

PROGRAMME STRUCTURE AND SYLLABUS
M.Sc. Zoology

School of Science

Department of ZOOLOGY



Uttarakhand Open University
Teenpani Bypass Road, Haldwani - 263139, Nainital
Uttarakhand

Uttarakhand Open University, Haldwani
Syllabus for M.Sc. Zoology: Semester Mode
(Based on Model Curriculum of UGC)

Preamble: Uttarakhand Open University (UOU) started B.Sc. and M.Sc. programmes in different subjects from year 2013. Zoology Department of School of Sciences participates in the undergraduate core program (B.Sc.) and runs M. Sc. program in Zoology. At present, the study material for M.Sc. is borrowed from Dr. B. R. Ambedkar Open University, Hyderabad. Now the department is in the process of the development of its own study material.

It is mentioned that:

1. The structure, courses and syllabus are designed after the detail study of syllabus and course structure of different universities (Including K.U., H.N.B.G.U., G.B.P.U.A. &T., B.H.U. and B.R.A.O.U.), UGC SCIR NET syllabus.
2. These courses will be helpful for further research of students in the area of his/her choice. This pattern fulfills the requirement of Open and Distant Learning system.
3. A well equipped laboratory will be established in UOU campus, Haldwani. The university organizes 10 day workshops in its own campus in future for practical support. However, before the establishment of own laboratories, the workshops is being organized in different main study centers like M.B.P.G. College Haldwani, BGR Campus Pauri, S.G.R.R. College Dehradun, G.P.G.C. Pithoragarh and R.C.U. G.P.G.C. Uttarkashi etc.
4. The syllabus is designed on the bases on CBCS as per UGC recommendation.

PROGRAMME STRUCTURE: MASTER OF ZOOLOGY

Name of Programme	MASTER OF SCIENCE IN ZOOLOGY
Programme Code	MSCZO
Programme Mode	Semester Wise

Eligibility: Bachelor Science with biology or Zoology as a subject combination in graduate level from any recognized University

Duration Min: 2 Years; Max: 4 Years

Self Learning Material (SLM): English (Hindi SLM will be developed by translating the English SLM by maintain technical terminology of English only)

Total Credit: 72

Objectives: To provide an opportunity for science education to the door steps of aspirants and for skill development to enhance employability or entrepreneurship.

M.Sc. Zoology

(Two years Degree Programme)

First Semester

Course code	Course Name	Marks			Credit	Minimum counseling hours
		Theory	Assignment	Total		
MSCZO-501	Invertebrates	80	20	100	3	9
MSCZO - 502	Taxonomy & Evolution	80	20	100	3	9
MSCZO - 503	Animal Physiology & Endocrinology	80	20	100	3	9
MSCZO - 504	Bio-Chemistry	80	20	100	3	9
MSCZO - 505(L)	Practical Zoology I (Practical Related to the syllabus of I st sem.)			200	6	18
		Total Credit			18	

Second Semester

Course code	Course Name	Marks			Credit	Minimum counseling hours
		Theory	Assignment	Total		
MSCZO - 506	Concepts of Cell Biology and Genetics	80	20	100	3	9
MSCZO-507	Molecular Biology & Biotechnology	80	20	100	3	9
MSCZO - 508	Environmental Biology	80	20	100	3	9
MSCZO 509	Animal Behavior	80	20	100	3	9
MSCZO - 510(L)	Practical Zoology II (Practical Related to the syllabus of II nd sem.)			200	6	18
		Total Credit			18	

Third Semester

MSCZO - 601	Vertebrates	80	20	100	3	9
MSCZO - 602	Developmental Biology & Immunology	80	20	100	3	9
MSCZO - 603	Bioinformatics, Biostatistics & Computer Application	80	20	100	3	9
MSCZO - 604	Microbiology	80	20	100	3	9
MSCZO - 605(L)	Practical Zoology III (Practicals Related to the syllabus of III rd sem.)			200	6	18
				Total Credit		18

FOURTH SEMESTER

SPECIAL PAPER: SPECIAL PAPER EITHER FISH AND FISHERIES OR ENTOMOLOGY

FISH AND FISHERIES

Course code	Course Name	Marks			Credit	Minimum counseling hours
		Theory	Assignment	Total		
MSCZO - 606	Fish and Fisheries (Structure and Functions)	80	20	100	3	9
MSCZO - 607	Fish and Fisheries (Applied Ichthyology) (Fisheries Culture, Nutrition and Pathology)	80	20	100	3	9
MSCZO - 608	Laboratory Course: Fishery (Practical Related to the syllabus of IV th sem.)	-	-	100	3	9
MSCZO - 609	Dissertation (Seminar & Viva-Voice)	-	-	Grade	9	27
				Total Credit		18

OR

ENTOMOLOGY

Course code	Course Name	Marks			Credit	Minimum counseling hours
		Theory	Assignment	Total		
MSCZO - 610	Entomology (Systematic and Applied Entomology)	80	20	100	3	9
MSCZO 611	Entomology (Morphology, Physiology & Development Biology)	80	20	100	3	9
MSCZO - 612	Laboratory Course: Entomology (Practical Related to the syllabus of IV th sem.)	-	-	100	3	9
MSCZO 613	Dissertation (Seminar & Viva-Voice)	-	-	Grade	9	27
				Total Credit		18

Note: 1-*Students have to opt “One Special Paper either fish and fisheries or Entomology” from the two given Specialization Courses (**MSCZO606-609 or MSCZO-610-613**) in the fourth semester. Student will have to do a Dissertation. Marks shall not be awarded to the student on the Dissertation, instead of marks Grade A, B, C or D shall be given after assessment of the Dissertation.

The syllabus is divided into three parts:

1. Core courses	15 courses	Total Credits = 54
2. Specialization courses	2 courses (2 theory 1 practical)	Total Credits = 9
3. Dissertation		Total Credits = 9

Total Credits for M.Sc. Degree = 72

Dissertation:

Compulsory research dissertation (master thesis) would be introduced in M.Sc. Zoology program. The research/project topic would be allotted to student as per the recommendation of guide/Advisory Committee. Advisory committee would be constituted with at least 2 members, one chairman of advisory committee (Advisor/Guide) and another member of the committee. The Advisory committee should be approved by the university. The dissertation would be evaluated by external examiner nominated by the university which should not be from same study center. The name of external examiner for the evaluation of dissertation/thesis must be approved from the university. Grade will be awarded to the students and result would be submitted to university. One copy of the dissertation would also be submitted to the university after incorporated all the correction made by the external examiner and successful completion.

SYLLABUS

Credits: 3

Course: I. Invertebrates (MSZO- 501)

Course objectives:

1. To comprehend the systematic position, functional morphology, mode of life, and biodiversity of invertebrates
2. To study their economic importance, affinities and adaptations.
3. To study the parasitic forms of various invertebrate groups and their effect on human and animals.
4. Understand the general features of animal life cycles and forms of reproduction.
5. Describe the general features used to classify animal groups such as type of symmetry, number of tissue layers, body cavities, segmentation and cephalization and distinctive larval forms
6. Describe the structure and function of animals in general at the cellular, tissue and organ level of structural organization.
7. To understand the International Code of Zoological Nomenclature, Its operative principals, Zoological nomenclature and formation of scientific names of various taxa.
8. To understand the Causes, Processes, and Consequences of Evolution.
9. To understand the Principal Mechanisms of Evolution through the process of macro, micro and mega evolutionary process

Syllabus

Organisation of Coelom: Acoelomates, Pseudocoelomates, Coelomates: Protostomes and Deuterostome. Locomotion (Flagella and ciliary movement in Protozoa, Hydrostatic movement in coelenterata, Annelida and Echinodermata); Nutrition and digestion (Patterns of feeding and digestion in lower metazoa, Filter feeding in polychaeta, Mollusca and Echinodermata). Respiration (Organs of respiration Gills, lungs and trachea, Respiratory pigments, Mechanism of respiration. Excretion (Organs of excretion Coelom, Coelomoducts, Nephridia and Malpighian tubules, Excretion and Osmoregulation, Mechanisms of Excretion); Nervous System (Primitive nervous system: Coelenterata and Echinodermata; Advanced Nervous system: Annelida, Arthropoda and Mollusca. Invertebrate larvae (Larval forms of free-living invertebrates, larval forms of parasites, strategies and evolutionary significance of larval forms. Minor Phyla: Organization and general characters.

UNIT SCHEDULE

Invertebrates

Block I:

Unit 1: Organization of coelom

Unit 2: Locomotion

Unit 3: Nutrition and Digestion

Unit 4: Respiration

Block II:

Unit 5: Excretion

Unit 6: Nervous System

Unit 7: Invertebrate larvae

Unit 8: Minor Phyla

Course I: Invertebrates (MSZCO- 501)

UNIT WISE CONTENTS (MSZCO- 501)

Unit 1: Organization of Coelom

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Acoelomates
- 1.4 Pseudocoelomates
- 1.5 Coelomates
- 1.6 Protostomia
- 1.7 Deuterostomia
- 1.8 Summary
- 1.9 Terminal Questions and Answers

Unit 2: Locomotion

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Flagella and Ciliary movement in Protozoa
- 2.4 Hydrostatic movement
 - 2.4.1 Coelentrata
 - 2.4.2 Annelida
 - 2.4.3 Echinodermata
- 2.5 Summary
- 2.6 Terminal Questions and Answers

Unit 3: Nutrition and Digestion

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Patterns of Feeding and Digestion in Lower Metazoa
- 3.4 Filter feeding
 - 3.4.1 Polychaeta
 - 3.4.2 Mollusca
 - 3.4.3 Echinodermata
- 3.5 Summary
- 3.6 Terminal Questions and Answers

Unit 4: Respiration

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Organs of respiration
 - 4.3.1 Gills
 - 4.3.2 Lungs
 - 4.3.2 Trachea
- 4.4 Respiratory Pigments
- 4.5 Mechanism of Respiration
- 4.6 Summary
- 4.7 Terminal Questions and Answers

Unit 5: Excretion

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Organs of Excretion
 - 5.3.1 Coelom
 - 5.3.2 Coelomoducts
 - 5.3.3 Nephridia
 - 5.3.4 Malpighian tubules
- 5.4 Mechanisms of Excretion
 - 5.4.1 Osmoregulation
- 5.5 Summary
- 5.6 Terminal Questions and Answers

Unit 6: Nervous System

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Primitive Nervous system
 - 6.3.1 Coelenterata
 - 6.3.2 Echinodermata
- 6.4 Advanced Nervous system
 - 6.4.1 Annelida
 - 6.4.2 Arthropoda (Crustacea and Insecta)
 - 6.4.3 Mollusca (Cephalopoda)
- 6.5 Trends in Neural Evolution
- 6.6 Summary
- 6.7 Terminal Questions and Answers

Unit 7: Invertebrate larvae

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Larval Forms of Free-Living Invertebrates
- 7.4 Larval forms of Parasites (Helminths)
- 7.5 Strategies and Evolutionary Significance of Larval Forms
- 7.6 Summary
- 7.7 Terminal Questions and Answers

Unit 8: Minor Phyla

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Organization and General Characters
- 8.4 Significance of Minor Phyla
 - 8.4.1 Mesozoa
 - 8.4.2 Gastrotricha
 - 8.4.3 Ctenophora
 - 8.4.4 Rhyncoela
 - 8.4.5 Rotifera
 - 8.4.6 Spinicula
 - 8.4.7 Protostomes
 - 8.4.8 Entoprocta
 - 8.4.9 Deuterostomes
- 8.5 Summary

Credits: 3

Course II. Taxonomy & Evolution (MSZO - 502)**Syllabus:**

Significance and applications of Taxonomy in Zoology. Modern approaches in taxonomy: Chemotaxonomy, Cytotaxonomy, Neotaxonomy and Molecular taxonomy. Dimension of speciation and taxonomic characters. Species concept. Procedures in Taxonomy: Taxonomic procedure, application and rules of International code of zoological nomenclature. Lamarck & Darwinism: Concept, Hardy-Weinberg law of genetic equilibrium and destabilizing forces. Quantifying Genetic Variability: Genetic and Phenotypic variations in populations. Molecular population genetics: Patterns of change in genetic material, significance of molecular variation and Neo Darwinism. Genetics of speciation: Phylogenetic, biological, Isolation, allopatric, sympatric & parapatric speciation. Origin of higher evolution: Gradualism and equilibrium, major trends in higher categories and Micro, Macro and Mega evolution.

UNIT SCHEDULE**Block I: Taxonomy****Unit 1:** Concept of Taxonomy**Unit 2:** Modern approaches in Taxonomy**Unit 3:** Dimension of Speciation and Taxonomic Characters**Unit 4:** Procedures in Taxonomy**Block II: Evolution****Unit 5:** Neo- Darwinism**Unit 6:** Quantifying Genetic Variability**Unit 7:** Genetic Speciation**Unit 8:** Origin of Higher Evolution

Course II: Taxonomy & Evolution (MSCZO-502)

Block I: Taxonomy

Unit 1: Concept of taxonomy

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Significance of Taxonomy
- 1.4 Applications of Taxonomy
- 1.5 Summary
- 1.6 Terminal Questions and Answers

Unit 2: Modern Approaches in Taxonomy

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Chemotaxonomy
- 2.4 Cytotaxonomy
- 2.5 Neotaxonomy and Molecular Taxonomy
- 2.6 Summary
- 2.7 Terminal Questions and Answers

Unit 3: Dimension of Speciation and Taxonomic Characters

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Dimension of Speciation
- 3.4 Mechanism of Speciation
- 3.5 Species Concept
 - 3.5.1 Species
 - 3.5.2 Category
 - 3.5.3 Concept
 - 3.5.4 Sub-species
 - 3.5.5 Infra species
- 3.6 Theories of Biological Classification
 - 3.6.1 Hierarchy of Categories
- 3.7 Taxonomic Characters
- 3.8 Summary
- 3.9 Terminal Questions and Answers

Unit4: Procedures in Taxonomy

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Taxonomic procedure
 - 4.3.1 Taxonomic collection
 - 4.3.2 Preservation
 - 4.3.3 Identification
- 4.4 International Code of Zoological Nomenclature (ICZN)
 - 4.4.1 Principals, Application and Rules
 - 4.4.2 Zoological Nomenclature and Formation of Scientific Names of Various Taxa
- 4.5 Summary
- 4.6 Terminal Questions and Answers

Block II: Evolution

Unit 5: Lamarck & Darwinism

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Concept & theories of Evolution
- 5.4 Hardy-Weinberg law of Genetic Equilibrium
- 5.5 Detailed account of Destabilizing Forces
 - 5.5.1 Natural Selection
 - 5.5.2 Mutation
 - 5.5.3 Genetic Drift
 - 5.5.4 Migration
- 5.6 Summary
- 5.7 Terminal Questions and Answers

Unit 6: Quantifying Genetic Variability

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Genetic structure of Natural Populations
- 6.4 Phenotypic Variations
- 6.5 Model Changes in Genetic Variation
- 6.6 Summary
- 6.7 Terminal Questions and Answers

Unit 7: Genetics of Speciation

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Phylogenetic, Biological and other Concepts of Species
- 7.4 Isolation
- 7.5 Patterns and Mechanisms of Reproductive Isolation
- 7.6 Models of Speciation
 - 7.6.1 Allopatric
 - 7.6.2 Sympatric
 - 7.6.3 Parapatric
- 7.7 Co-evolution and Sexual Selection, Altruism
- 7.8 Summary
- 7.9 Terminal Questions and Answers

Unit 8: Origin of Higher Evolution

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Phylogenetic Gradualism and Punctured equilibrium
- 8.4 Major Trends in the Origin of Higher Categories
- 8.5 Micro, Macro and Mega Evolution
- 8.6 Evolution of Man
- 8.7 Summary
- 8.8 Terminal Questions and Answers

Suggested Reading:

1. The invertebrates. Vol.1, 2 & 8. Hyman, L.H. McGraw Hill Co., New York.
2. Invertebrate Zoology Barnes, RD. W.B.Saunders Co., Philadelphia
3. A Biology of higher invertebrates, Russel-Hunter, WD. McMillan Co. Ltd., London
4. Student Text Book of Zoology. Vol.I.II and III. Sedgwick.A. Central Book Depot, Allahabad
5. Text book of Zoology. Parker, T.J., Haswell. W.A.Macmillan Co., London.
6. Biodiversity, E.O. Wilson, academic Press; Washington.
7. Principle of Animal Taxonomy; G.G. Simpson. Oxford IBH Publishing Company.
8. Theory and Practice of Animal Taxonomy. V.C. Kapoor. Oxford & IBH Publishing Co. Pvt. LTD.
9. Advancement in Invertebrate Taxonomy and Biodiversity. Rajeev Gupta. Agrobios International.
10. Moody: Introduction to Evolution (1978, Kalyani).
11. Savage: Evolution (1963, Holt, Reinhart and Winston)
12. Rastogi: Organic Evolution (1988, Kedarnath & Ramnath)
13. Strickberger: Evolution (2004, Jones & Bartlett)

Course III: Animal Physiology & Endocrinology (MSZO -503)**Course objectives:**

The course objectives include (1) to provide an understanding of the fundamental principles of animal physiology; (2) to understand how these principles are incorporated into the adaptations of different animal groups; (3) to provide experience in researching, discussing, and answering questions about animal physiology; (4) to provide practical experience in investigating physiological questions, and collecting, analyzing, interpreting, and reporting experimental data; and (5) to understand the source, significance and deficiency and dysfunctions of enzymes, vitamins, protein, carbohydrates and lipids.

