition. Scientific American Books, W.H. Freeman and Company, New York.
4. Levine L. 1973. *Biology of the Gene*. 2<sup>nd</sup> Edition.
5. Pragma Khanna. 2008. *Cell and Molecular Biology*. I.K. International Publ. House Pvt. Ltd. New Delhi
6. White MJD. 1973. *Animal Cytology and Evolution*. Cambridge University Press.
7. Weaver. 1999. *Molecular Biology*. WCB McGraw Hill.

**PRACTICAL - I: INVERTEBRATES, VERTEBRATES AND BIODIVERSITY**  
**CODE No. ZP 1**

**Invertebrates**

1. Nervous system of *Squilla/Sepia*.
2. Digestive system of *Squilla/Sepia*.
3. Nervous system of Prawn.
4. Digestive system of Prawn.
5. Appendages of Prawn.
6. Sting of Honey bee.
7. Gnathochilarium of Millipede.
8. Museum specimens and slides relevant to the type study in theory.

**Vertebrates**

9. *Trichiurus* – IX and X cranial nerves.
10. Catfish – Weberian ossicles.
11. *Anabas* – Accessory respiratory organs.
12. Museum specimens and slides relevant to the type study in theory.

**Biodiversity**

13. List of local fauna (invertebrates and vertebrates).
14. Faunal diversity of man-made ecosystem.
15. Endangered species of Indian sub-continent (invertebrates and vertebrates).

**M.Sc. ZOOLOGY**  
**I – SEMESTER**  
**PRACTICAL - II: DEVELOPMENTAL BIOLOGY AND**  
**MOLECULAR CELL BIOLOGY**  
**CODE No. ZP 2**

**Developmental Biology**

1. Identification of shrimp larvae.
2. Frog developmental stages – egg, 4 and 8 celled stage, blastula, gastrula and tadpole larva.
3. Chick embryonic stages – 18hour, 24hour, 36hour, 48 hour and 72 hour embryo.
4. Embryos of rat, rabbit and pig.
5. Estimation of calcium and phosphorus in egg shell.
6. Estimation of carbohydrates and proteins in egg.

**Molecular Cell Biology**

1. Identification of different stages of Mitosis and Meiosis.
2. Observation of Mitosis in Onion root-tip cells.
3. Observation of Meiosis in Cricket/ Grasshopper testis.
4. Preparation and Staining of Blood Smear.
5. Buccal Smear preparation for identification of Barr body.
6. Observation of permanent slides of Cytology.

**M.Sc ZOOLOGY**

**II - SEMESTER**  
**PAPER – V: GENETICS AND EVOLUTION**  
**CODE No. Z 2.1**

**UNIT – I**

1. **Genetic Principles:** Mendelian principles; interaction of genes, linkage and crossing over, sex linkage and sex determination; Extrachromosomal inheritance.
2. Behavioural genetics in *Drosophila* and bees.

**UNIT – II**

1. **Human Genetics:** Human Genome Project, Pedigree analysis, Quantitative and qualitative traits of human beings, blood group inheritance, concepts of eugenics.
2. Inborn errors of metabolism; Chromosomal abnormalities.

**UNIT – III**

1. **Concepts of Evolution:** Theories of organic evolution – Lamarckism, Darwinism, Modern synthetic theory, Mutations.
2. Hardy-Weinberg law of equilibrium; genetic drift – random genetic drift.

**UNIT – IV**

1. **Mega Evolution:** Isolation, pattern and mechanisms of reproductive isolation;
2. Mechanism of speciation, phylogenetic and biological concepts of species; models of speciation – allopatric, parapatric and sympatric.

**UNIT – V**

1. Convergent and divergent evolution;
2. Adaptive radiation in amphibians, reptiles and mammals..

**REFERENCE BOOKS**

1. Burns GW. 1972. *The Science of Genetics. An Introduction to Heredity.* Mac Millan Publ. Co.Inc.
2. Gardner EF. 1975. *Principles of Genetics.* John Wiley & Sons, Inc. New York.
3. Harth and Jones EW. 1998. *Genetics – Principles and Analysis.* Jones and BarHett Publ. Boston.
4. Levine L. 1969. *Biology of the Gene.* Toppan.
5. Pedder IJ. 1972. *Genetics as a Basic Guide.* W. Norton & Company, Inc.
6. Rastogi VB. 1991. *A Text Book of Genetics.* Kedar Nath Ram Nath Publications, Meerut, Uttar Pradesh, India.
7. Rastogi VB. 1991. *Organic Evolution.* Kedar Nath Ram Nath Publications, Meerut, Uttar Pradesh, India.
8. Stahl FW. 1965. *Mechanics of Inheritance.* Prentice-Hall.
9. White MJD. 1973. *Animal Cytology and Evolution.* Cambridge Univ.Press.

**M.Sc. ZOOLOGY**  
**II - SEMESTER**  
**PAPER – VI: COMPARATIVE ANIMAL PHYSIOLOGY**  
**CODE No. Z 2.2**

**UNIT – I**

Transformation of energy in animals: Bio-energetics; diversity in operations, Factors regulating enzyme activity, energy producing reactions, proteolytic enzymes, pathways of cellular metabolism. Nutrition impairment and stress.