Syllabus:

Concept of poikilothermy, homeothermy, cold resistance and cold death, heat resistance and heat death. Respiration: Respiratory organs in different animals Transport of O₂ and CO₂, respiratory pigments and control of respiratory activity. Circulation: Types of heart, Cardiac cycle, haemodynamics and Homeostasis. Nutrition & Digestion: Patterns of digestion, absorption and role of digestive enzymes in animals. Excretion: Functions of kidney, types of nitrogenous wastes, Urea production and osmoregulation in reptiles, Aves and mammals. Nervous system: Structure of a neuron, Generation of nerve impulsion and propagation and Concept of sensory receptors. Muscle stimulation: Structure, kinds, functions and characteristics of muscles. Brief history and scope of endocrinology, Characteristic feature, structural organization, hormone secretion and functions of Pituitary gland, Thyroid gland, Adrenal gland, Pancreas, mammalian testes and ovary hormones. General study of pheromones.

Unit Schedule**Block I. Response to Cell & Functional Physiology**

Unit 1: Thermoregulation and Respiration

Unit 2: Circulation and Cardiovascular System

Unit 3: Physiology of Digestion and Excretion

Unit 4: Physiology of Nervous system and Muscle stimulation

Block II: Endocrinology

Unit 5: History and Scope of Endocrinology

Unit 6: Pituitary and Thyroid Gland

Unit 7: Pancreas and Adrenal Gland

Unit 8: Vertebrate Reproductive Endocrinology

Course III: Animal Physiology & Endocrinology (MSCZO -503)
UNIT WISE CONTENTS (MSCZO-503)

Block I. Response to Cell & Functional Physiology

Unit 1: Thermoregulation and Respiration

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Concept of Poikilothermy and Homeothermy
- 1.4 Survival Mechanism in Poikilotherms and Homeotherms
- 1.5 Cold Resistance and Cold Death, Heat Resistance and Heat Death
- 1.6 Respiratory Organs in Different Animals
- 1.7 Transport of Oxygen and Carbon dioxide
- 1.8 Respiratory Pigments
- 1.9 Summary
- 1.10 Terminal Questions and Answers

Unit 2: Circulation and Cardiovascular System

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Types of heart
- 2.3.1 Concepts of Neurogenic and Myogenic Hearts
- 2.4 Cardiac cycle, ECG patterns in Mammals
- 2.5 Homeostasis and Blood Clot Formation
- 2.6 Summary
- 2.7 Terminal Questions and Answers

Unit 3: Physiology of Digestion and Excretion

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Patterns of Digestion and Absorption in Animals
- 3.4 Role of Digestive Enzymes
- 3.5 Digestion, Absorption and Assimilation of Various Food Stuffs
- 3.6 Functions of Kidney
- 3.7 Types of Nitrogenous Wastes in Different Animal Groups and their Excretion
- 3.8 Urea production – Hans *Krebs* and Kurt *Henseleit* cycle, Urine Formation
- 3.9 Osmoregulation
- 3.9.1 Reptiles, Aves & Mammals
- 3.10 Summary
- 3.11 Terminal Questions and Answers

Unit 4: Physiology of Nervous system and Muscle stimulation

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Structure of a Neuron
- 4.4 Generation of Nerve Impulsion and Propagation
- 4.5 Synaptic Transmission and Neurotransmitters
- 4.6 Concept of Sensory Receptors (Chemo and Photo)
- 4.7 Structure, Kinds and Characteristics of Muscles
- 4.8 Mechanism of Muscle Stimulation and Contraction
- 4.9 Neuro - Muscular Junction
- 4.7 Summary
- 4.8 Terminal Questions and Answers

Block II: Endocrinology

Unit 5: History and Scope of Endocrinology

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Brief history and Scope of Endocrinology
- 5.4 Classification and Chemical Nature of Hormones
- 5.5 Summary
- 5.6 Terminal Questions and Answers

Unit 6: Pituitary and Thyroid Glands

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Structural organization
- 6.4 Hormone secretion and its functions - Hypothalamic control
- 6.5 Thyroid Gland - Structural Organizations
- 6.6 Parathyroid its Structure and Functions
- 6.7 Summary
- 6.8 Terminal Questions and Answers

Unit 7: Pancreas and Adrenal Glands

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Structure of pancreas
 - 7.3.1 Pancreatic hormones and their functions
 - 7.3.2 Dysfunction and disease of pancreatic hormones
- 7.4 Structural Organizations of Adrenals
- 7.5 Functions of Cortical and Medullary Hormones
- 7.6 Summary
- 7.7 Terminal Questions and Answers

Unit 8: Vertebrate Reproductive Endocrinology

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Structure of Mammalian Testes and Ovary
- 8.4 Male and Female Sex Accessory Organs
- 8.5 Hormones of Testes and Ovary – Estrous and Menstrual Cycle
- 8.6 Hormones of Pregnancy - Parturition
- 8.7 Hormonal Control of Lactation
- 8.8 Pheromones
- 8.8 Summary
- 8.9 Terminal Questions and Answers

Suggested Readings:

Animal Physiology:

1. William S. Hoar- General and Comparative Physiology, prentice hall of India ltd.
2. Wood E.W. Principle of Animal physiology
3. Nagbhushnum R., Sarojini R., Kodarkar M.S. –Animal Physiology
4. Verma , Agarwal & Tyagi-animal physiology
5. Moeye K.-Animal Physiology, Cambridge low prize edition.
6. Dantzler, W.H. Comparative Physiology (Handbook of Physiology): Vol. 1, 2, (ed.) Oxford University Press, New York, USA
7. R. Eckert. Animal Physiology: Mechanisms and Adaptation. W.H.
8. Mohan Arora – animal physiology, Himalaya publication
9. A.K. Berry. –animal physiology .
10. Goel, K.A. and Shastry, K.B. : Animal Physiology, Rastogi Publication, Meerut. Dalela, R.C. : Animal Physiology, S. Chand & Co. Ltd., New Delhi
11. Agarwal, R.A., Srivastava, Anil Kumar and Kaushal Kumar : Animal Physiology and Biochemistry, S. Chand & Co. Ltd., New Delhi
12. Kulshrestha, V.V.: Experimental Physiology, Vikas Publishing House, New Delhi
Samasiviah, I. et.al. : Text Book of Animal Physiology and Ecology, S. Chand & Co.Ltd., New Delhi
13. Verma, P.S., Tyagi, B.S. and Agarwal, V.K. : Animal Physiology, S. Chand & Co. Ltd., New Delhi

Course IV: Biochemistry (MSCZO-504)**Syllabus:**

Chemical Equilibrium: Concepts of thermodynamics, High energy compounds (ATP), oxidation and reduction and buffering mechanism of the body. Enzymes: Nomenclature, classification, action mechanism and factors affecting enzyme activity. Chemical structure and classification, sources and deficiency state of vitamins. Carbohydrates: Structure, classification sources and metabolism. Proteins: Chemical structure, classification, sources, metabolism and defects of protein nutrition. Lipids: Structure, classification and sources, Biosynthesis of fatty acids, Cholesterol, Porphyrins and bile pigments. Glycolysis, Gluconeogenesis, Glycogenesis, Glycogenolysis, Electron Transport Chain and Hexose–Monophosphate Shunt.

Biological Chemistry**Block I**

Unit 1: Chemical Equilibrium

Unit 2: Enzymes

Unit3: Vitamins

Unit4: Carbohydrates

Block II

Unit 5: Proteins

Unit 6: Lipids

Unit 7: Biochemical Oxidation

Course IV: Bio-chemistry (MSCZO -504)
UNIT WISE CONTENTS (MSCZO-504)

Course IV: Biochemistry (MSCZO-504)

Block I

Unit 1: Chemical Equilibrium

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Concepts of Thermodynamics
- 1.4 High Energy Compounds with Special Reference to ATP
- 1.5 Concepts of Oxidation and Reduction
- 1.6 Buffering Mechanism
- 1.7 Summary
- 1.8 Terminal Questions and Answers

Unit 2: Enzymes

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Nomenclature and Classification
- 2.4 Enzyme Kinetics
- 2.5 Mechanism of Enzyme Action
- 2.6 Factors Influencing Enzyme Activity
- 2.7 Chemical Structure and Significance of Coenzyme and their Specificity
- 2.8 Summary
- 2.9 Terminal Questions and Answers

Unit3: Vitamins

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Chemical Structure
- 3.4 Classification
- 3.5 Sources and Deficiency State of Fat and Water Soluble Vitamins
- 3.6 Summary
- 3.7 Terminal Questions and Answers

Unit4: Carbohydrates

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Structure
- 4.3.1 Classification and sources
- 4.4 Metabolism
- 4.4.1 Glycolysis
- 4.4.2 Glycogenolysis
- 4.4.3 Glycogenesis
- 4.4.4 Gluconeogenesis
- 4.4.5 Hexose–Monophosphate Shunt and Electron Transport Chain (ETC)
- 4.5 Summary
- 4.6 Terminal Questions and Answers

Block II.

Unit 5: Proteins

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Chemical Structure, Classification and Sources
- 5.4 Metabolism of Proteins
 - 5.4.1 Decarboxylation
 - 5.4.2 Transamination
 - 5.4.3 Transmethylation
- 5.5.4 Deamination of Essential and Non-essential Amino Acids
- 5.5 Summary
- 5.6 Terminal Questions and Answers

Unit 6: Lipids

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Structure, Classification and Sources
- 6.4 Biosynthesis and Utilization of Fatty Acids
 - 6.4.1 Ketone Bodies
 - 6.4.2 Cholesterol
- 6.5 Porphyrins and Bile Pigments
- 6.6 Summary
- 6.7 Terminal Questions and Answers

Unit 7: Biochemical Oxidation

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Breakdown of Carbohydrates
- 7.4 β -oxidation of Fatty Acids
- 7.5 Bioenergetics of High Energy Compounds
- 7.6 Electron Transport Chain and production of ATP
- 7.7 Summary
- 7.8 Terminal Questions and Answers

Suggested Readings:

Biochemistry:

1. J.L. Jain –biochemistry S.Chand Publication, Meerut
2. Lehninger- Biochemistry, Kalyani Publications
3. Stryer-Biochemistry, W.H Freeman and Co., New York
4. Granner and Rodwell - Harper's Illustrated Biochemistry, Murray, (27th Ed.), McGraw Hill, New York, USA
5. Nelson and Cox - Principles of Biochemistry. Lehninger. 2nd Ed. CBS publishers.
6. J H Wet - General Biochemistry Wiley Eastern Ltd.
7. Rangnatha Rao K-Text Book of Biochemistry, Prentice-Hall of India
8. C.B.Powar- Biochemistry – (Himalaya Pub.)
9. Srivastava, H.S.: Elements of Biochemistry, Rastogi Publications, Meerut

Course V: Laboratory Exercise (MSZO -505 L) Practical Zoology

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session. The practical work shall comprise:

Unite Schedule:

Block I

Unit 1: Study of permanent prepared slides of different Phyla.

Unit 2: Study of the museum specimens belonging to the different invertebrate phyla.

Unit 3: Permanent slide preparations of the material available/provided.

Unit 4: Parasitology: Study of life-cycle of some parasites through charts, models or live materials.

Block II

Unit 5: Evolution

Unit 6: Systematics

Unit 7: Physiology Experiments

Unit 8: Bio-chemistry Experiments

Course V: Laboratory Exercise (MSZO -505 L) Practical Zoology

Unit Wise Contents

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session. The practical work shall comprise:

Unit 1: Study of permanent prepared slides of different Phyla

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Prepared slides study of Invertebrate Phyla
- 1.4 Summary
- 1.5 Terminal questions & Answers

Unit 2: Study of the Museum Specimens Belonging to the Following Invertebrate Phyla

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Museum specimens of Invertebrate Phyla
 - 2.3.1 Protozoa
 - 2.3.2 Porifera
 - 2.3.3 Coelentrata
 - 2.3.4 Platyhelmenthis
 - 2.3.5 Nematoda
 - 2.3.6 Annelida
 - 2.3.7 Arthropoda
 - 2.3.8 Mollusca
 - 2.3.9 Echinodermata
- 2.4 Summary
- 2.5 Terminal Questions and Answers

Unit 3: Permanent slide preparations of the material available/provided

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Permanent preparations of the material provided
- 3.4 Summary
- 3.5 Terminal Questions and Answers

Unit 4: Parasitology: Study of life-cycle of some parasites through charts, models or live materials

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Parasitology: Life cycle study of parasites
- 4.4 Summary
- 4.5 Terminal Questions and Answers

Unit 5: Evolution

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Study of evolution of Horse, Elephant, and Man (through charts/ models.)
- 5.4 Adaptive modification in feet of Birds/mouthparts of Insects (through charts/ slides).
- 5.5 Embryological evidences of Evolution (through chart).
- 5.6 Analogy and Homology (wings of Birds and Insects, forelimbs of Bats and Rabbits through charts.)
- 5.7 Summary
- 5.8 Terminal Questions and Answers

Unit 6: Systematic

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Identification of local fauna on the basis of their morphological characters (5 each)
- 6.4 Construction of a dichotomous key
- 6.5 Zoological names of some local fauna (Mammals and Birds)
- 6.6 Summary
- 6.7 Terminal Questions and Answers

Unit 7: Physiology Experiments

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Estimation of total Leucocytes number per cubic mm
- 7.4 Differential count of Leucocytes
- 7.5 Estimation of total Erythrocyte count per cubic mm of blood
- 7.6 Summary
- 7.7 Terminal Questions and Answers

Unit 8: Bio-chemistry Experiments

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Chemical test of Urine for the presence of Urea, Sugar, Proteins and Ketone Bodies
- 9.4 Tests for Carbohydrates, Proteins and Lipids
- 9.5 Determination of Hemoglobin (%) in human blood; also calculation of color index and the mean corpuscular hemoglobin concentration
- 9.6 Summary
- 9.7 Terminal Questions and Answers

Course I: Concepts of Cell Biology and Genetics (MSZO -506)

Objective:

1. To understand the fine structure of genetic materials and regulation of their action. To know the chromosomal basis of genetic disorders, development and differentiation. Also, to know the importance of population genetics and nuances of genetic engineering and applied genetics
2. The purpose of the course is to provide a working knowledge of cytogenetics, the preparation of materials for study, and the importance of chromosomal variations in structure and number in such fields as plant and animal breeding, population genetics, evolutionary genetics, taxonomy and the medical sciences
3. To develop knowledge on different aspects of chromosomal structure, number, and behavior, and their effects at the organism, population and species levels
4. To describe the general principles of gene organization and expression in both prokaryotic and eukaryotic organisms
5. To interpret the outcome of experiments that involves the use of recombinant DNA technology and other common gene analysis techniques
6. To explain various levels of gene regulation and protein function including signal transduction and cell cycle control
7. To understand the structure and molecular basis of cellular interactions, energy transformation, regulation and control of genes, cell cycle and information transfer

Syllabus:

Structure and classes of DNA, Chromosomal proteins, interphase and metaphase stages, organization of interphase nucleus, Giant chromosomes: polytene and lampbrush chromosome. Sex chromosomes and mechanism of sex determination in Mammals and *Drosophila*. Cell division: Mitosis, Meiosis, Chromosome pairing and recombination and genetic regulation of meiosis. Somatic cell genetics: Cell fusion and hybrids, heterokaryon and radiation in hybrids. Human cytogenetics: Karyotype and nomenclature of metaphase chromosome bands, Chromosomes their anomalies and disease, common syndromes, compound anomalies and human genome. Molecular cytogenetic techniques: FISH, GISH, DNA Fingerprinting, Karyotyping and Chromosome painting. Genome Analysis: prokaryotic & eukaryotic genomes, role of Transposable elements in genetic regulation and genome analysis. Gene mapping, gene mapping in human and bacteria. Cell Cycle: cell division regulation in yeast and eukaryotes and molecular basis of cellular checkup and neoplasia.

Unit Schedule

Cytogenetics:

Block I

Unit 1: Biology of chromosome

Unit 2: Sex chromosome, sex determination and Dosage compensation in *Drosophila*

Unit 3: Cell division

Unit 4: Somatic cell genetics

Block II

Unit 5: Human Cytogenetics

Unit 6: Microbial Cytogenetics

Unit 7: Molecular Cytogenetic Techniques

Unit 8: Genome Analysis and Genetics of Cell cycle

Concepts of Cell Biology and Genetics (MSZO-506)

UNIT WISE CONTENTS

Cytogenetics

Block I:

Unit1: Biology of chromosome

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Classes of DNA
- 1.4 Chromosomal proteins: Histone and their modifications
- 1.5 -Nucleosome model
- 1.6 Centromere, Kinetochore and Telomere
- 1.7 Metaphase chromosome banding
- 1.8 Chromosome and Chromosomal aberrations
- 1.9 Giant chromosomes: Polytene and Lampbrush chromosome
- 1.10 Summary
- 1.11 Terminal Questions and Answers

Unit 2: Sex chromosome, sex determination and Dosage compensation in *Drosophila* and Humans

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Sex chromosomes
- 2.4 Sex determination
- 2.5 Dosage compensation
 - 2.5.1 in *Drosophila*
 - 2.5.2 in Human beings
- 2.6 Summary
- 2.7 Terminal Questions and Answers

Unit 3: Cell division

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Mitosis
 - 3.3.1 Role of Maturation Promoting Factors
 - 3.3.2 Chromosomal movement
 - 3.3.3 Exit from Mitosis
 - 3.3.4 Cytokinesis
- 3.4 Meiosis
 - 3.4.1 Chromosome Pairing and Recombination
 - 3.4.2 Genetic regulation of Meiosis
- 3.5 Summary
- 3.6 Terminal Question and Answers

Unit 4: Somatic Cell Genetics

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Cell fusion and hybrids
- 4.3.2 Agents and mechanism of fusion
- 4.4 Heterokaryon – selecting hybrid and chromosome segregation
- 4.5 Summary
- 4.6 Terminal Question and Answers

Block II:

Unit 5: Human cytogenetics

- 5.1 Objectives
- 5.2 Summary
- 5.3 Karyotype and Nomenclature of Metaphase Chromosome Bands
- 5.5 Types of Chromosomes their Anomalies and Disease
- 5.6 Common Syndromes caused by Aneuploidy, Polyploidy, Mosaicism, Deletion and Duplication
- 5.7 Chromosomal Anomalies in Malignancy
- 5.7.1 Chronic Myeloid Leukemia
- 5.8 Human Genome
- 5.9 Summary
- 5.10 Terminal Questions and Answers

Unit 6: Microbial Cytogenetics

- 6.1 Objective
- 6.2 Introduction
- 6.3 Bacterial chromosome. Bacterial Transformation, Transduction and Conjugation
- 6.4 Bacteriophages
- 6.4.1 Types
- 6.4.2 Structure and morphology of T₄ phase
- 6.4.3 Morphogenesis
- 6.5 Summary
- 6.6 Terminal Questions and Answers

Unit 7: Molecular cytogenetic techniques

- 7.1 Objectives
- 7.2 Introduction
- 7.3 FISH, GISH
- 7.4 DNA Fingerprinting
- 7.5 Flow Cytometry
- 7.6 Summary
- 7.7 Terminal Questions and Answers

Unit 8: Genome Analysis and Genetics of Cell cycle

- 8.1 Objectives
- 8.2 Introduction
- 8.3 C- Value paradox
- 8.3.1 Detailed account of various models of Prokaryotic Genomes
- 8.3.2 Viral Genome and Eukaryotic Genomes
- 8.3.3 Organization of Genes in Organelle Genomes
- 8.4 Molecular analysis of Genomic DNA in Yeast
- 8.5 Transposable elements in Prokaryotes and Eukaryotes
- 8.7 Genome analysis
- 8.7.1 Humans and Yeast
- 8.8 Gene Mapping in Human and Bacteria

- 8.9 Genetic regulation of Cell Division in Yeast and Eukaryotes
- 8.10 Molecular basis of cellular check up
- 8.11 Molecular basis of Neoplasia
- 8.12 Summary
- 8.13 Terminal Questions and Answers

Course II: Molecular Biology and Biotechnology (MSZO -507)

DNA replication: Prokaryotic and eukaryotic DNA replication, replication mechanism and enzymes and proteins involved in DNA replication. Prokaryotic and eukaryotic Transcription mechanism, regulation and termination. Post-transcriptional modifications in RNA: 5'- Cap formation, End processing and polyadenylation, Splicing, editing and nuclear export of mRNA. Prokaryotic and eukaryotic Translation, its regulation and proteins modifications. Recombinant DNA Technology: Gene cloning, Restriction enzymes, Hybridization techniques, Molecular markers and Cloning Vectors. Applications of Biotechnology: Cell, Organ and Whole embryo culture, In vitro fertilization (IVF) technology, Dolly sheep, Embryo transfer in humans, Transgenic animals Human gene therapy, Cryobiology.

Block I: Molecular Biology

Unit 1: DNA replication

Unit 2: Transcription

Unit 3: Post-transcriptional modifications in RNA

Unit 4: Translation

Block II: Biotechnology

Unit 5: Recombinant DNA Technology

Unit 6: Cloning Vectors

Unit 7: Animal Biotechnology and its application

Molecular Biology and Biotechnology (MSZO -507)

UNIT WISE CONTENTS

Block I: Molecular Biology and Biotechnology

Unit 1: DNA replication

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Prokaryotic and Eukaryotic DNA Replication
- 1.4 Enzymes and accessory proteins involved in DNA replication
- 1.5 Mechanics of DNA replication
- 1.6 DNA damage and repair mechanism
- 1.7 Summary
- 1.8 Terminal Questions and Answers

Unit 2: Transcription

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Prokaryotic & Eukaryotic transcription
- 2.4 Transcriptional activators & repressors
- 2.5 Regulatory elements and mechanisms of transcription regulation
- 2.6 Transcriptional polymerase, Capping, Elongation & Termination
- 2.6.1 Structure and Function of different type of RNA
- 2.6.2 RNA Transport
- 2.7 Summary
- 2.8 Terminal Questions and Answers

Unit 3: Post-transcriptional modifications in RNA

- 3.1 Objectives
- 3.2 Introduction
- 3.3 5'- Cap formation
- 3.4 End processing and Polyadenylation
- 3.5 Splicing and editing
- 3.6 Nuclear export of mRNA
- 3.7 Summary
- 3.8 Terminal Questions and Answers

Unit 4: Translation

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Genetic code
- 4.4 Prokaryotic and Eukaryotic Translation
- 4.5 Regulation of Translation
- 4.6 Post-translation modifications of Proteins
- 4.7 Summary
- 4.8 Terminal Questions and Answers

Block II: Biotechnology

Unit 5: Recombinant DNA Technology

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Gene cloning - the basic steps
- 5.4 Restriction enzymes – ligase, linkers and adaptors. cDNA transformation
- 5.5 Selection of Recombinants
- 5.6 Hybridization Techniques
- 5.6.1 Blotting techniques: Southern blotting, Northern blotting and Western blotting
- 5.7 Gene probe - Molecular finger printing (DNA finger printing)
- 5.8 Molecular Markers in genome analysis (RFLP, RAPD and AFLP)
- 5.9 Genomic Library
- 5.10 Summaries
- 5.11 Terminal Question and Answers

Unit 6: Cloning Vectors

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Plasmid Biology
- 6.4 Cloning Vector
- 6.4.1 Yeast
- 6.4.2 *E. coli*
- 6.4.3 PBR 322
- 6.5 Summary
- 6.6 Terminal Questions and Answers

Unit 7: Animal Biotechnology and its Application

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Cell, Organ and Whole embryo culture
- 7.4 In-vitro fertilization (IVF) technology
- 7.4.1 Dolly, Embryo transfer in human
- 7.5 Transgenic animal
- 7.6 Human gene therapy, Cryobiology
- 7.7 Summary
- 7.8 Terminal Questions and Answers

Suggested Readings:

1. Brooker: Genetics : Analysis and Principles (1999, Addison-Wesley)
2. Gardner *et al*: Principles of Genetics (1991, John Wiley)
3. Griffith *et al*: An Introduction to Genetic Analysis (2005, Freeman)
4. Hartl & Jones: Essential Genetics: A Genomic Perspective (2002, Jones & Bartlet)
5. Russell: Genetics (2002, Benjamin Cummings)
6. Snustad & Simmons: Principles of Genetics (2006, John Wiley)

Biotechnology:

1. Purohit, S.S. and S.K.Mathur. 1999. Biotechnology Fundamentals and Application. Agro Botanica, New Delhi.
2. R.C. Dubey 2001 A text book of biotechnology. Rajendra Ravindra Printer. New Delhi.
3. T.A. Brown 2004 Gene cloning and DNA analysis. Blackwell Science, Osney Mead, Oxford.
4. Dawson, M.T., Powell .R, and Gannon, F. 1996. Gene Technology. Bios Scientific Publishers.

Course III: Environmental biology (MSZO -508)

Course Objectives:

1. To generate up-to-date knowledge on environmental conservation and management through a comprehensive understanding of the components of ecosystem, biological cycles, habitat ecology, resource ecology, pollution and its management
2. To develop understanding on the evolutionary approach – how animals behave (i.e., the proximate, or mechanistic perspective) and why they behave in a certain way (i.e., the ultimate, or evolutionary perspective)
3. To develop the understanding on the ecological realm of biology that integrates the interactions and interdependencies between organisms and their environment

Syllabus:

Community Ecology Nature of Community, Community Structure, Level of species diversity, Edges & Ecotone. Ecology of population: Characteristic of population, Population growth curve, Population regulation Life history strategies (R & K selection), Population age structure, Population Growth Curves/forms: Growth of organism with non overlapping generation, model of population growth, matrix. Models of prey-predation dynamics, optimal foraging theory and role of predation in nature. Intra-specific and inter-specific competition, niche concepts and Symbiosis. Succession: Type of Ecological Succession, Concept of Climax. Environmental Pollution, Global environmental changes, Principle of Conservation. Major drivers of diversity changes.

Block I: Environmental biology

Unit 1: Ecology of population

Unit 2: Population Growth

Unit3: Predation

Block II

Unit4: Competition and niche theory

Unit5: Community Ecology and Ecological Succession

Unit6: Applied Ecology and Conservation Biology

Environmental biology
UNIT WISE CONTENTS (MSZO-508)

Block I: Environmental biology

Unit 1: Ecology of population

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Characteristic of population
- 1.4 Population growth curve
- 1.5 Population regulation
- 1.6 Life history strategies (R & K selection)
- 1.7 Age structure Population
- 1.7 Summary
- 1.8 Terminal Questions and Answers

Unit 2: Population Growth

- 2.1 Objectives
- 2.2 Introduction
- 2.3. Growth of organism with non overlapping generation
- 2.4 Stochastic and time lag model of population growth
- 2.5 Exponential growth, Verhulst–Pearl logistic growth model
- 2.6 Stable age distribution
- 2.7 Population growth projection using Leslie Matrix
- 2.8 Summary
- 2.9 Terminal Questions and Answers

Unit 3: Predation

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Patterns of abundance
- 3.4 Models of Prey-Predation dynamics
- 3.5 Optimal foraging theory
 - 3.5.1 Patch choice
 - 3.5.2 Diet
 - 3.5.3 Prey
 - 3.5.4 Selectivity
 - 3.5.5 Foraging time
- 3.6 Role of predation in nature
- 3.7 Summary
- 3.8 Terminal Questions and Answers

Block II

Unit 4: Competition and Niche theory

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Competition
 - 4.3.1 Intra-specific competition
 - 4.3.2 Inter-specific competition
- 4.4 History of niche concepts
- 4.5 Symbiosis
- 4.6 Summary
- 4.7 Terminal Questions and Answers

Unit 5: Community Ecology and Ecological Succession

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Nature of Community
- 5.4 Community Structure
- 5.5 Level of species diversity
- 5.6 Edges & Ecotones
- 5.7 Succession & Type of Ecological Succession
- 5.8 Concept of Climax
- 5.9 Summary
- 5.10 Terminal Questions and Answers

Unit 6: Applied Ecology and Conservation Biology

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Environmental Pollution
- 6.4 Global environmental changes
- 6.5 Principle of Conservation
- 6.6 Major drivers of diversity changes
- 6.7 Summary
- 6.8 Terminal Questions and Answers

Course IV: Animal behavior (MSZO-509)**Syllabus:**

Migratory Behavior: Migrations of fishes, turtles and birds. Evolution of mutualism, interaction between plants and pollinators, basic models of interactions. Genetic and environmental development of behavior. Neural and hormonal control of behavior. Modes of communication. Ecological aspect of behavior: Habitat and food selection, aggression, homing, territoriality, dispersal and host parasite relations. Social behavior: Aggression, group and kin selection/Altruistic Behavior. Reproductive behavior: Sex and reproductive strategies, selection, mating and courtship. Biological rhythms: Circadian, Circa-annual. Learning and Memory: Conditioning, habituation, Insight and association learning, reasoning and cognitive skills.