**UNIT – II**

1. Digestion: Process of digestion and absorption; energy balance; Basal Metabolic Rate.
2. Respiration: Mechanism of gaseous exchange in animals; neural and chemical regulation.
3. Blood: Composition and function of blood; respiratory pigments and their functions.
4. Circulation: Comparative account of circulatory system in animals.

**UNIT – III**

1. Thermoregulation in poikilotherms and homeotherms.
2. Muscles: Structure and function of muscles; Theories of muscle contraction.
3. Nervous system: Neurons, action potential, neural control of muscle tone and posture; propagation of nerve impulse and synaptic transmission in animals.

**UNIT – IV**

1. Excretion and Osmoregulation: Comparative account of structure and function of kidneys in animals; regulation of water and electrolyte balance.
2. Endocrinology and reproduction: Endocrine glands in animals, mechanism of hormonal action; Hormonal regulation in reproduction; growth and development – Regeneration, moulting and metamorphosis.

**UNIT – V**

Chromatophores and Significance of chromatophores and colour change in animals--Photo-receptors, Phono- receptors, Tango receptors, and Chemoreceptor's occurrence and Functional significance of Bioluminescence

**REFERENCE BOOKS**

1. Eckert H. Animal Physiology: Mechanisms and Adaptation. W.H. Freeman & Company.
2. Flory E. An Introduction to General and Comparative Animal Physiology. W.B. Saunders Co., Philadelphia.
3. Goel KA and Satish KV. 1989. A Text Book of Animal Physiology, Rastogi Publications, Meerut, U.P.
4. Hoar WS. General and Comparative Physiology. Prentice Hall of India, New Delhi.
5. Lehninger AL. Nelson and Cox. Principles of Biochemistry. Lange Medical Publications, New Delhi.
6. Prosser CL and Brown FA. Comparative Animal Physiology. W.B. Saunders Company, Philadelphia.
7. Schmidt-Nielsen K. Animal Physiology. Cambridge University Press, Cambridge.

**PAPER – VII: PRINCIPLES OF ECOLOGY**  
**CODE No. Z 2.3**

**UNIT – I**

1. **Ecology:** Nature and scope of ecology; ecosystem structure and function.
2. **Composition:** Abiotic and biotic components; classification of ecosystem with examples; feedback loop.
3. Major terrestrial biomes; ecotone, edge effect and advantages and disadvantages.

**UNIT – II**

1. **Trophic dynamics of ecosystem:** Energy flow; food chain; food web; trophic levels; ecological pyramids
2. **Limiting factors:** Liebig's law of the minimum and Shelford's law of tolerance.
3. **Habitat and niche:** Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning and character displacement

**UNIT – III**

1. **Population ecology:** Population characteristics – density, natality, mortality, immigration and emigration; life tables generation
2. **Population growth:** Population growth of organisms with non-overlapping generations; Verhulst-Pearl logistic growth models; stochastic and time log models of population growth; net reproductive rate and reproductive value.
3. Stable distribution; population growth projection using Lesile Matrix method.
4. Life history strategies: *r-k* selection; survivorship curves.

**UNIT – IV**

1. **Community ecology:** Nature of communities; community structure and attributes; levels of species diversity and its measurement
2. **Population regulation:** Inter specific relationships and intra specific relationships (extrinsic and intrinsic mechanism of population regulation).
3. An overview on **sustainable development** of ecosystems.

**UNIT-V**

1. **Biological magnification.**
2. **Productivity:** Concept of productivity – primary, secondary, tertiary; Recycling of materials.
3. **Biomonitoring:** Biological monitoring programme; principles of conservation and conservation of ecosystems.

**REFERENCE BOOKS**

1. Chapman JL and Reiss MJ. 1995. *Ecology Principles and Application*. Cambridge Univ. Press.
2. Kormondy EJ. *Concepts of Ecology*. Eastern Economy Edition.
3. Krebs CJ. *Ecology*. Harper and row, New York.
4. Krebs CJ. *Ecological Methodology*. Harper and Row, New York.
5. Odum EP. 1983. *Basic Ecology*. Saunders Publishing.
6. Sharma PD. 1991. *Ecology and Environment*.
7. TrivedyRK, Goel and Trisa. 1997. *Practical methods in Ecology & Environmental Science*.

## CODE No. Z 2.4

### UNIT – I

1. **Microscopes:** Working principle and types of Optical Microscopy – dark-field, phase-contrast, interference, polarization and fluorescence microscopy;
2. **Electron Microscopy:** Working principle and types of Electron Microscopy – Transmission electron microscopy (TEM), Scanning electron microscopy (SEM) and Scanning-Transmission electron microscopy (STEM); Different fixation and staining techniques for electron microscopy.

### Unit -II

1. **Spectroscopies:** Working principle of UV-Visible spectrophotometer, IR spectroscopy, Atomic Absorption Spectroscopy (AAS), Fluorescence and Phosphorescence spectroscopy,
2. Electron Spin Resonance (ESR) spectroscopy, Mass spectrometry, X-ray crystallography and Nuclear Magnetic Resonance (NMR) spectroscopy.

### UNIT – III

1. **Chromatography:** Principles and applications of Gel filtration, Paper, Column, Ion-exchange, Affinity, Thin layer (TLC), Gas liquid (GLC) and High Performance Liquid Chromatography (HPLC)
2. **Electrophoresis:** Agarose gel electrophoresis, Pulsed Field Gel Electrophoresis (PFGE), Polyacrylamide Gel Electrophoresis (PAGE), Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE), Two-dimensional electrophoresis - Iso-electric focusing (IEF).