Block I: Animal behavior

Unit 1: Concept and Classification
Unit 2: Control of behavior
Unit 3: Developmental of behavior
Unit 4: Communication
Unit 5: Ecological aspect of behavior

Block II

Unit6: Social behavior
Unit7: Reproductive behavior
Unit8: Biological rhythms
Unit9: Learning and Memory

Animal behavior
UNIT WISE CONTENTS (MSZO-509)

Block I: Animal behavior

Unit 1: Concept and classification

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Ethology as a branch of biology
- 1.4 Animal psychology
 - 1.4.1 Classification of behavioral patterns
 - 1.4.2 Analysis of behavior (Ethogram)
- 1.5 Innate Behavior
- 1.6 Summary
- 1.7 Terminal Questions and Answers

Unit 2: Control of behavior

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Neural behavior
- 2.4 Hormonal behavior
- 2.5 Summary
- 2.6 Terminal Questions and Answers

Unit 3: Developmental behavior

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Genetic components
- 3.4 Environmental components
- 3.5 Summary
- 3.6 Terminal Questions and Answers

Unit 4: Communication

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Chemical
- 4.4 Visual
- 4.5 Light
- 4.6 Audio
- 4.7 Specific specificity of Songs
- 4.8 Evolution of Language (primates)
- 4.9 Summary
- 4.10 Terminal Questions and Answers

Unit 5: Ecological aspects of behavior

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Habitat selection
- 5.4 Food selection

- 5.5 Optimal forage theory
- 5.6 Anti predation defenses
- 5.7 Aggression
- 5.8 Homing
- 5.9 Territoriality
- 5.10 Dispersal
- 5.11 Host parasite relations
- 5.12 Summary
- 5.13 Terminal Questions and Answers

Block II

Unit 6: Social behavior

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Aggression
 - 6.3.1 Schooling in fishes
 - 6.3.2 Flocking in birds
 - 6.3.3 Herding in mammals
- 6.4 Group selection
 - 6.4.1 Kin selection
- 6.5 Social organization in Insects and Primates
- 6.6 Summary
- 6.7 Terminal Questions and Answers

Unit 7: Reproductive behavior

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Evolution of Sex and Reproductive strategies
- 7.4 Mating systems
- 7.5 Courtship
- 7.6 Sperm competition
- 7.7 Sexual selection
- 7.8 Summary
- 7.9 Terminal Question and Answers

Unit 8: Biological rhythms

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Circadian and Circa-annual rhythms
- 8.4 Orientations and navigation
- 8.5 Migration of fishes, turtles and birds
- 8.6 Summary
- 8.7 Terminal Questions and Answers

Unit 9: Learning and Memory

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Conditioning
- 9.4 Habituation
- 9.5 Insight learning
- 9.6 Association learning

- 9.7 Reasoning
- 9.8 Cognitive skills
- 9.9 Summary
- 9.10 Terminal Questions and Answers

Suggested Readings:

Animal Behavior

1. Drickamer & Vessey : Animal Behaviour – concepts, processes and methods (2nd ed. 1986, Wadsworth,)
2. Freeland: Problems in Practical Advanced Level Biology (1985, Hodder & Stoughton,)
3. Goodenough et al.: Perspectives on Animal Behaviour (1993, Wiley)
4. Grier: Biology of Animal Behaviour (1984, Mosby)
5. Lorenz: The Foundation of Ethology (1981, Springer)
6. Manning & Dawkins: An Introduction to Animal Behaviour (5th ed. 1998, Cambridge).
7. Mcfarland : Animal Behaviour, Psychology, Ethology and Evolution (1985, Pitman).
8. Slater: An Introduction to Ethology (1985, Cambridge).

Ecology & Environmental Biology

1. Cunningham and Cunningham: Environmental Science (2003, McGraw Hill)
2. Odum: Fundamental of Ecology (1971, Saunders)
3. Raven, Berg and Jhonson: Environment (1993, Saunders)
4. Ricklefs: Ecology (1990, Freeman)
5. Sharma: Ecology and Environment (2003, Rastogi)
6. Turk and Turk: Environmental Science (1998, Saunders)

Course V: Laboratory Exercise (MSZO-510) Practical Zoology

Unit 01: Cytology Experiment

Unit 02: Experiment on Genetics

Unit 03: Experiment on Ecology

Unit 04: Study of permanent cytological slide

Course V: Laboratory Exercise (MSZO-510) Practical Zoology

UNIT WISE CONTENTS (MSZO-510)

Unit 01: Cytology Experiment

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Study of different stages of Mitosis with the help of Onion Root Tip.
- 1.4 Study of different stages of Meiosis with the help of Grasshopper testis.
- 1.5 Laboratory preparation of following models using beads and wire:
 - 1.5.1 Adenosine triphosphate (ATP)
 - 1.5.2 DNA and RNA bases
 - 1.5.3 Nucleosides
 - 1.5.4 Nucleotides

Unit 02: Experiment on Genetics

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Morphological study of *Drosophila* for Genetic Traits
- 2.4 Preparation of chromosomal maps in *Drosophila* based on percent of crossing over.
- 2.5 Genetics exercise (data to be provided)
- 2.6 Summary
- 2.7 Terminal Questions and Answers

Unit 3: Experiments on Ecology: Calculation of the following shall be done on the basis of given data

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Calculation of similarity index between different communities
- 3.4 Calculation of concentration of dominance for different communities
- 3.5 Calculation of Shannon Weiner Index of diversity in different communities
- 3.6 Calculation of similarity index between different communities.
- 3.7 Calculation of concentration of dominance for different communities.
- 3.8 Determination of dissolved oxygen.
- 3.9 Determination of free CO₂ in water sample.

Unit: 04 study of permanent cytological slide

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Prepared slide study of Meiosis and Mitosis
- 4.4 Summary
- 4.5 Terminal Questions and Answers

M.Sc. Final**Course I: Vertebrates (MSZO-601)****Course objectives:**

1. To understand the systemic and morphology) of various groups of chordates.
2. To understand the origin and evolutionary patterns of chordate.
2. To study their affinities and adaptations to different modes of life.
3. To Understand the general features of animal life cycles and forms of reproduction
4. To describe the general features used to classify animal groups such as type of symmetry, number of tissue layers, body cavities, segmentation and cephalization, distinctive larval forms
5. To understand the general features of animal life cycles and forms of reproduction
6. To describe the structure and function of animals in general at the cellular, tissue and organ level of structural organization.
7. To study the comparative endocrinology, anatomy, morphology and histology of endocrine tissues of vertebrates organs and their functions.
8. To imbibe the current knowledge pertaining to the development of animal embryos of diverse taxonomic groups through experimental analyses based on modern biological tool.

Syllabus

Classification of the chordates up to order level and characteristic features. Origin, evolution and adaptive radiation of chordates. Salient features and affinities of Protochordates. Origin, evolution and general characters of Agnatha : Ostracoderms and Cyclostomes. The early Gnathostomes (Placoderms). General account of the Elasmobranchii, Holocephali, Dipnoi and Crossopterygii. Adaptive radiation in bony fishes. Origin, evolution and adaptive radiation of Amphibia. Origin and evolution of Reptiles: Seymouria and Cotylosauria. Skull of Reptiles. Venom in Ophidians. Dinosaurs. Living fossil: a brief account of Rhynchocephalia. Chelonia, Crocodilia and Squamata. Origin and evolution of birds. Origin of flight: Flight adaptations. Ratitae (Flightless Birds). Modifications of Beak, Feet and Palate in Birds. Migration. Origins of mammals: Organisation, distribution and affinities of primitive mammals (Prototheria and Metatheria).

Course I: Vertebrates (MSZO-601)

UNIT SCHEDULE:

Block I: Biology of chordates

Unit 1: Taxonomy and Origin of Chordates

Unit 2: Protochordates

Unit 3: Agnatha & Gnathostomes

Unit 4: Pisces

Block II:

Unit 5: Amphibia

Unit 6: Reptilia

Unit 7: Aves

Unit 8: Mammalia

Vertebrates (MSZO-601)

UNIT WISE CONTENTS (MSZO-601)

Block I: Biology of chordates

Unit 1: Taxonomy and Origin of chordates

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Classification of the Chordates up to order level
- 1.4 Habit & Habitats
- 1.5 Characteristic features
- 1.6 Origin, evolution and Adaptive Radiation of Chordates
- 1.7 Summary
- 1.8 Terminal Questions and Answers

Unit 2: Protochordates

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Salient features of Protochordates
 - 2.3.1 Hemichordata
 - 2.3.2 Urochordata
 - 2.3.3 Cephalochordata
- 2.4 Affinities and Interrelations
- 2.5 Summary
- 2.6 Terminal Questions and Answers

Unit 3: Agnatha & Gnathostomes

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Origin and evolution of Agnatha: Ostracoderms and Cyclostomes
 - 3.3.1 General characters of Agnatha
- 3.4 The early Gnathostomes (Placoderms)
- 3.5 Affinities and organization of Agnatha and Gnathostomes
- 3.6 Summary
- 3.7 Terminal Questions and Answers

Unit 4: Pisces

- 4.1 Objectives
- 4.2 Introduction
- 4.3 A general account of the Elasmobranchii, Holocephali, Dipnoi and Crossoptergii
- 4.4 Adaptive radiation in bony fishes
- 4.5 Affinities and phylogenetic significance of fishes
- 4.6 Summary
- 4.7 Terminal Questions and Answers

Block II

Unit 5: Amphibia:

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Origin, evolution and adaptive radiation of Amphibia
- 5.4 Axolotl larva and its evolutionary significance
- 5.5 Affinities of Pisces and Amphibia
- 5.6 Summary
- 5.7 Terminal Questions and Answers

Unit 6: Reptilia

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Origin, Evolution and Adaptive Radiation of Reptiles: Seymouria and Cotylosauri
 - 6.3.1 General account and affinities
- 6.4 Skull of Reptiles
- 6.5 Venom in Ophidians
- 6.6 Dinosaurs
- 6.7 Living Reptiles a brief account of
 - 6.7.1 Rhynchocephalia
 - 6.7.2 Chelonia
 - 6.7.3 Crocodilia
 - 6.7.4 Squamata
- 6.8 Summary
- 6.9 Terminal Questions and Answer

Unit 7: Aves

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Origin and Evolution of birds
- 7.4 Origin of flight: Flight adaptations
- 7.5 Ratitae (Flightless Birds)
- 7.6 Modifications of Beak, Feet and Palate in Birds
- 7.7 Affinities of birds
- 7.8 Birds migration
- 7.9 Summary
- 7.10 Terminal Questions and Answers

Unit 8: Mammalia

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Origin of Mammals
- 8.4 Organisation, Distribution and Affinities of Primitive Mammals (Prototheria and Metatheria)
- 8.5 General account on Adaptive Radiations in Mammals
- 8.6 Dentition in Mammals
- 8.7 Dentition, Stomach and Uterus modifications in Aquatic Mammals
- 8.8 Summary
- 8.9 Terminal Questions and Answers

Suggested Readings:

1. E.J.W. Barrington, General and Comparative Endocrinology, Oxford, Clarendon Press.
2. R.H. Williams, Textbook of Endocrinology, W.B. Saunders
3. Mathews, C. K., Van Holde, K. E. & Ahern K. G. (2001). *Biochemistry*. 3 ed. Person Education.
4. Metzler, D. E. (2003). *Biochemistry: The Chemical reactions of living cell..* Vol. 1 & 2. Academic Press.
5. Murray, R. K., Granner, P., Mayes A. & Rodwell, V. W. (2003). *Harper's Illustrated Biochemistry*. 25 ed. McGraw-Hill.
6. Nelson, D. L. & Cox. M. M. (2004). *Lehninger's Principles of Biochemistry*. 2nd ed., Macmillan Worth Publishers.
7. Switzer, R. L. & Garrity, L. F. (1999). *Experimental Biochemistry*. W. H. Freeman & Company.
8. Voet, D., Voet, J. G. & Pratt C. W. (1999). *Fundamentals of Biochemistry*. Upgrade edition. John Wiley & Sons.
9. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
10. Kotpal: The Birds (4th ed 1999, Rastogi Publications)
11. Sinha, Adhikari and Ganguli: Biology of Animals, Vol. II (1988, New Central Book Agency)

Developmental Biology (MSZO-602)

Syllabus

Structure of gametes, sperms, egg, Mechanism of fertilization, Pre fertilization and Post fertilization, Mechanism of cleavage, determinate and indeterminate cleavage, influence of yolk on cleavage, metabolic changes during cleavage, morulation and blastulation in frog , chick and rabbit, types of blastulae. Major events of gastrulation, cellular mechanism, comparative account and significance of gastrulation. Early vertebrate development: Neurulation and ectoderm origin. Primary Neurulation, Secondary Neurulation, Mesoderm and Endoderm. Organogenesis. Organizer Concept: Embryonic induction, primary organiser and its morphological differentiation, origin of primary organiser, inductive interactions, nature of inductive signal (Possible mechanism of neural induction), competence. Differentiation: Cellular basis, embryonic induction, primary organiser and its morphological differentiation, origin of primary organiser, inductive interactions, nature of inductive signal (Possible mechanism of neural induction), competence. Metamorphosis: Kinds of metamorphosis , metamorphosis in Amphibia, Physiological and biochemical changes during metamorphosis, hormonal control of metamorphosis. Genetic and environmental teratogenesis, developmental mechanisms of teratogenesis.

Block I: Developmental Biology

- Unit 1: Concept of Developmental Biology
- Unit 2: Gamete and Fertilization
- Unit 3: Cleavage, Blastulation and Gastrulation
- Unit 4: Early Development

Block II:

- Unit 5: Organogenesis and Organizer Concept
- Unit 6: Regeneration and Metaplasia
- Unit 7: Metamorphosis
- Unit 8: Teratogenesis

Developmental Biology (MSZO -602)

UNIT WISE CONTENTS (MSZO-602)

Block I: Developmental Biology

Unit 1: Concept of Developmental Biology

- 1.1 Objectives
- 1.2 Introduction
- 1.3 History of Development
- 1.3 Principal feature and patterns of development
 - 1.3.1 Coelom
 - 1.3.2 Segmentation
 - 1.3.3 Somites
 - 1.3.4 Diploblast
 - 1.3.5 Protostomes and Deuterostomes
 - 1.3.6 Development in Eukaryotes
- 1.4 Summary
- 1.5 Terminal Questions and Answers

Unit 2: Gamete and Fertilization

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Ultra structure of Gamete
 - 2.3.1 Sperms
 - 2.3.2 Egg
- 2.4 Mechanism of Fertilization
 - 2.4.1 Pre Fertilization
 - 2.4.2 Post Fertilization
 - 2.4.3 Biochemistry of Fertilization
- 2.5 Summary
- 2.6 Terminal Questions and Answers

Unit 3: Cleavage, Blastulation and Gastrulation

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Patterns of Cleavage
- 3.4 Determinate and Indeterminate Cleavage
- 3.5 Influence of Yolk on Cleavage
- 3.6 Metabolic Changes during Cleavage
- 3.7 Morulation and Blastulation in Frog, Chick and Rabbit
- 3.8 Types of Blastulae
- 3.9 Major events of Gastrulation and Fate maps
- 3.10 Morphogenetic movements in Frog, Chick and Rabbit
- 3.11 Significance of Gastrulation and Exogastrulation
- 3.12 Summary
- 3.13 Terminal Questions and Answers

Unit4: Early Development

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Neurulation and Ectoderm origin and fate of Neural Crest cells
 - 4.3.1 Neurulation
 - 4.3.2 Primary Neurulation
 - 4.3.3 Secondary Neurulation
- 4.4 Development of Mesoderm
- 4.5 Development of Endoderm
- 4.6 Summary
- 4.7 Terminal Questions and Answers

Block II:**Unit 5: Organogenesis and Organizer Concept**

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Development of organs in Chick
 - 5.3.1 Brain, Eye and Heart
- 5.4 Embryonic induction
- 5.5 Primary organiser and its Morphological Differentiation
- 5.6 Origin of primary Organiser, Inductive Interactions
- 5.7 Nature of Inductive Signal (Possible mechanism of neural induction)
- 5.8 Competences
- 5.9 Summary
- 5.10 Terminal Question and Answers

Unit 6: Regeneration and Metaplasia

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Distribution of Regenerative Ability
- 6.4 Polarity in Regeneration
- 6.5 Mechanism of regeneration of Amphibian limb and lens
- 6.6 Metaplasia
- 6.7 Super-regeneration and heteromorphosis
- 6.8 Summary
- 6.9 Terminal Questions and Answers

Unit 7: Metamorphosis

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Kinds of Metamorphosis
- 7.4 Metamorphosis in Amphibia
- 7.5 Physiological and Biochemical changes during Metamorphosis
- 7.6 Hormonal control of Metamorphosis
- 7.7 Summary
- 7.8 Terminal Question and Answers

Unit 8: Teratogenesis

8.1 Objectives

8.2 Introduction

8.3 Types of teratogenesis

8.3.1 Mechanisms of genetic and environmental teratogenesis

8.3.2 Phenocopies

8.3.3 Developmental mechanisms of teratogenesis

8.4 Summary

8.5 Terminal Questions and Answers

Course III: Bioinformatics & Biostatistics (MSZO -603)**Course objectives:**

1. To study the application of information sciences (mathematics, statistics and computer sciences) in biology.
2. To study the application of information technology to the management and analysis of biological data.
3. To acquire a basic knowledge of the microbes in general and of the environmental, medical and industrial important microbes in particular in order to have an integrated approach in biology.
4. To know the basics of sterilization and culture methods.
5. To acquire a basic knowledge of the microbes in general and of the environmental, medical and industrial important microbes in particular in order to have an integrated approach in biology. Also, to know the basics of sterilization and culture methods
6. To familiarize the use of the data and techniques of engineering and technology in biology for the study of living organisms, or derivatives of thereof, to make or modify products or processes for specific use. Also, to find solution of problems concerning human activities including agriculture, medical treatment, industry and environment

Syllabus

Basics of Computer, Applications of bioinformatics, Scope of bioinformatics, Primary, secondary and composite databases, Nucleotide sequence databases, Protein sequence databases, Gene Expression Database and Structural databases. Computational tools and biological databases, National centre for Biotechnology information (NCBI), European Bioinformatics Institute (EBI), EMBL Nucleotide Sequence Database, DNA Data Bank of Japan (DDBJ), Swiss-Prot. The evolutionary basis of sequence alignment, Database similarity searching, Sequence Similarity search tools: BLAST and FASTA, Concept of Alignment, Multiple Sequence Alignment (MSA), Percent Accepted Mutation (PAM), Blocks of Amino Acid and Substitution Matrix (BLOSUM). Database submission, Data retrieval, Relationship between sequence and biological functions. Importance of statistics in biological research. Calculation of Measures Central tendency and Variability Concepts of co-efficient of variation, skewness and kurtosis. Simple correlation and linear regression (scatter diagram, regression coefficients, and regression lines).