### UNIT – IV

1. **Nucleic acid blotting techniques:** Southern blotting, Northern blotting and Western blotting; Polymerase Chain Reaction (PCR); DNA fingerprinting; Genomics and Proteomics.
2. **Sequences and nomenclature:** IUPAC symbols, nomenclature of DNA sequences, nomenclature of protein sequences, directionality of sequences, types of sequences used in bioinformatics.
3. **Information sources:** NCBI, GDB, MGB, data retrieval tools, database similarity searching, resources for gene level sequences, use of bioinformatics tools in analysis.

### UNIT – V

1. **Bio-statistics:** Measures of central tendency and dispersal – mean, median and mode; Probability distributions - binomial, poisson and normal; Sampling distribution.
2. Standard deviation, standard error and confidence interval; Regression and Correlation.
3. **Tests of significance:** Levels of significance, X<sup>2</sup> test, t-test and Analysis of Variance (ANOVA). Usage of Statistical Package for Social Sciences (SPSS).

### REFERENCES BOOKS

1. Brewer JM, Pesce AJ & Ashworth RB. 1974. *Experimental Techniques in Biochemistry*. Prentice Hall.
2. Diamond PS & Denman RF. 1966. *Laboratory Techniques in Chemistry and Biochemistry* Butterworths
3. Dubey, R.C., 2006. *A Text Book of Biotechnology*. S. Chand & Company Ltd., New Delhi.
4. Eaton AD, Clesceri LS, Rice EW & Greenberg AE. 2005. *Standard Methods for the Examination of Water and Wastewater*. APHA/WWA-WEF, Washington DC.
5. Fishbein L. 1973. *Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants*. Elsevier.
6. Jeffery GH, Basset J, Mendham J & Denney RC.(Eds.).1989. *Vogel's Textbook of Quantitative Chemical Analysis*. Longman.
7. Nelson DL and Cox MM. 2005. *Lehninger Principles of Biochemistry*. WH Freeman.
8. Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.
9. Narayanan, P. 2005. *Essentials of Biophysics*, New Age International (P) Ltd., New Delhi, India.
10. Satyanarayana, U. 2005. *Biotechnology*. Books and Allied (P) Ltd., Kolkata, India.
11. Sparks DL, Page AL, Helmke PA, Loepfert RH, Soltanpour PN, Tabatabai MA, Johnston CT & Sumner ME. (Eds.). 1996. *Methods of Soil Analysis: Part 3. Chemical Methods*. SSSA- ASA, Madison.
12. Welch PS. 2003. *Limnological Methods*. Narendra Publ. House.
13. Wilson K & Walker J. 2002. *Practical Biochemistry: Principles and Techniques*. Cambridge University Press, Oxford.
14. Anderson TW.1984. *An Introduction to Multivariate Statistical Analysis*. Wiley Series in Probability and Statistics, Singapore
15. Biradar RS. 2002. *Course Manual on Fisheries Statistics*. 2nd Ed. CIFE, Mumbai.
16. Ghosh S. 1999. *Multivariate Analysis, Design of Experiments and Survey Sampling*. Marcel Dekker.
17. Keller G. 2001. *Applied Statistics with Microsoft Excel*. Duxbury.

## M.Sc. ZOOLOGY

## II – SEMESTER

## PRACTICAL – III: GENETICS AND ANIMAL PHYSIOLOGY

**CODE No. ZP3**

**Genetics**

1. Genetic disorders – photographs.
2. Genetic exercises/problems based on:
  - (i) Dihybrid cross.
  - (ii) Law of independent assortment.
  - (iii) Multiple alleles.
  - (iv) Interaction of genes.

**Animal Physiology**

3. Estimation of glycogen.
4. Estimation of proteins.
5. Estimation of lipids.
6. Estimation of haemoglobin.
7. Qualitative identification and estimation of ammonia and urea.

**M.Sc. ZOOLOGY  
II – SEMESTER**

**PRACTICAL – IV: ECOLOGY AND TOOLS & TECHNIQUES IN BIOLOGY  
CODE No. ZP 4**

**Ecology**

1. Area species curve.
2. Quadrature species curve.
3. Determination of frequency.
4. Analysis of soil – temperature, colour, texture, pH, moisture content, phosphorus content, carbonate content and nitrate content.
5. Estimation of primary productivity (light and dark bottle method).

**Tools and Techniques in Biology**

6. Microscopy - description and working methodology.
7. Spectrophotometry - principle and working methodology.
8. Paper chromatography - separation of molecules.
9. Thin layer chromatography - isolation of molecules.
10. Calculation of mean, median, mode, standard deviation and standard error.
11. Analysis of Variance (ANOVA).

**III - SEMESTER**  
**PAPER - IX: ANIMAL BIOTECHNOLOGY AND MICROBIOLOGY**  
**CODE No. Z 3.1**

**UNIT – I:** Biotechnology 1. Genetic Engineering: Recombinant DNA technology, tools of genetic engineering – Restriction endonucleases, DNA ligases, topoisomerases, methylases, nucleases, polymerases, reverse transcriptase and their properties and functions.