Unit Schedule:**Block I: Bioinformatics**

Unit1: Biological Databases

Unit2: Database and search tool

Unit3: Sequence alignment and database searching

Unit4: Computational Tools for DNA Sequence Analysis

Block II: Biostatistics

Unit 5: Introduction to Biostatistics

Unit 6: Measures of central tendency and variability

Unit7. Correlation and Regression

**Course III: Bioinformatics, Biostatistics and Computer Application)
(MSZO-603)**

Block I: Bioinformatics

Unit 1: Biological Databases

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Scope and applications of bioinformatics
- 1.4 Primary, secondary and composite databases
 - 1.4.1 Nucleotide sequence databases
 - 1.4.2 Protein sequence databases
 - 1.4.3 Gene Expression Database and Structural databases
- 1.5 Summary
- 1.6 Terminal Questions and Answers

Unit 2: Database and search tool

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Computational tools and biological databases
 - 2.3.1 National Centre for Biotechnology Information (NCBI)
 - 2.3.2 European Bioinformatics Institute (EBI)
 - 2.3.3 EMBL Nucleotide Sequence Database
 - 2.3.4 DNA Data Bank of Japan (DDBJ)
 - 2.3.5 Swiss-Prot
- 2.4 Summary
- 2.5 Terminal Questions and Answers

Unit 3: Sequence alignment and database searching

- 3.1 Objectives
- 3.2 Introduction
- 3.3 The evolutionary basis of sequence alignment
- 3.4 Database similarity searching
 - 3.4.1 Sequence Similarity search tools: BLAST and FASTA
- 3.5 Concept of Alignment
 - 3.5.1 Multiple Sequence Alignment (MSA)
 - 3.5.3 Percent Accepted Mutation (PAM)
 - 3.5.4 Blocks of Amino Acid and Substitution Matrix (BLOSUM)
- 3.6 Summary
- 3.7 Terminal Questions and Answers

Unit 4: Computational Tools for DNA Sequence Analysis

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Database submission
- 4.4 Data retrieval
- 4.5 Relationship between sequence and biological functions
- 4.6 Molecular Phylogeny
- 4.8 Consistency of Molecular Phylogenetic Prediction
- 4.9 Application of bioinformatics
- 4.10 Summary
- 4.11 Terminal Questions and Answers

Block II: Biostatistics

Unit 5: Introduction to Biostatistics

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Statistical symbols
- 5.4 Scope & Applications of biostatistics
- 5.5 Collection, organization and representation of data
- 5.6 Importance of statistics in biological research
- 5.7 Summary
- 5.8 Terminal Questions and Answers

Unit 6: Measures of central tendency and variability

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Mean, Mode & Median
- 6.4 Mean deviation
- 6.5 Standard deviation & Standard error
- 6.6 Variance and coefficient of variation
- 6.7 Chi –Square test
- 6.8 Student T - test
- 6.9 Summary
- 6.10 Terminal Questions and Answers

Unit 7: Correlation and Regression

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Types of correlation
 - 7.3.1 Simple correlation and linear regression
 - 7.3.2 Methods of studying correlation
- 7.4 Regression analysis
 - 7.4.1 Uses of regression analysis
- 7.5 Summary
- 7.6 Terminal questions and Answers

Microbiology & Immunology (MSZO-604)**Syllabus:**

History and importance of microbiology. Techniques of microbial sterilization and culture. Environmental Microbiology: effects of microbes on air, water and soil. Role of microorganisms in the productivity of ecosystems. Interactions between microorganisms, plants and animals. Introduction to immune system: Resistance and immunity, Active vs. passive immunity. Application of immunological principles. Characteristic and uses of ideal adjuvants, natural and chemically defined adjuvant and their role on immunodulation. Antigen and Antibody. *In vitro* reactions : Phagocytosis, Precipitation and agglutination and biological activity of complement fixation and cytolysis. *In vivo* reactions: Hyper sensitivity classification and mechanism of *In vivo* reactions and hypersensitivity. Tissue transplantation: Graft vs. host reactions, Tissue typing, Immunology of rejection, organ transplantation, selective transplantation, Immuno-suppression and principles of autoimmunity.

Block I: Microbiology

Unit 1: Structure and Classification of Microbiology

Unit 2: Techniques of Sterilization and Culture

Unit 3: Environmental Microbiology

Unit 4: Clinical Microbiology

Block II: Immunology

Unit 5: Introduction to immune system

Unit 6: Application of immunological principles

Unit 7: Adjuvant

Unit 8: Antigen & Antibody

Unit 9: *In vitro* & *In vivo* reactions

Microbiology & Immunology (MSZO-604)

Unit Schedule:

Block I: Microbiology

Unit 1: Structure and Classification of Microbiology

- 1.1 Objectives
- 1.2 Introduction
- 1.3 History and importance of microbiology
- 1.4 Structures and classification of virus, bacteria and fungi
 - 1.4.1 Morphology and Physiology of Bacteria and Virus
 - 1.5.1 Chemical composition of virus & Bacteria
 - 1.5.2 Reproduction of virus & Bacteria
- 1.6 Summary
- 1.7 Terminal Questions and Answers

Unit 2: Techniques of Sterilization and Culture

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Sterilization: Principles - dry heat, moist heat, filtration
 - 2.3.1 Tantalization, pasteurization
 - 2.3.2 Radiation - disinfection
- 2.4 Culture techniques - media preparation
 - 2.4.1 Aerobic and anaerobic culture techniques
- 2.5 Different Staining methods
- 2.6 Summary
- 2.7 Terminal Questions and Answers

Unit 3: Environmental Microbiology

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Microbial ecology
 - 3.3.1 Role of microorganisms in the productivity of ecosystems
 - 3.3.2 Interactions between microorganisms and animals
- 3.4 Microbiology of Soil
 - 3.4.1 Types of microorganisms in soil
 - 3.4.2 Factors for microbial growth
 - 3.4.3 Soil enzymes
- 3.5 Microbiology of Water
 - 3.5.1 Microorganisms of water
 - 3.5.2 Microbiology of potable water
 - 3.5.3 Purification of water
 - 3.5.4 Microbiology of sewage & Bioremediation
- 3.6. Airborne diseases
- 3.7 Summary
- 3.8 Terminal Questions and Answers

Unit 4: Clinical Microbiology

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Pathogenic microbes of bacterial, viral, fungal and protozoan diseases
- 4.4 Preventive measures of cure and control of microbial pathogens
- 4.5 Classifications, source and mode of action of Antibiotics
- 4.6 *Escherichia coli* and *Staphylococcus aureus* case studies, collection, identification and causative Agents
- 4.7 AIDS Virus
- 4.8 Summary
- 4.9 Terminal Questions and Answers

Block 11: Immunology

Unit 5: Introduction to immune system

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Resistance and immunity
 - 5.3.1 Cellular immunity v/s humoral immunity
 - 5.3.2 Active v/s passive immunity
- 5.4 Summary
- 5.5 Terminal Questions and Answers

Unit 6: Application of immunological principles

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Diagnostics
 - 6.3.1 Vidal test
 - 6.3.2 ELISA test
- 6.4 Vaccines
- 6.5 Active vs. passive immunity
- 6.6 Summary
- 6.7 Terminal Questions and Answers

Unit 7: Adjuvant

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Characteristic and uses of ideal adjuvant
- 7.4 Natural and chemically defined adjuvant and their role on immunodulation
- 7.5 Summary
- 7.6 Terminal Questions and Answers

Unit 8: Antigen v/s Antibody

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Antigenic determination
- 8.4 Haptens and antigenicity
- 8.5 Theories of antibody formation
- 8.6 Structure and classification of immunoglobulin's and their properties
- 8.7 immunoglobulin's synthesis at molecular level
- 8.8 Summary
- 8.9 Terminal Questions and Answers

Unit 9: *In vitro* & *In vivo* reactions

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Phagocytosis
- 9.4 Precipitation and agglutination
- 9.5 Biological activity of complement fixation and cytolysis
- 9.6 Mechanism of *In vivo* reactions and hypersensitivity
- 9.7 Summary
- 9.8 Terminal Questions and Answers

Suggested Readings:

Biostatistics & Bioinformatics

1. Statistics – SP Gupta 1996 S. Chand and Co., New Delhi.
2. Jerold H. Zar Bio statistical analysis [2nd Edition] Printice Hall of International edition, 1984
3. Goutham Roy. Introduction to Computing and Computing lab and Cad[2002] Books and allied [pvt] Ltd. Kolkata
4. MS. OFFICE for Win-Microsoft office press.
5. Developing Application with MS. OFFICE – Christine. Solomon- Microsoft Office Press.
6. Developing Bioinformatics Computer Skills Cynthia Gibbs, Sheoff Publishers & Distribtors Pvt. Ltd., Mumbai.
7. Arthur. M. Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
8. Arthur. M.Lesk, Introduction to Protein Structures Oxford University Press, New Delhi, 2000
9. Baxevanis, A and Outllette. Bioinformatics a practical guide to the analysis of genes and proteins, Wily - Interscience, Hoboken, NJ. USA 2005.

Microbiology:

1. Tortora, G.J., Funke, R.B. and Case, C.L. 1992. Microbiology - An Introduction. The Benjamin / Cummings Publishing Co., Inc. Sydney.
2. Black, J.G. 1999. Microbiology - Principles and Explorations. John Wiley and Sons Inc. New York.
3. Atlas, R.M. 1995. Principles of Microbiology. Mosby - Year Book Inc.
4. Pelczer, M.J., Reid, R.D. and Chan, E.C.S. 1996. Microbiology. Tata McGraw Hill Co., Ltd. New Delhi.
5. Prescott L.M. Harley J.O. Klein D.A. 1990. Microbiology. WCB Publishers, Sydney.
6. Ananthanaryanan, T. and Paniker, J.C.K. 2000. Text Book of Microbiology Oriental Longman Ltd., Madras.
7. Ahmed, M. and Basumatary. S.K. 2006. Applied Microbiology. MJP Publishers, Chennai.

Course V: Laboratory Exercise (MSZO -605(L)) Practical Zoology

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session. The practical work shall comprise:

Unit Schedule:

Block I: Vertebrates

Unit 1: Microtome of vertebrate tissues

Unit 2: Study of the skeleton of Frog

Unit 3: Study of permanent slides of Protochordates and chordates

Unit 4: Study of the museum specimens of Protochordata and of the different classes of vertebrates.

Block II: Biostatistics and Microbiology

Unit 5: Exercises on Developmental Biology of Blastula, Gastrula and different stages of chick embryo and Endocrine glands

Unit 6: Instrumentation

Unit 7: Biostatistics Exercise

Unit 8: Microbiology Experiments

Course V: Laboratory Exercise (MSZO -605 L) Practical Zoology

Block I: Vertebrates, Developmental Biology, Biostatistics and Microbiology

Unit 1: Microtome of vertebrate tissues

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Material and methods
- 1.4 Observation
- 1.5 Results/ Exercise

Unit 2: Study of the skeleton

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Skeleton study of Frog, *Varanus*, *Chelonia*, crocodile, snake, rabbit
- 2.4 Vertebrae and skull of poisonous and non-poisonous snake
- 2.5 Gallos and various types of palate
- 2.6 Skull of bat, dog, hedgehog, monkey, sheep, rodent and other mammal
- 2.7 Summary
- 2.8 Terminal Questions and Answers

Unit 3: Study of permanent slides of Protochordates and chordates

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Study of permanent slides
 - 3.3.1 Protochordates
 - 3.3.2 Chordates
- 3.4 Summary
- 3.5 Terminal Questions and Answers

Unit 4: Study of the museum specimens of Protochordata and of the different classes of vertebrates

- 4.1 Objective
- 4.2 Introduction
- 4.3 Study of Muséum specimens
 - 4.3.1 Protochordata
 - 4.3.2 Chordata
- 4.4 Summary
- 4.5 Terminal Questions and Answers

Block II:**Unit 5: Exercises on Developmental Biology & Endocrinology**

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Study of eggs from collected / preserved material
- 5.4 Study of development of frog, chick through models/charts/slides
- 5.5 Study of chick embryos from 16-18 hrs, 24-28 hrs 33-36 hrs, 42-72 hrs of development (Whole mount models, charts)
- 5.6 Study of development of chick by window preparation
- 5.7 Endocrine glands of rat, insect (Location through models, Charts)
- 5.8 Endocrine disorders (Photographs)
- 5.9 Summary
- 5.10 Terminal Questions and Answers

Unit 6: Instrumentation

- 6.1 Objective
- 6.2 Introduction
- 6.3 General principle, functioning and utility of some common instruments
 - 6.3.1 Microscopes, Microtome's, Colorimeter
 - 6.3.2 Spectrophotometer, Centrifuge, Autoclave and Electrophoresis
- 6.4 Summary
- 6.5 Terminal Questions and Answers

Unit 7: Biostatistics Exercise

- 7.1 Introduction
- 7.2 Objectives
- 7.3 .1 Calculation of mean, median, mode, standard deviation, standard error
- 7.3.2 Chi- square test and Student- t- test from the data provided
- 7.4 Results
- 7.5 Summary
- 7.6 Terminal Questions and Answers

Unit 8: Microbiology Experiments

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Preparation of culture media for bacteria
- 8.4 Staining of microorganisms
- 8.5 Antibiotic sensitivity test
- 8.6 Bacteriological testing of milk
- 8.7 Summary
- 8.8 Terminal Questions and Answers

Special/Optional paper

Course I: Fish and Fisheries (Structure and Functions) (MSZO -606)

Course VIII: Fish and Fisheries (Structure and Functions): Zoo-606

Course objectives

The aim of the paper is to understand the morphology, classification and identification of fishes and the fisheries and fishery resources of India. Moreover information about the biology of the fishes goes a long way in managing the fishery resources and their sustainable utilization. As fishes constitute perishable commodity, preservation and processing are also quite essential.