2. Cloning vectors: Bacterial plasmid vector – pBR322 and its derivatives; bacteriophage vectors – SV40, phage  $\lambda$ , phage M13; cosmids; viral vectors; shuttle vectors.

**UNIT – II 1.** Applications of biotechnology in veterinary science: Artificial insemination, multiple ovulation, embryo transfer, in-vitro fertilization (IVF), embryo cloning; transgenic animals.

2. Applications of biotechnology in medicine: Production of monoclonal antibodies (Hybridoma technology), production of vaccines and production of growth hormone.

3. Gene therapy: Adenosine Deaminase (ADA) deficiency, Duchenne Muscular Dystrophy (DMD), haemophilia, phenylketonuria and thalassaemia.

**UNIT – III:** Microbiology 1. History and scope of microbiology: Microbial nutrition; growth and their control; normal microbial flora of human body - skin, nose, oral cavity, pharynx, respiratory tract, eye, ear, stomach, intestine and genitourinary tract.

2. Microbial diseases and their control: Bacterial diseases- tuberculosis, plague, anthrax, tetanus, cholera; Viral diseases- influenza, AIDS, rabies, hepatitis, poliomyelitis, ebola; Fungal diseases- superficial mycosis, cutaneous mycosis, subcutaneous mycosis, systemic mycosis;

**UNIT – IV:** 1. Microbiology of fermented food: Dairy products, meat and fish. 2. Industrial microbiology: Types of fermentation process; alcoholic beverages;

**UNIT – V:** 1. Cloning and selection and screening analysis of recombinants-colony hybridization techniques, immunological tests in-situ hybridization.

**2. Protozoan diseases-** Ameobiosis, Malaria, Typhoid.

**REFERENCE BOOKS**

1. Anathnarayan R and Jayaram Panikar CK. 1990. Text Book of Microbiology. 4 th Ed. Orient Longmen, Hyderabad, India.

2. Balasubramanian D et al. 2005. Concepts in Biotechnology. Universities Press (India) Pvt. Ltd., Hyderabad.

3. Dubey RC. 2006. A Text Book of Biotechnology. S. Chand & Company Ltd. New Delhi.

4. Pelzar MJ Jr and Chan ECS. 1981. General Microbiology. International Students Edition, McGrawHill International Book Co., New Delhi.

5. Range MM. 2000. Animal Biotechnology. Agrobios, India.

6. Satyanarayana U. 2005. Biotechnology. Books and Allied (P) Ltd. Kolkata, India

**M.Sc. ZOOLOGY**  
**III - SEMESTER**  
**PAPER – X: ICHTHYOLOGY**

## CODE No. Z 3.2

### UNIT – I

1. **Classification of fishes:** Major groups up to subclass and their important characters.
2. **Skin:** Structure and function of skin in fishes.
3. **Scales:** Structure of placoid, cycloid, ctenoid, cosmoid and ganoid scales.

### UNIT – II

1. **Feeding in fishes:** Natural food of fishes.
2. **Feeding habits:** Predators, grazers, strainers, suckers and parasites.
3. **Feeding adaptations** and stimuli for feeding in fishes.

### UNIT – III

1. **Zoogeography:** Major groups of freshwater fish and their distribution.
2. **Age:** Methods of determination of age.
3. **Growth:** Methods for studying growth. Length-Weight relationship and Condition factor

### UNIT – IV

1. **Respiratory system:** Structure and functioning of gills and accessory respiratory organs.
2. **Circulatory system:** Structure and functioning of cardiovascular system.
3. **Osmoregulation:** Ionic regulation in freshwater, marine and diadromous fishes.
4. **Excretory system:** Structure and function of kidneys in fishes.

### UNIT – V

1. **Nervous system:** Structure and function of brain in elasmobranchs and teleosts.
2. **Endocrine glands:** Structure and function of pituitary gland, thyroid gland, ultimobranchial glands, chromaffin tissue, adrenocortical tissue and corpuscles of stannius.
3. **Reproduction:** Reproductive structures in elasmobranchs and teleosts; maturity stages of gonads.
4. Oviparity, ovo viviparity and viviparity; parental care in fishes; fecundity; gonadosomatic index.

### REFERENCE BOOKS

1. Bond E. Carl. 1979. *Biology of Fishes*, Saunders.
2. Halver JE. 1972. *Fish Nutrition*. Academic Press.
3. Hoar WS and Randall DJ. 1970. *Fish Physiology*, Vol. I-IX, Academic Press, New York.
4. Lagler KF, Bardach, JE, Miller, RR, Passino DRM. 1977. *Ichthyology*, 2<sup>nd</sup> Ed. John Wiley & Sons, New York.
5. Lovell J. 1989. *Nutrition and Feeding of Fish*. Van Nostrand Reinhold, New York.
6. Moyle PB and Joseph J. Cech Jr. 2004. *Fishes: An Introduction to Ichthyology*. 5<sup>th</sup> Ed. Prentice Hall.
7. Nikolsky GV. 1963. *Ecology of Fishes*, Academic Press.
8. Norman JR and Greenwood PH. 1975. *A History of Fishes*, Halsted Press.
9. Potts GW and Wootten RJ. 1984. *Fish Reproduction: Strategies and Tactics*, Academic Press.