Syllabus:

Classification of fishes up to order level, habit and habitats, evolutionary trends, significance and affinities of Holocephali and Dipnoi. Integument and exoskeleton: Epidermis, Dermis, scales, chromatophores and significance and role of exoskeleton and integument. Locomotion in fishes. Origin and evolution of fins, types of fins and functions of swim bladder. Locomotor muscle, modes of swimming and hydrodynamics of propulsion and significance of swim bladder in swimming; non swimming locomotion. Nutrition and digestive system: Food, feeding habits and feeding adaptations/behavior; structure of the alimentary canal and physiology of digestion and absorption. Blood vascular system: Structure of the Heart; principal blood vessels and circulation of Blood (elasmobranchs, teleost and Dipnoi). Organization of gills in fishes; structure of a typical teleostean gill: physiology of gill respiration gill ventilation. Gill surface area. Blood flow through gills. Water-blood barrier. gas exchange at the gill surface and gas exchange between blood and tissues. Air-breathing fishes: causative factors and structural adaptations. Structure and functions of the kidney: nitrogenous end products and pattern of their excretion. Water and electrolyte regulation in marine, freshwater and euryhaline fishes. Structure and functions of the central, Peripheral and autonomic nervous systems; anatomy and function of the Mauthner neurons. Sensory system Structure and functions of the sense organs: Eye; visual pigments and vision, Chemoreceptors: Olfactory and gustatory. Biological significance of chemoreception. Pituitary, Thyroid, Gonads, Adrenal, Endocrine pancreas, Ultimobranchial, Caudal neurosecretory cells and urophysis, Pineal. Fish immune system. Organs of reproduction; modes of reproduction, viviparity, hormonal and environmental regulation of reproduction. Reproductive strategies, environmental and endocrine factors regulating reproduction. Reproductive behavior: Secondary sexual character. Nest building and parental care. patterns of migration. Adaptations: Coloration, sound production, electric organs, luminescent organs (location, structure, physiology and biological significance). Adaptations fishes: deep sea, hill-stream and cave-dwelling.

Unit Schedule

Block I (External Morphology)

Unit 1: Classification and evolutionary trend

Unit 2: Integument and exoskeleton

Unit 3: Fins and Swim bladder

Unit 4: Locomotion

Block II (Physiology)

Unit 5: Digestive System

Unit 6: Circulatory system

Unit 7: Respiratory system

Unit 8: Excretory System

Unit 9: Nervous and Sensory system:

Unit 10: Endocrine System

Unit 11: Immune System

Unit 12: Reproductive system

Unit 13: Adaptations in fishes

Course I: Fish and Fisheries (Structure and Functions) (MSZO -606)

UNIT WISE CONTENTS (MSZO -606)

Block I (External Morphology)

Unit1: Classification and evolutionary trend

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Classification of fishes up to order level
- 1.4 Habit and habitat
- 1.5 Distribution pattern
- 1.6 Summary
- 1.7 Terminal Questions and Answers

Unit 2: Integument and Exoskeleton

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Dermis and Epidermis
- 2.4 Different Scales & their Modification
- 2.5 Uses of Scales
- 2.6 Chromatophores
- 2.7 Significance of Chromatophores
- 2.8 Summary
- 2.9 Terminal Questions and Answers

Unit 3: Fins and Swim bladder

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Origin and evolution of fins
 - 3.3.1 Types of fins
 - 3.3.2 Structure
 - 3.3.3 Modifications and functions of fins
- 3.4 Swim bladder species
- 3.5 Composition of swim bladder gas, its secretion and maintenance
- 3.6 Structure and functions of swim bladder
- 3.7 Summary
- 3.8 Terminal Questions and Answers

Unit 4: Locomotion

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Locomotion by body movements
- 4.4 Locomotion by fins and Tail
- 4.5 Forces acting on the body for locomotion
- 4.6 Types of locomotion
- 4.7 Summary
- 4.8 Terminal Questions and Answers

Block II (Physiology)

Unit 5: Digestive System

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Food resource
 - 5.3.1 Supplementary food and artificial food
- 5.4 Feeding habits and nutrient requirement for various stages
- 5.5 Feeding behavior and adaptations of feeding
- 5.6 Alimentary canal and its modification in relation of food and feeding habits
- 5.7 Digestion and absorption
- 5.8 General characteristics, food and feeding habits of fresh water fishes
- 5.9 Summary
- 5.10 Terminal Questions and Answers

Unit 6: Circulatory system

- 6.1 Objectives
- 6.2 Summary
- 6.3 Blood vascular system: Structure of the heart
- 6.4 Principal blood vessels and circulation of blood (Elasmobranchs, Teleost and Dipnoi)
- 6.5 Hemodynamics
- 6.6 Cardiac output
- 6.7 Circulation time
- 6.8 Fish haemoglobin
- 6.9 Summary
- 6.10 Terminal Questions and Answers

Unit 7: Respiratory system

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Gills and aquatic respiration
- 7.4 Organization of gills
- 7.5 Mechanisms of respiration
- 7.6 Structure of a typical Teleostean gill
 - 7.6.1 Physiology of gill respiration
 - 7.6.2 Gill ventilation
- 7.7 Gill surface area
- 7.8 Counter current principle
- 7.9 Water flow across the gills
- 7.10 Gas exchange
- 7.11 Air-breathing fishes: causative factors and structural adaptations
 - 7.11.1 Accessory respiratory organs and respiratory epithelium
- 7.12 Summary
- 7.13 Terminal Questions and Answers

Unit 8: Excretory System and Osmoregulation

- 8.1 Objectives
- 8.2 Structure and functions of the kidney, nitrogenous waste and excretion
- 8.3 Glomerular and aglomerular kidneys
- 8.4 Excretion of nitrogenous wastes, water and ion balance

- 8.5 Urea cycle
- 8.6 Osmoregulation in Fish
- 8.7 Stenohaline teleosts
- 8.8 Euryhaline teleosts
- 8.9 Migratory teleosts
- 8.10 Water and electrolyte regulation in marine, freshwater and euryhaline fishes
- 8.11 Summary
- 8.12 Terminal Questions and Answers

Unit 9: Nervous and Sensory system

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Structure and functions of the brain and cranial nerves
- 9.4 Receptors
- 9.5 Anatomy and function of the Mauthner neurons
- 9.6 Structure and functions of the sense organs: eye, visual pigments and vision
- 9.7 Chemoreceptors: Olfactory, gustatory and electroreceptors
- 9.8 Biological significance of chemoreception
- 9.9 Acoustico-lateralis system
 - 9.9.1 Labyrinth
 - 9.9.2 Lateral line organs
- 9.10 Summary
- 9.11 Terminal Questions and Answers

Unit 10: Endocrine System

- 10.1 Objectives
- 10.2 Introduction
- 10.3 Hypothalamo-hypophyseal system
- 10.4 Neurosecretory system and neuro-hypophyseal hormones
- 10.5 Functional morphology of pituitary
- 10.6 Hypothalamic control of pituitary
- 10.7 Corpuscles of Stannius
- 10.8 Urophysis
- 10.9 Pineal
- 10.10 Summary
- 10.11 Terminal Questions and Answers

Unit 11: Immune System

- 11.1 Objectives
- 11.2 Introduction
- 11.3 Development of Immune System
- 11.4 Cell and tissues of Immune System
- 11.5 Fish Immune Response Modulation
- 11.6 Humoral and Cell mediated immune defence
- 11.7 Fish Antibody Molecule and their effector function
- 11.8 Host-parasite interaction
- 11.9 Summary
- 11.10 Terminal Questions and Answers

Unit 12:

- 12.1 Objectives
- 12.2 Introduction
- 12.3 Types and mode of reproduction
- 12.4 Organs of reproduction

- 12.5 Gametogenesis modes of reproduction viviparity
- 12.6 Role of environmental factors (photoperiod, temperature, rainfall, salinity) on gonad
- 12.7 Gonadal steroidogenesis and its control
- 12.8 Reproductive strategies, environmental and endocrine factors regulating reproductive system
- 12.9. Sexuality: intersex, bisexuality, hermaphroditism
- 12.10 Nest building and parental care
- 12.11 Behavior and cognition patterns of migration
- 12.12 Summary
- 12.13 Terminal Questions and Answers

Unit 13: Adaptations in fishes

- 13.1 Objectives
- 13.2 Introduction
- 13.3 Coloration
- 13.4 Sound production, electric organs, and luminescent organs
(Species, location, structure, physiology and biological significance)
- 13.5 Adaptations in deep sea
- 13.6 Hill-stream and cave-dwelling fishes
- 13.7 Summary
- 13.8 Terminal Questions and Answers

Suggested Readings:

1. Day, F. 1981. Fishes of India, Vol.I and Vol. II. William Sawson & Sons Ltd., London.
2. Jhingran, C.G. 1981. Fish and Fisheries of India. Hindustan Publishing Co., India.
3. Maheswari, K. 1993. Common fish diseases and their control. Institute of Fisheries Education, Powakads, M.P.
4. Santhanam,R. 1980. Fisheries Science. Daya Publishing House, New Delhi.
5. Yadav, B.N. 1997. Fish and Fisheries. Daya Publishing House, New Delhi
6. FAO Volumes for fish identification.
7. Bal D.V. and Rao, K.V. 1990. Marine Fisheries of India. Tata McGraw Hill Publishing Co. Ltd., New York.
8. Biswas, K. P. 1996. A Text Book of Fish, Fisheries and Technology. Narendra Publishing House, Delhi.

(Fish Culture, Breeding and Pathology)**Course II: Fish and Fisheries (Applied Ichthyology): (MSZO -607)****Course objective:**

1. To study the various fish and fishery resources in India
2. To study the aquaculture practices of cold water, sewage fed, exotic fishes, larvivorous and carp fish
3. To understand the various fishing gear, pond and hatchery management and breeding techniques of various fish species
4. To understand the water quality, phytoplankton, zooplankton and Benthic community on fish production and health
5. To study the various modes of fish disease and parasites and their management
6. To understand the fish preservation techniques and by products of fishery

Syllabus: survey of the marine, estuarine and inland capture fisheries of India with particular reference to fishery resources of Uttarakhand. Fish farm: construction and lay out of different types of ponds. Formulation and operation of different types of hatcheries. Hatchery management. Physico-chemical properties of pond water and soil and their maintenance. Manuring (organic and inorganic) and liming. Composite fish farming and polyculture. Predatory and weed fishes and their eradication. Aquatic vegetation and its control. Biological means of increasing production. Other systems: cage, raft, pens, raceways. Induced spawning and hybridization. Cold water fishery and its scope in Uttarakhand Sewage-fed fisheries. Exotic fishes and their role in fish farming. Larvivorous fishes and their role in biological control of mosquitoes. Carp Culture : Maturation and fecundity, spawning and seed collection, hatching techniques and hatcheries, rearing, stocking, transport and mortality of fish, composite fish culture. Integrated Aquaculture: Fish-cum poultry, Fish-cum duckery, Fish-cum piggery, Paddy-cum fish culture. Nutrition, feeds and Growth: Food and feeding habits of freshwater fishes, prawn, mussel and oysters Nutrient requirement (proteins, lipids, carbohydrates, minerals and vitamins) for various growth stages of freshwater carps and fishes. Supplementary feed, Kind of supplementary feeds. Fish preservation, transport and marketing. Pond Ecology and fish: Effect of various physicochemical properties of pond water on fishes. Fish disease: Protozoan diseases, Bacterial diseases, Fungal diseases, Bacterial diseases, Viral disease and Nutritional disease. Fish Parasite: Helminth parasites and Crustacean parasite. Management of fish disease and parasite.

Block I: General Fishery Management

- Unit 1: General fishery resource in India and Uttarakhand
- Unit 2: Fish growth and Age
- Unit 3: Fish breeding and Spawning
- Unit 4: Fish culture systems & management
- Unit 5: Inland fishing gears and fishing methods

Block II: Aquaculture Practices

- Unit 6: Cold water aquaculture and its scope in Uttarakhand
- Unit 7: Exotic fishes and their role in fish farming
- Unit 8: Larvivorous fishes and their culture
- Unit 9: Integrated Aquaculture
- Unit10: Fish nutrition and pathology

(Fish Culture, Breeding and Pathology)

Course II: Fish and Fisheries (Applied Ichthyology): (MSZO -607)

UNIT WISE CONTENTS

Block I: General Fishery Management

Unit 1: General fishery resource in India and Uttarakhand

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Resources
 - 1.3.1 Riverine fisheries
 - 1.3.2 Regulation and exploitation
 - 1.3.3 Improvement of fish stocks
 - 1.3.4 River pollution
 - 1.3.5 Dams, their effect on fish migration and remedial measures
- 1.4 Lacustrine fishery: management, development and exploitation
- 1.5 Cold water fishery: management, development and exploitation
- 1.6 Estuarine fisheries: management, development and exploitation
- 1.7 Marine fishery: exploitation of marine fishery resources of India
- 1.8 Summary
- 1.9 Terminal Questions and Answers

Unit 2: Fish growth and Age

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Factors responsible for growth
- 2.4 Age and growth relationship
- 2.5 Natural fish food organism & their role in fish growth: Plankton, Benthos.
- 2.6 Summary
- 2.7 Terminal Questions and Answers

Unit 3: Fish Breeding and Spawning

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Factors responsible for induced breeding
 - 3.3.1 Hypophysation
 - 3.3.2 Use of different synthetic and natural hormones, their formulation and Mechanism of action
- 3.4 Bundh breeding
- 3.5 Hapa breeding
- 3.6 Hatchery management
 - 3.6.1 Flow through hatchery for Mahseer and Trout
 - 3.6.2 Ploidy induction
 - 3.6.3 Production of monosex population
 - 3.6.4 Hybridization
 - 3.6.5 Cryo-preservation of gametes and embryo
 - 3.6.6 Transgenic fish
- 3.7 Summary
- 3.8 Terminal Questions and Answers

Unit 4: Fish culture systems and management

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Ponds and pond ecology
- 3.4 Fish farm: construction and lay out of different types of ponds
- 3.5 Different types of culture system.
- 3.6 Cultivable indigenous & exotic fishes.
- 3.7 Pond management: Water, soil, manuring and liming.
- 3.8 Manuring (organic and inorganic) and liming
- 3.9 Concept of Composite fish farming and polyculture
- 3.10 Summary
- 3.11 Terminal questions and Answers

Unit 5: Inland fishing gears and fishing methods

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Biological factors in fishing
- 4.4 Types of fishing gears
- 4.5 Natural and synthetic fibers
- 4.6 Preparation and maintenance of fishing nets
- 4.7 Different fishing method
- 4.8 Summary
- 4.9 Terminal Questions and Answers

Block II: Aquaculture Practices

Unit 6: Cold water aquaculture and its scope in Uttarakhand

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Scope of aquaculture for sustainable livelihood
- 5.4 Aquaculture of cold water fishes
- 5.5 Polyculture of carps
- 5.6 Sewage feed fisheries
- 5.7 Summary
- 5.8 Terminal Questions and Answers

Unit 7: Exotic fishes and their role in fish farming

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Exotic fishes for aquaculture
- 6.4 Trout farming in uplands and culture of common carp
- 6.5 Summary
- 6.6 Terminal Questions and Answers

Unit 8: Larvivorous fishes and their culture

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Larvivorous fishes
 - 7.3.1 Indigenous
 - 7.3.2 Exotic
 - 7.3.3 Culture of larvivorous fishes
- 7.4 Use of larvivorous fishes for biological control
- 7.5 Summary
- 7.6 Terminal Questions and Answers

Unit 9: Integrated Aquaculture

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Concept of integrated fish farming
- 9.4 Different practices of integrated fish farming
 - 9.4.1 Fish-cum-poultry
 - 9.4.2 Fish-cum-duckery
 - 9.4.3 Fish-cum-piggery
 - 9.4.4 Fish-cum-Horticulture
 - 9.4.5 Paddy-cum-fish culture
 - 9.4.6 Economic and biological importance of integrated fish culture
- 9.5 Summary
- 9.6 Terminal Questions and Answers

Unit 10: Fish nutrition and pathology

- 10.1 Objectives
- 10.2 Introduction
 - 10.2.1 Nutritional requirement of fish
 - 10.2.2 Feed and feed formulation
 - 10.2.3 Different type of feed
 - 10.2.4 Artificial feeding
 - 10.2.5 Feeding devices
- 10.3 Fish diseases and their control
 - 10.3.1 Different fish pathogens: Viral, Bacterial, Fungal and Parasitic
 - 10.3.2 Different fish diseases: Pathogenic, Nutritional, Parasitic and Environmental.
 - 10.3.3 Prophylactic measures to control fish diseases.
 - 10.3.4 Summary
 - 10.3.5 Terminal Questions and Answers

Suggested Readings:

1. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
2. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing)
3. Singh: Advances in Fish Research, Vol. I and II (1993 and 1997, Narendra Publishing House)
4. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
5. Srivastava, Gopalji: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
6. Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand)
7. Santhanam: Fisheries Science (1990, Daya Publishing House)
8. Pillay, T. V. R. (1993). *Aquaculture*. Fishing News Books.
9. Srivastava, C. B. L. (1999). *Fish Biology*. Narendra Pub. House.
10. Ayappan, S. (2011): Hand book of fisheries & Aquaculture, ICAR Publication.