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## PAPER-XI: LIMNOLOGY Code No. Z 3.3

### Unit-I

1. Definitions and Facets of Limnology.
2. Lake definition, Origin, Evolution and Classification of lakes.
3. Anomalous properties of water, their influence on biota in Inland waters.
4. Morpho and Bathymetric indices of lakes.

### Unit-II

1. Thermal stratification of lakes and its impact.
2. Thermal classification of lakes.
3. Factors effecting light penetration in natural water bodies.

### Unit-III

1. Sources, losses and distribution patterns of dissolved oxygen in lakes.
2. Identification of Oxygen depletion problems and control mechanisms in lakes.
3. Sources, losses and distribution patterns of carbon dioxide in lakes and Role of Carbon dioxide in chemical buffering.
4. Biogeochemical cycles: Nitrogen and phosphorous cycles

### Unit-IV

1. Plankton : Definition, Classification and distribution pattern in lakes.
2. Benthos : Definition, composition, classification and distribution in lakes and rivers.
3. Nekton : Composition of Nekton and its significance in lakes.
4. Macrophytes: Classification, distribution and their limnological significance.

### Unit-V

1. Productivity:  
Concept of Productivity; Methods for the estimation of primary, secondary and tertiary productivity, Indices of productivity in lakes;
2. Classification of lakes based on productivity.
3. Eutrophication: Definition, types, causes, consequences and control mechanism in lakes.
4. Turbidity: Causes, consequences and control mechanism in lakes and inland water bodies.

### REFERENCE BOOKS:

1. Allan, J.D. 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman & Hall.
2. Cole, G.A. 1983. *Text book of Limnology*. C.Y. Mosby Company, St. Louis, Missouri, USA.
3. Goldman, C.R. and Home, A.J. 1983. *Limnology*. Mc Graw-Hill International Book Company.
4. Golterman, H.L. 1975. *Physiological Limnology*. Elsevier Publishing Co., Amsterdam.
5. Hutchinson, G.E. 1957. *A Treatise on Limnology: Vol 1. Geography, physics and chemistry*. John Wiley and Sons, Inc., New York.
6. Hutchinson, G.B. 1967. *A Treatise on Limnology. Vol II. Introduction to lake Biology and the Limnoplankton*. John Wiley and Sons, Inc., New York.
7. Reid, G.R. 1961. *Ecology and Inland waters and Estuaries*. Reinhold Corp., New York.
8. Runner F. 1953. *Fundamentals of Limnology*. Uni. of Toronto press, Toronto.
9. Welch P.S. 1952. *Limnology*. 2<sup>nd</sup> Ed. Mc Graw-Hill Book Co. New York.
10. Wetzel, R.G. 1975. *Limnology*, W.B. Sanders Company, Philadelphia.

## CODE No. Z 3.4

### UNIT – I

1. **Water pollution and analysis:** Sources of water pollution, physical and chemical characterization of water, minor components of water, important trace elements in water;
2. Biological investigation of water – DO, BOD; microbiological examination of water, water pollution and diseases.

### UNIT – II

3. **Industrial pollution:** Effluent from chemical industries, apparel industries, energy industry and service industries; waste water from food processing and material industry;
4. Analysis of metal pollutants, non-metal pollutants and gases, waste water treatment.

### UNIT – III

5. **Sewage treatment and analysis:** Treatment of domestic sewage, primary treatment of sewage, chemical treatment of sewage, biological treatment, tertiary treatment of sewage, disposal of sewage, characterization and analysis of sewage – DO, COD, BOD.
6. **Pesticide pollution:** Classification of pesticides, bio-concentration, bioaccumulation, sources of contamination, bio-magnification, effects on non-target organisms, metabolites – uptake and depuration of toxic chemicals, control of pesticide pollution.

### UNIT- IV

1. **Thermal pollution:** Source of thermal pollution, effects of discharge of heat, control of thermal pollution – artificial lakes or cooling ponds, cooling towers and improved electric generating plants.
2. **Radiation pollution:** Sources of radiation, effects of ionizing radiation on life, nuclear energy, the most dangerous radioactive pollutants, harmful effects of radiation and monitoring of radiation.

### UNIT V

3. **Environmental Impact Assessment (EIA)** – Analysis: Introduction, EIA under National Environmental Policy Act (NEPA), EIA in action, implementation of EIA, Case studies  
–water quality impact analysis and nuclear power plant impact.
4. Pollution control **Acts and Laws** of India; The Environment (Protection) Act, 1986.

### REFERENCE BOOKS

1. Andrews HL. 1974. *Radiation Bio-physics*. Prentice Hall, Inc., New York, USA.
2. Chanlett ET. 1973. *Environmental Protection*. McGraw Hill, Inc., Japan.
3. Edwards CA. 1973. *Environmental Pollution by Pesticides*. Plenum Press, London/NY.
4. Khopkar SM. 2005. *Environmental Pollution Monitoring and Control*. New Age International(P) Limited, New Delhi, India. Laws EA. 1981. *Aquatic Pollution*. Wiley & Sons, New York.
5. Mohammad Abdul Quadden Khan. 1978. *Pesticides in Aquatic Environment*.

M.Sc. ZOOLOGY

III – SEMESTER

PRACTICAL – V: BIOTECHNOLOGY, MICROBIOLOGY AND ICHTHYOLOGY

CODE No. ZP 5

### **Biotechnology**

1. Isolation of DNA from blood sample.
2. Isolation of DNA from saliva.
3. Cloning vectors – diagrams, properties and functions.
4. Transgenic animals – photographs.