Course III: Laboratory Exercise (MSZO -608(L)) Practical Zoology

Block II Laboratory Course: Fish and Fisheries

Unit 1: Fish Eco-biology

Unit 2: Fish habitat ecology exercise

Unit 3: Fish Physiology and biochemistry exercises

Course III: Laboratory Exercise (MSZO -608(L)) Practical Zoology**UNIT WISE CONTENTS (MSZO -608(L))**

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session. The practical work shall comprise:

Block II Laboratory Course: (Fish and Fisheries): (MSZO -608)**Unit 01: Fish Eco-biology**

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Skeletons of Cyprinoid and Siluroid fish
- 1.4 Taxonomic studies of fresh water fishes
- 1.5 Observation of length, weight and Length-weight relationship.
- 1.6 Determination of age & growth.
- 1.7 Permanent preparation of scales, sensory, ampullae etc.
- 1.8 Morphometry & Histology of fish body and organs.
- 1.9 Microscopic study of fish parasite, pathogens, Fungi and pathogenic bacteria.
- 1.10 Study of pituitary gland & preparation of PGE.
- 1.11 Study of respiratory organs of fish.
- 1.12 Study of reproductive organs of fish.
- 1.13 Study of nervous & sensory organs of fish.
- 1.14 Summary
- 1.15 Terminal Questions and Answers

Unit 02: Fish habitat ecology exercise

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Determination of CO₂
- 2.4 Determination of DO
- 2.5 Determination of PH
- 2.6 Determination of turbidity
- 2.7 Determination of total alkalinity
- 2.8 Determination of hardness
- 2.9 Study of pond ecosystem.
- 2.9.1 Measurement of primary productivity
- 2.9.2 Microscopic study of plankton.
- 2.10 Summary
- 2.11 Terminal Questions and Answers

Unit 03: Fish Physiology and biochemistry exercises

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Material and Methods for estimation/counting
 - 3.3.1 Protein
 - 3.3.2 Lipids
 - 3.3.3 Haematological analysis of fish blood.
 - 3.3.4 Hemoglobin in fish blood

- 3.3.5 WBC/ RBC/DLC in fish blood
- 3.3.6 Results
- 3.4 Terminal Questions and Answers

Course IV: Dissertation Work (Fish & Fisheries Science) (MSZO-609)

- Flow through hatchery for mahseer and trout and its operation.
- Polyculture of carp in mid hills condition.
- Study of fish pathogens.
- Fish feed formulation and feeding.
- Induced breeding of carp in coldwater condition.
- Culture of ornamental fishes.
- Common carp breeding.
- Migratory behavior of Golden mahseer.
- Raceways culture of trout.
- Commercial importance of indigenous coldwater fishes.
- Captive breeding of Snow-trout (*Schizothorax richardsonii*).
- Captive breeding of coldwater mirror carp.
- Culture of fish food organism.
- Itchy-faunal study of Lake.

Insect Systematic, Ecology and Applied entomology

Course I: Entomology (Systematic and Applied entomology) (MSZO-610)

Course objectives:

1. To study the historical aspect, origin, evolution and classification of insects
2. To understand the importance of fossil records in insect systematic
3. To study the systematic study of family of various insects orders
4. To study the social behavior and importance of applied entomology : Mulberry sericulture, Non Mulberry Sericulture, Eri Culture, Muga Culture and Apiculture
5. To study the insects pest of agro horticulture, Food grain, House hold pest, and farm animals
6. To study the integrated pest management using biological, chemical and manual practices

Syllabus: Historical review of insect classification. Phylogeny of Arthropoda and Hexapoda. Introduction to primitive insects. Origin and evolution of insects with special reference to fossil insects. Causes of success of insects. Detailed classification, habit and habitats of important and selected super families and families of the following orders- Thysanura, Collombola Orthoptera, Isoptera, Hemiptera, Homoptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera. Insect pest: Pests of stored grains: Pests of Sugarcane, Pests of Cotton, Pests of Cereals, Pests of Vegetables and Pests of Fruits, Causes of success of insects pests, Origin of insect pests, Factors affecting the abundance of insects. Household pests: cockroaches, ants, wasps, carpet beetles, furniture beetles and booklice. Pest of farm animals and their control: Blood-sucking flies. Myiasis flies, Lice and Fleas. Medical entomology: Pests of public importance and their control, Insect borne diseases, Venoms and allergens, Insect venoms and Blister and urtica-inducing insects. Insect pest control: Natural, Chemical control, Biological. Mulberry sericulture, Non-mulberry sericulture, Muga sericulture, Eri sericulture and Apiculture.

Unit Schedule:

Block I: Insect origin and Systematics

Unit 1: Historical review of insect classification and Phylogeny of Arthropoda and Hexopoda.

Unit 2: Origin and evolution of insects with special reference to fossil insects.

Detailed classification, habit and habitats of important and selected families of the following orders-

Unit 3: Thysanura, Collembola, Orthoptera and Isoptera

Unit 4: Heteroptera, Homoptera , and Coleoptera

Unit 5: Lepidoptera, Hymenoptera and Diptera

Block II: Integrated Insect Pest Management

Unit 6: Insect pests (Agro horticultural)

Unit 7: Household pests

Unit 8: Pest of farm animals and their control

Unit 9: Medical entomology

Unit10: Insect pest control: Natural control

Unit 11: Chemical control

Unit 12: Biological control

Block III: Applied and Sustainable Entomology

Unit 13: Mulberry sericulture

Unit 14: Non-mulberry sericulture

Unit 15: Muga sericulture

Unit 16: Eri sericulture

Unit 17: Apiculture

Insect Systematic, Ecology and Applied entomology

Course I: Entomology (Systematic and Applied entomology) (MSZO-610)

UNIT WISE CONTENTS

Block I: Insect origin and Systematics

Unit 1: Origin and evolution of insects

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Origin of insects
- 1.4 Evolution
 - 1.4.1 Evolutionary history
 - 1.4.1.1 Devonian
 - 1.4.1.2 Carboniferous
 - 1.4.1.3 Permian
 - 1.4.1.4 Triassic
 - 1.4.1.5 Jurassic
 - 1.4.1.6 Cretaceous
 - 1.4.1.7 Paleogene
 - 1.4.1.8 Neogene
- 1.5 Phylogeny
- 1.6 Summary
- 1.7 Terminal Questions and Answers

Unit 2: Insect classification

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Historical basis of Insect classification
- 2.4 Phylogeny of Arthropoda and Hexapoda
- 2.5 Introduction to Primitive Insects
- 2.6 Construction of Dichotomous key for identification
- 2.7 Summary
- 2.8 Terminal Questions and Answers

Unit 3: Methods of Collection and Preservation

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Collection of insects
 - 3.3.1 Killing jars
 - 3.3.2 Relaxing jars
 - 3.3.3 Aerial Nets
 - 3.3.4 Sweeping or Beating Nets
 - 3.3.5 The Aspirator
 - 3.3.6 Light traps
 - 3.3.7 Pitfall traps
 - 3.3.8 Pan traps

- 3.4 Preservation
 - 3.4.1 Soft bodied Insects
 - 3.4.2 Hard bodied Insects
- 3.5 Pinning, Mounting and Displaying of Insects
- 3.6 Summary
- 3.7 Terminal Questions and Answers

Unit 4: Parental Care

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Care for Eggs
- 4.4 Brood care
- 4.5 Brood Parasitism
- 4.6 Summary
- 4.7 Terminal Questions and Answers

Insect Systematics

Unit 5: Generalized structure, habit and habitat of the following Orders with Families

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Thysanura (Machilidae, Lepismatidae)
- 5.4 Collembola
- 5.5 Isoptera
- 5.6 Phthiraptera (Anoplura and Mallophaga)
- 5.7 Orthoptera (Acrididae, Tettigonidae, Gryllidae)
- 5.8 Phase theory of Locust
- 5.9 Summary
- 5.10 Terminal Questions and Answers

Unit 6: Generalized structure habit and habitat of the following Orders with Families:

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Heteroptera (Pentatomidae, Pyrrhocoridae, Coreidae, Reduviidae, Nepidae, and Belostomatidae)
- 6.4 Homoptera (Fulgoridae, Membracidae, Cicadidae, Aphidae, Coccidae)
- 6.5 Coleoptera (Hydrophilidae, Meloidae, Coccinellidae, Curculionidae, Scarabaeidae, Chrysomelidae, Cerambycidae)
- 6.6 Summary
- 6.7 Terminal questions and Answers

Unit 7: Generalized structure habit and habitat of the following Orders with Families:

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Lepidoptera (Noctuidae, Sphingidae, Bombycidae, Nymphalidae, Pieridae, Papilionidae, Pyralididae and Saturniidae)
- 7.4 Hymenoptera (Ichneumonidae, Chalcididae, Braconidae, Vespidae, Apidae, Formicidae)
- 7.5 Diptera (Tipulidae, Chironomidae, Culicidae, Muscidae, Tabanidae, Tachinidae, Drosophilidae, and Bombyliidae)
- 7.6 Summary
- 7.7 Terminal Questions and Answers

Block II: Pest and their control

Unit 8: Insect pests (Agro Horticultural)

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Origin of insect pests
- 8.4 Factors affecting the abundance of insect pests
- 8.5 Types of insect pest
- 8.6 Pests of stored grains: *Sitophilus*, *Trogoderma*, *Rhyzopertha*, *Tribolium*, *Bruchus*.
- 8.7 Pests of Sugarcane: *Pyrilla*, *Chilo*, *Emmalocera*, *Scirpophaga*
- 8.8 Pests of Cotton: *Dysdercus*, *Earias* and *Pectinophora*, *Sylepta*
- 8.9 Pests of Cereals: *Heliathis*, *Leptocorisa varicornis*, *Hieroglyph*, *Tryporyza*
- 8.10 Pests of Vegetables: *Epilachna*, *Aulacophora foveicollis*, *Pieris brassicae*, *Thrips tabaci*
- 8.11 Pests of Fruits: *Dacus cucurbitae*, *Papilio demoleus*, *Idiocerus atkinsoni*, *Anomala*
- 8.12 Polyphagous insect pest: locusts, termites, cutworms, gram pod borer, aphids
- 8.13 Summary
- 8.14 Terminal Questions and Answers

Unit 9: Household Pests: Classification, types, habit and habitat and damage of household items

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Cockroaches
- 9.4 Ants
- 9.5 Wasps
- 9.6 Carpet beetles
- 9.7 Furniture beetles
- 9.8 Booklice
- 9.9 Summary
- 9.10 Terminal Questions and Answers

Unit 10: Pest of Farm Animals and their control

- 10.1 Objectives
- 10.2 Introduction
- 10.3 Blood-sucking flies: Systematic position
 - 10.3.1.1 Causes/Mode of parasitism
 - 10.3.2 Disease/Effectuated host
 - 10.3.3 Control measures
- 10.4 Myiasis flies: Systematic position
 - 10.4.1 Cause / Mode of parasitism
 - 10.4.2 Disease/ loss
 - 10.4.3 Control measures
- 10.5 Lice: systematic position
 - 10.5.1 Causes/Mode of parasitism
 - 10.5.2 Disease /Effectuated host
 - 10.5.3 Control measures
- 10.6 Fleas: systematic position
 - 10.6.1 Causes/ mode of parasitism
 - 10.6.2 Disease/ Effectuated host
 - 10.6.3 Control measures
- 10.7 Ticks: Systematic position
 - 10.7.1 Causes/Mode of parasitism
 - 10.7.2 Disease/ Effectuated host
 - 10.7.3 Control measures

- 10.8 Mites: Systematic position
- 10.8.1 Causes/Mode of parasitism
- 10.8.2 Disease/ Effected host
- 10.8.3 Control measures
- 10.9 Summary
- 10.10 Terminal Questions and Answers

Unit 11: Medical entomology

- 11.1 Objectives
- 11.2 Introduction
- 11.3 Pests of public importance and their control:
 - 11.3.1 Mosquitoes
 - 11.3.2 House flies
 - 11.3.3 Bedbugs
- 11.4 Insect borne diseases
 - 11.4.1 Typhus
 - 11.4.2 Yellow fever
 - 11.4.3 Dengue fever
 - 11.4.4 Sleeping sickness
 - 11.4.5 Encephalitis
 - 11.4.6 Leishmaniasis
- 11.5 Venoms and allergens
- 11.6 Blister and urtica-inducing insects
- 11.7 Arthropods of forensic importance
- 11.8 Insects succession on corpse and its relationship in determining time of death
- 11.9 Summary
- 11.10 Terminal Questions and Answers

Unit 12: Insect Pest Control: Natural Control

- 12.1 Objectives
- 12.2 Introduction
- 12.3 Applied control
- 12.4 Cultural control: Agronomic practices
 - 12.4.1 Crop rotation
 - 12.4.2 Tillage practice
 - 12.4.3 Planting/harvesting date manipulation
 - 12.4.4 Sowing/plant density
 - 12.4.5 Inter cropping
 - 12.4.6 Trap cropping and irrigation
- 12.5 Summary
- 12.6 Terminal Question and Answers

Unit 13: Chemical control

- 13.1 Objectives
- 13.2 Introduction
- 13.3 Formulations and Insecticide Toxicity
- 13.4 Botanical Pesticide
 - 13.4.1 Pyrethrins
 - 13.4.2 Rotenone
 - 13.4.3 Sabadilla
 - 13.4.4 Nicotine
 - 13.4.5 Neem
- 13.5 Synthetic Organic Insecticides and their Mode of Action

- 13.5.1 Organochlorines
- 13.5.2 Organophosphates
- 13.5.3 Carbonates
- 13.5.4 Pyrethroids
- 13.5.5 Neonicotinoids
- 13.6 Insect Growth Regulators (IGR)
- 13.6.1 Juvenoids
- 13.6.2 Ecdysoids
- 13.6.3 Anti hormones
- 13.6.4 Chitin inhibitors
- 13.7 Summary
- 13.8 Terminal Questions and Answers