### **Microbiology**

5. Isolation of bacteria from soil.
6. Isolation of bacteria from water.
7. Media preparation for bacterial culture.
8. Standard plate count of bacteria (SPC).
9. Soil, water and air borne microbes – slides/photographs.

### **Ichthyology**

10. Collection, preservation and identification of a fish: general description of a fish, recording biometric data and identification up to genus level using taxonomic key.
11. Identification of commercially important freshwater, brackish water and marine water fishes.
12. Identification of stages of maturation of fish gonads.
13. Study of the guts in fish with different feeding habits.
14. Dissection and mounting of pituitary gland.
15. Mounting of fish scales.

**M.Sc. ZOOLOGY**  
**III – SEMESTER**  
**PRACTICAL – VI: LIMNOLOGY AND TOXICOLOGY**  
**CODE No. ZP 6**

### **Limnology**

1. Determination of temperature, pH and salinity in the pond water sample.
2. Estimation of total alkalinity and total hardness.
3. Estimation of dissolved oxygen and free carbondioxide.
4. Estimation of phosphates and nitrites.
5. Estimation of COD and BOD.

### **Toxicology**

6. Determination of LC<sub>50</sub> value.
7. Determination of LD<sub>50</sub> value.
8. Identification of pesticides in thin layer chromatography.
9. Acute toxicity tests – design and experiment.
10. Histopathological study of toxicant exposed tissues.

**M.Sc. ZOOLOGY**  
**IV - SEMESTER**  
**PAPER – XIII: FISH PATHOLOGY**  
**CODE No. Z 4.1**

## **UNIT – I**

### **Fish Diseases:**

1. History, species affected, Clinical symptoms, pathology and control measures of Viral Hemorrhagic Septicemia (VHS) and Infectious Hematopoietic Necrosis (IHN).

### **Shrimp Diseases:**

2. History, species affected, Pathology, clinical symptoms, prevention and treatment of Monodon Baculoviral disease (MBV), Infectious Hypodermal and Hematopoietic Necrosis (IHHN), Hepato Pancreatic Parvovirus disease (HPPV), Yellow-head virus disease, Taura syndrome and White spot syndrome.

## **UNIT – II:**

### **Fish Diseases:**

1. History, species affected, Clinical symptoms, pathology, prevention and control measures of Bacterial Hemorrhagic Septicemia (BHS), Bacaterial gill disease and Tail and fin rot.
2. Pathology, clinical symptoms, prevention and control measures of Saprolegniasis and Branchiomycosis.

### **Shrimp Diseases:**

3. History, species affected, Clinical symptoms, pathology, prevention and control measures of Black gill disease, Filamentous bacterial gill disease.
4. History, species affected, Clinical symptoms, pathology, prevention and control measures of *Lagenidium* disease (Larval Mycosis) and Brown gill disease.

## **UNIT – III:**

### **Fish Diseases:**

1. History, species affected Clinical symptoms, pathology and control measures of Ichthyophthiriasis, Enterococcidiasis, Whirling disease and Nodular disease.
2. History, species affected Clinical symptoms, pathology and control measures of Gyrodactylosis and Dactylogyrosis.
3. History, species affected Clinical symptoms, pathology and control measures of Argulosis and Lernaesis.

### **Shrimp Diseases:**

History, species affected, History, Etiology, morphology and control measures of *Zoothamnium* and *Acineta*.

## **UNIT – IV:**

### **Fish Diseases:**

1. History, species affected clinical symptoms, pathology and control measures of gas bubble disease and lack of oxygen.
2. **Shrimp Diseases:** History, species affected Clinical symptoms, pathology and control measures of cramped tails, and Blue shell syndrome.

## **UNIT – V:**

### **Fish Diseases:**

1. History, species affected, clinical symptoms, pathology, prevention and control measures of Epizootic Ulcerative syndrome.

### **Shrimp Diseases:**

2. History, species affected, Clinical symptoms, pathology and control measures of Muscle Necrosis, Gas bubble disease, Black death disease and Chronic soft shell syndrome.

## **REFERENCE BOOKS**

1. Cheng TC. 1964. *The Biology of Animal Parasites*. W.B. Saunders Company, Philadelphia, Pennsylvania, USA.
2. Conroy CA and Herman RL. 1968. *Text book of Fish Diseases*.TFH (Great Britain) Ltd, England.
3. Lightner DV. 1996. *A Handbook of Shrimp Pathology and Diagnostic Procedures for Diseases of Cultured Penaeid Shrimp*. World Aquaculture Society, Louisiana, USA.
4. Reichenbach KH. 1965. *Fish Pathology*. TFH (Gt. Britain) Ltd, England.
5. Ribelin WE and Miguki G. 1975. *The Pathology of Fishes*. The Univ. of Wisconsin Press Ltd, Great Russel Street, London, UK.
6. Shuzo Egusa.1978. *Infectious Diseases of Fish*. Oxonian Press Pvt. Ltd. New Delhi.
7. Van Duijn, C. 1973. *Diseases of Fishes*. Cox and Wyman Ltd. London.

**M.Sc. ZOOLOGY**  
**IV - SEMESTER**  
**PAPER – XIV: IMMUNOLOGY**  
**CODE No. Z 4.2**

**UNIT – I**

1. **Antigens:** Chemical nature of Antigens, Haptens, Epitopes, Paratopes; Binding forces of antigen-antibody interactions – Affinity, Avidity and Cross reactivity; Antigenicity and Immunogenicity.
2. **Lymphoid Organs:** Primary lymphoid organs – Thymus, Bone marrow and Bursa of fabricius; Secondary lymphoid organs – Spleen, Lymphnodes, MALT and GALT.
3. **Cells of the immune system:** Origin of the cells - Stem cells; Lymphoid lineage – T-lymphocytes, B-lymphocytes, Null cells; Myeloid lineage – Monocytes, Polymorphonuclear (PMN) leukocytes; Accessory cells.

#### UNIT-II

1. **Antibody molecules/Immunoglobulins:** Basic structure of the immunoglobulin molecule; Structure and function of IgG, IgA, IgM, IgE and IgD molecules.
2. **Major Histocompatibility Complex (MHC):** Structure of MHC molecules, Antigen processing and presentation by MHC molecules.
3. **Complement System:** Classical and Alternative Pathways; Biological functions of complement.

#### UNIT-III

1. **Cytokines:** Interleukins (ILs), Interferons (INFs), Tumor Necrosis Factors (TNFs), Colony Stimulating Factors (CSFs) and Chemokines.
2. **Innate Immunity:** Phagocytosis- intracellular killing, Humoral and Cellular components
3. **Acquired Immunity:** Humoral immunity, Cell-mediated immunity; Primary and Secondary immune response, Memory function; Active and Passive immunity, Types of Vaccines.

#### UNIT - IV

1. **Hypersensitivity:** Types of Hypersensitivity reactions and Regulatory mechanisms.
2. **Tolerance:** Immune and Self Tolerance; Autoimmunity and Autoimmune disorders.
3. **Tumor Immunology:** Immunity to tumours, tumour-specific antigens; Immunosurveillance

#### UNIT - V

1. **Immunodiffusion:** Simple diffusion, Radial immunodiffusion and Double immunodiffusion.
2. **Immuno electrophoresis:** Counter and Rocket immunoelectrophoresis.
3. **Radioimmunoassay (RIA):** Competitive R.I.A, and Excess Reagent R.I.A.
4. **Enzyme Linked Immuno Sorbent Assay (ELISA).**
5. **Hybridoma Technology** – Production of monoclonal antibodies.

#### REFERENCE BOOKS

1. Goldsby AR, Kindt TJ and Osborne BA. 2000. *KUBY Immunology*. W.H. Freeman and Company, NY.
2. Ivon M. Roitt. 2001. *Essential Immunology*. Blackwell Science Ltd, Mishawaka, IN, USA.
3. Joshi KR and Osamo NO. 1994. *Immunology*. Agro Botanical Publishers, India.
4. Nandini Shetty. 2008. *Immunology Introductory Text*. Wiley Eastern Limited, New Age International Publishers, New Delhi.
5. Rajasekara Pandian M and Senthil Kumar B. 2007. *Immunology and Immunotechnology*. Panima Publishing Corporation, New Delhi, India.

**M.Sc. ZOOLOGY**  
**IV - SEMESTER**  
**PAPER – XV: AQUACULTURE**  
**CODE No. Z 4.3**

#### UNIT – I

1. History, Significance and Classification of Aquaculture; Major cultivable species for aquaculture; A knowledge of inland water bodies suitable for culture in India.
2. Criteria for the selection of a species for culture.
3. Culture practices of fish and shrimp: Traditional, extensive, modified extensive, semi-intensive and intensive cultures.

#### **UNIT – II**

1. Concept of Monoculture, polyculture and integrated fish farming.
2. Bundh breeding and Induced breeding of carp by hypophysation and use of synthetic hormones.
3. Preparation and Management of Indian major carp culture ponds – nursery, rearing and production ponds.

#### **UNIT – III**

1. Culture of air-breathing fishes in India.
2. Culture of Giant freshwater prawn, *Macrobrachium rosenbergii*
3. Culture of brackishwater fish – *Chanos* and *Lates*.

#### **UNIT – IV**

1. Culture of shrimp, *Penaeus monodon* / *Litopenaeus vannamei*.
2. Culture of pearl oysters.
3. Culture of sea weeds: Major seaweed species of commercial importance; methods of culture

#### **UNIT – V**

1. Culture of ornamental fishes.
2. Improvement of fish stocks: Genetic improvement/Hybridization of fish – Indian studies.
3. Biotechnological approaches: Gynogenesis, Androgenesis, Polyploidy, Transgenic fish and Cryopreservation of fish gametes.

#### **REFERENCES BOOKS**

1. Bardach, JE *et al.* 1972. *Aquaculture – The farming and husbandry of freshwater and marine organisms*. John Wiley & Sons, New York.
2. Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn*. Daya Publ. House.
3. FAO. 2007. *Manual on Freshwater Prawn Farming*.
4. Huet J. 1986. *A text Book of Fish Culture*. Fishing News Books Ltd.
5. ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR.
6. Jhingran V.G. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corporation, India.
7. Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.
8. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.
9. MPEDA: *Handbooks on culture of carp, shrimp, etc.*
10. New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.
11. Pillay TVR. 1990. *Aquaculture- Principles and Practices*. Fishing News Books Ltd., London.
12. Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*. 2<sup>nd</sup> Ed. Blackwell
13. Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.
14. Stickney RR. 1979. *Principles of Warmwater Fish Culture*. John Wiley & Sons.

### **M.Sc. ZOOLOGY**

#### **IV- SEMESTER**

### **PAPER – XVI: AQUACULTURE MANAGEMENT**

**CODE No. Z 4.4**

#### **UNIT - I: Aquaculture Engineering**

1. Types of culture systems: Open culture system (cages, pens, rafts and racks); semi-closed culture system (Ponds and Raceways) and closed culture system (Tanks, , Water recirculation systems).
2. Design and construction of a freshwater fish farm and hatchery.
3. Design and construction of a shrimp farm and hatchery.

#### **UNIT - II: Management of fish ponds**

1. Management of fish production; Natural productivity of ponds; Biological means of increasing fish production.
2. Identification of oxygen depletion problems and control mechanisms in fish and shrimps ponds.
3. Liming, organic manures, chemical fertilizers and their implications in fish ponds.
4. Techniques and management practices adopted for the Reservoir Fisheries in India.

#### **UNIT - III: Feed Management**

1. Natural food, culture of live food – *Spirulina*, *Chaetoceros*, *Brachionus*, *Artemia* for hatcheries.
2. Supplementary feeds: Types of feeds– wet, moist and dry feeds, mash, pelleted feeds-floating and sinking pellets; Feed additives- binders, antioxidants, enzymes, pigments, growth promoters, feed stimulants. Use of preservatives.
3. Feed formulation and manufacturing. Feed storage methods.
4. Feeding strategies: Feeding devices, feeding schedules and ration size. Feed evaluation - feed conversion efficiencies and ratios.

#### **UNIT - IV: Economics and Fish processing**

1. Principles of aquaculture economics – Capital costs, Variable costs, Cost-benefit analysis.
2. Fish harvesting in ponds; Fish handling and packaging; methods of transport; fish marketing methods in India.
3. Methods of fish and shrimp preservation and processing; Fishery by-products.
4. Organic Aquaculture – Concept, Principles and Practices.

#### **UNIT - V:**

1. Methods of fish/shrimp preservation and processing
2. Principles and practices of organic aquaculture.
3. Impact of aquaculture on environment

#### **REFERENCES BOOKS**

1. Bose AN. *et al.* 1991. *Coastal Aquaculture Engineering*. Oxford & IBH Publ.Co. Pvt. Ltd.
2. Boyd, CE. 1982. *Water Quality Management for Pond Fish Culture*. Elsevier Sci. Publ. Co.
3. Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn*. Daya Publ. House.
4. CIFE. 1993. *Training Manual on Culture of Live Food Organisms for Aqua Hatcheries*. CIFE, Versova, Mumbai
5. De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall Aquaculture Series.
6. Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.
7. Govindan, TK. 1985. *Fish Processing Technology*, Oxford-IBH.
8. Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.
9. Jhingran VG. 1982. *Fish and Fisheries of India*. Hindustan Publishing Corporation, India.
10. Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Chapman & Hall.
11. MPEDA: *Handbooks on culture of carp, shrimp, etc.*
12. New MB. 1987. *Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*. FAO – ADCP/REP/87/26.
13. Pillay TVR. 1990. *Aquaculture- Principles and Practices*, Fishing News Books Ltd., London.

### **M.Sc. ZOOLOGY**

#### **IV – SEMESTER**

#### **PRACTICAL – VII: FISH PATHOLOGY AND IMMUNOLOGY**

**CODE No. ZP 7**

**Fish Pathology**

1. External examination of the diseased fish – diagnostic features and procedure.
2. Exploration of the skin smear.
3. Exploration of the gill smear.
4. Autopsy of fish – examination of the internal organs.
5. Maceration and squash preparation of organs for microscopic observation of pathogens.
6. Collection and mounting of some important ecto and endoparasites of fish.
7. Identification of fish diseases.
8. Identification of common shrimp diseases.
9. Preparation of paraffin blocks and the study of histology of internal organs - gills, kidney and intestine.

**Immunology**

10. Haemagglutination – detection of blood group antigens.
11. Immunodiffusion – detection of antigen-antibody reaction.
12. Estimation of total RBC count.
13. Estimation of total WBC count.
14. Estimation of differential leucocytes count (DLC).
15. ELISA test – qualitative determination of antigens or antibodies.

**M.Sc. ZOOLOGY****IV – SEMESTER****PRACTICAL - VIII: AQUACULTURE AND AQUACULTURE MANAGEMENT****CODE No. ZP 8**

1. Identification of important cultivable species of fin fish and shell fish.
  2. Common unwanted (weed and predatory) fishes in culture ponds – identification and their impact in aquaculture.
  3. Dissection of pituitary gland and preparation of pituitary extract, method of dosage preparation and injection of pituitary extract for induced breeding of fish.
  4. Collection, preservation and identification of common phytoplanktonic organisms in ponds.
  5. Collection, preservation and identification of common zooplanktonic organisms in ponds- Rotifers, Cladocerans and Copepods.
  6. Identification of aquatic insects and molluscs in ponds.
  7. Common floating, emergent and submerged aquatic vegetation in ponds.
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