Unit 14: Biological control

- 14.1 Objectives
- 14.2 Introduction
- 14.3 Parasites
- 14.4 Parasitoids
- 14.5 Predators
- 14.6 Methods for using biocontrol agents
- 14.6.1 Classical biological control
- 14.6.2 Augmentation and inoculation techniques
- 14.6.3 Conservation biological control
- 14.6.4 Microbial control (virus, bacteria and fungi)
- 14.7 Behavioral control
- 14.7.1 Types of pheromones
- 14.7.2 Uses of pheromones in pest management (monitoring, mass trapping and mating disruption)
- 14.8 Genetic and biotechnological control
- 14.9 Insect attractants, repellents and antifeedants
- 14.10 Summary
- 14.11 Terminal Question and Answers

Block III: Applied & Sustainable Entomology

Unit 15: Mulberry and non mulberry sericulture

- 15.1 Objectives
- 15.2 Introduction
- 15.3 Cultivation of Food Plants
- 15.4 Rearing of Silkworms
- 15.5 Harvesting and Processing of Cocoons
- 15.6 Genetic improvement of Silkworms
- 15.7 Diseases of Silkworm
- 15.8 Economic importance and Sustainable livelihood through Sericulture
- 15.9 Summary
- 15.10 Terminal Questions and Answers

Unit 16: Apiculture

- 16.1 Objectives
- 16.2 Introduction
- 16.3 Conservation of important Bee Flora for Forage
- 16.4 Types of honeybees
- 16.5 Organization of bee Colony
- 16.6 Life history and behavior of Bees

- 16.7 Diseases of Honeybees
- 16.8 Beekeeping Methods
 - 16.8.1 Equipment and tools
 - 16.8.2 Apiary Management
 - 16.8.3 Controlling Swarming
 - 16.8.4 Handling of Bees
 - 16.8.5 Extraction of Honey and Wax and other Bee Products
- 16.9 Role of honey Bee in Crop Pollination
- 16.10 Summary
- 16.11 Terminal Questions and Answers

Unit 17: Lac culture

- 17.1 Objectives
- 17.2 Introduction
- 17.3 Lac Insect and its Life History
- 17.4 Host Plant Management
- 17.5 Strains of Lac Insects
- 17.6 Propagation of Lac Insects
- 17.7 Lac Crop Management
- 17.8 Natural Enemies of Lac Insects and their Management
- 17.9 Lac extraction
- 17.10 Summary
- 17.11 Terminal Questions and Answers

Suggested Readings:

1. Ananthakrishnan, T.N. 2002. Insect Plant Interactions. Oxford and I.B.H, New Delhi.
2. P.G.Fenemore, Alkaprakash. 1992. Applied Entomology, Wiley Eastern Ltd., Delhi.
3. Nayar, K.K., Ananthakrishnan, T.N. and B.V.David. 1989. General and Applied Entomology. Tata McGraw Hill Publications, New Delhi.
4. Larry P.Pedigo. 1989. Entomology and Pest Mangement. Prentice Hall, New Jersey.
5. Metcalf, C.V. and Flint, W.P. 1979. Destructive and useful insects, their habitats and control. Tata McGraw Hill Publications, New Delhi.
6. Chapman, R.F.1988. The insect structure and Function. Cambridge University Press, U.K.
7. Richards, O.W. and Davies, R.G. 1997. Imm's General Text Book of Entomology Tenth Edition. Vol I and II. R.I Publications, New Delhi.
8. Rajeev K.Upadhyay, Mukerjii K.G. Chanda, B.P. and Dubey, O.P. 1998. Integrated Pest and Disease Management. APH Publishing Corporation, New Delhi.
9. David B.V., Muralirangan M.C. and Meera Murali Rangan. 1992. Harmful and Beneficial Insects. Popular Book Depot, Chennai.
10. Ramakrishna Ayyar T.V. 1989. Handbook of Economic Entomology for South India. Books and Periodicals Supply Service, New Delhi.
11. Frost S.W.1994. General Entomology. Narendra Publishing House, Delhi.
12. Dennis S.Hill. 1993. Agricultural Insect Pests of the Tropics and their Control. Second Edition, Cambridge University Press, U.K.
13. Saxena. A.B. 1996. Harmful Insects. Anmol Publications, New Delhi.

14. Patton. W.S. and Cragg F.W.1981. A Text Book of Medical Entomology. International Books and Periodicals Supply Service, New Delhi.
15. Rathinaswamy, T.K.1986. Medical Entomology. S.Viswanathan and Co., Madras.
16. Sundari, M.S.N. and Santhi, R. 2006. Entomology. MJP Publishers, Chennai.

Course II: Entomology (Morphology Physiology & Development Biology) (MSZO-611)**Course objectives:**

1. To understand the morphological features of insects (head, body, thorax and wings and legs)
2. To learn and discuss basic principles used in the study of insect morphology and physiology through a systems approach illustrated by both generalized and specialized taxa
2. To understand the physiological mechanism of various insect systems, their modification and adaptations for survival in different climatic and habitat conditions
3. To understand the neuro-hormone and hormonal importance in the activity of insects
4. To understand the function and significance of auditory, receptor, light and sound producing organs in the insects
5. To learn the developmental mechanism of insect through various life stages.

Syllabus:

Structure of typical eye, modification of eye, structure of ommatidium, mechanism of image formation in diurnal and nocturnal insects. Structure and modification of antennae, mouth parts of typical insects and modifications of mouth parts in different insects. Structure of typical leg, modification of different Legs, structure of a typical wing, types of wings, hypothetical wing venation, wing coupling mechanisms and flight mechanism. Thorax , Abdomen: Male and female genitalia. Digestive System (Nutrition, nutritional requirement, Ectosymbiotic fungi, Endosymbionts, modification of alimentary canal in insects; food and feeding mechanism in different types of insects. Fat body: physiology and biochemistry. Circulatory System Structure and functions of blood and mode of circulation in insects, Haemocytes, Type, Origin and longevity & Haemopoietic organs. Excretory System (organs of excretion of insects found in different habitats, Nitrogenous excretion, Excretory products, Storage excretion, Production of urine and its hormonal regulation, Terrestrial and Water insect, **Control of diaeresis**. Water regulation, Detoxification) Physiology of excretion with special reference to osmoregulation in insects. Respiratory System (Modification and functioning of various types of respiratory organs, Ultrastructure of malpighian tubule, modes of respiration and physiology of respiration in terrestrial, aquatic and endoparasitic insects. Reproductive system (Anatomy of reproductive organs, Spermatogenesis and oogenesis, modification of reproductive organ, mating, insemination, oviposition and Special modes of reproduction). Nervous System and its modifications. Neuroendocrine System (Endocrine organs, mode of action of hormones, chemical nature and functions, Exocrine glands, pheromones, semiochemicals and defensive secretions and importance for metamorphosis and development of insects). Sensory Organs (Mechanoreceptors, Chemoreceptor). Auditory organs, light producing organ, sound producing organ, visual organ (Compound eye and ocelli). Embryology: Structure of egg, embryonic and post embryonic development. Types of larvae, pupae and metamorphosis

Unit Schedule:

Block I: General organization of insect body

Unit 1: Head

Unit 2: Thorax

Unit 3: Abdomen

Block II: Insect Physiology

Unit 4: Digestive System

Unit 5: Circulatory System

Unit 6: Excretory System

Unit 7: Respiratory System

Unit 8: Reproductive System

Unit 9: Nervous System

Unit 10: Neuro-endocrine System

Unit 11: Sensory, Vocal, Auditory and Visual organs

Unit 12: Endocrine system

Unit 13: Embryology

**Course I: Entomology (Morphology Physiology & Development Biology)
(MSZO611)**

UNIT WISE CONTENTS

Block I: General organization of insect body

Unit 1: Head

- 1.1 Objectives
- 1.2 Introduction
- 1.3 Structure of typical eye
 - 1.3.1 Modification of eye
 - 1.3.2 Structure of ommatidium
 - 1.3.3 Mechanism of image formation
 - 1.3.3.1 Diurnal insects
 - 1.3.3.2 Nocturnal insects
- 1.4 Structure and modification of antennae
- 1.5 Mouth parts of typical insects
- 1.6 Modifications of mouth parts in different insects
- 1.7 Summary
- 1.8 Terminal questions and Answers

Unit 2: Thorax

- 2.1 Objectives
- 2.2 Introduction
- 2.3 Structure of typical Leg
 - 2.3.1 Modification of different Legs
- 2.4 Structure of a typical Wing
 - 2.4.1 Types of Wings
 - 2.4.2 Hypothetical Wing Venation
 - 2.4.3 Wing Coupling Mechanisms
 - 2.4.4 Flight Mechanism
- 2.5 Summary
- 2.6 Terminal Questions and Answers

Unit 3: Abdomen

- 3.1 Objectives
- 3.2 Introduction
- 3.3 Structure of Genitalia
 - 3.3.1 Male Genitalia
 - 3.3.2 Female Genitalia
- 3.4 Summary
- 3.5 Terminal Questions and Answers

Block II: Insect Physiology

Unit 4: Digestive System

- 4.1 Objectives
- 4.2 Introduction
- 4.3 Structure and Modification of Alimentary Canal in Insects
- 4.4 Food and Feeding Mechanism
- 4.5 Digestion in different Insect
- 4.6 Absorption
- 4.7 Nutrition
- 4.8 Nutritional Requirements
- 4.9 Ectosymbiotic Fungi
- 4.10 Endosymbionts
- 4.11 Summary
- 4.12 Terminal Questions and Answers

Unit 5: Circulatory System

- 5.1 Objectives
- 5.2 Introduction
- 5.3 Circulation
- 5.4 Types of Haemocytes
- 5.5 Haemopoietic Organs
- 5.6 Changes in Haemocyte Number
- 5.7 Haemolymph Proteins
- 5.8 Summary
- 5.9 Terminal Questions and Answers

Unit 6: Excretory System

- 6.1 Objectives
- 6.2 Introduction
- 6.3 Organs of Excretion
- 6.4 Nitrogenous Excretion
- 6.5 Excretory Products
- 6.6 Storage Excretion
- 6.7 Production of Urine and its Hormonal Regulation
- 6.8 Terrestrial and Salt Water Insects
- 6.9 Control of Diuresis
- 6.10 Water Regulation
- 6.11 Detoxification
- 6.12 Summary
- 6.13 Terminal Questions and Answers

Unit 7: Respiratory System

- 7.1 Objectives
- 7.2 Introduction
- 7.3 Types of respiratory Organs
- 7.4 Structure and functions of Various Respiratory Organs
- 7.5 Respiratory system and its Modifications
- 7.6 Respiration in Terrestrial, Aquatic and Endoparasitic Insects.
- 7.7 Aquatic Respiratory Adaptations

- 7.8 Summary
- 7.9 Terminal Questions and Answers

Unit 8: Nervous System

- 8.1 Objectives
- 8.2 Introduction
- 8.3 Generalized plan of Nervous System in Insects
- 8.4 Modifications of Nervous System in Terrestrial and Aquatic Insects
- 8.5 Summary
- 8.6 Terminal Questions and Answers

Unit 9: Sensory, Vocal and Auditory and Visual organs

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Structure and functions of different types of Sensory Organs
- 9.4 Structure and functions of Visual Organs
- 9.5 Sound producing Organs
- 9.6 Light Producing Organs: Mechanism, Control and Significance
- 9.7 Chemoreceptor and Mechanoreceptor: Functions and physiology
- 9.8 Summary
- 9.9 Terminal Questions and Answers

Unit 10: Reproductive System

- 10.1 Objectives
- 10.2 Introduction
- 10.3 Structure and Modification of Male and Female Reproductive Organs
- 10.4 Spermatogenesis and Oogenesis
- 10.5 Mating
- 10.6 Inseminations
- 10.7 Oviposition
- 10.8 Special Modes of Reproduction
- 10.9 Summary
- 10.10 Terminal Questions and Answers

Unit 11: Neuroendocrine System

- 11.1 Objectives
- 11.2 Introduction
- 11.3 Neuroendocrine System in Insects
- 11.4 Role of Neurosecretion in Various Metabolic Activities
- 11.5 Metamorphosis and Development of Insects
- 11.6 Summary
- 11.7 Terminal Questions and Answers

Unit 12: Pheromones

- 12.1 Objectives
- 12.2 Introduction
- 12.3 Structure of Pheromone Producing Glands
- 12.4 Different types of Pheromones
- 12.5 Chemical Natures of Pheromones
- 12.6 Importance of Pheromones in Insect Activity
- 12.7 Summary
- 12.8 Terminal Questions and Answers

Unit 13: Embryology

- 13.1 Introduction
- 13.2 Objectives
- 13.3 Early Embryonic Development
- 13.4 Structure of Egg
- 13.5 Maturation
- 13.6 Cleavage
- 13.7 Blastokinesis
- 13.8 Formation of Germ Layers and Segmentation
- 13.9 Different types of Larvae and Pupae
- 13.10 Polyembryony and Parthenogenesis in Insects
- 13.12 Summary
- 13.14 Terminal Questions and Answers

Suggested Readings:

1. The Insect: Structure and function by R.F. Chapman
2. Comparative Insect physiology, Biochemistry and Pharmacology .Vol :1-13.
Edited by G.A. Kerkut and L.I. Gilbert.
3. Entomophagous Insect by Clausen
4. Entomology bu Gilbert
5. Principles of Insect Physiology by Wigglesworth.
6. Fundamentals of Entomology by Elzinga
7. Insect Physiology by Wigglesworth.
8. Insect morphology by Mat Calf and Flint
9. Applied Agricultural Entomology by Dr. Lalit Kumar Jha

ENTOMOLOGY

Course III: Laboratory Exercise (MSZO612) Practical Zoology

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session. The practical work shall comprise of following units:

Block I Laboratory Course: (Entomology): Zoo- 605

Unit 01: Insect Anatomy and Physiology Exercise

Unit 02: Taxonomy and Biosystematics

Unit 03: Applied Entomology Exercise

Unit 04: Insect Ecology Exercise

ENTOMOLOGY**Course III: Laboratory Exercise (MSZO612) Practical Zoology****UNIT WISE CONTENTS**

Candidates must produce at the time of practical examination their preparations, collection and practical record books containing a complete record of the laboratory work done during the session. The practical work shall comprise of following units:

Block I: Laboratory Course, Entomology**Unit 01: Insect Anatomy and Physiology Exercise**

- 9.1 Objectives
- 9.2 Introduction
- 9.3 Study of models of Nervous System of Insects
- 9.4 Counting of Haemocytes in Insects
- 9.5 Estimation of Proteins, Sugars & Lipids in Insect Haemolymph by Colorimetric Methods.
- 9.6 Permanent preparation of sting apparatus of honey bee/wasp, tympanum of locust, salivary glands of Cockroach, mouth parts, legs and wings of different insects.
- 9.7 Microtomy of Insect Tissues
- 9.8 Determination of pH of the gut contents of any Insect
- 9.9 Summary
- 9.10 Terminal Questions and Answers

Unit 02: Taxonomy and Biosystematics of Insects

- 10.1 Objectives
- 10.2 Introduction
- 10.3 Use of dichotomous key in the Identification of Insects
- 10.4 Identification of insects up to Family of the Orders
 - 10.4.1 Thysanura (Machilidae, Lepismatidae)
 - 10.4.2 Collembola
 - 10.4.3 Isoptera
 - 10.4.4 Phthiroptera (Phthiraptera) (Anoplura and Mallophaga)
 - 10.4.5 Orthoptera (Acrididae, Tettigoniidae and Gryllidae)
 - 10.4.6 Heteroptera (Pentatomidae, Pyrrhocoridae, Coreidae, Reduviidae, Nepidae, and Belostomatidae)
 - 10.4.7 Homoptera (Fulgoridae, Membracidae, Cicadidae, Aphidae, Coccidae)
 - 10.4.8 Coleoptera (Hydrophilidae, Meloidae, Coccinellidae, Curculionidae, Scarabaeidae, Chrysomelidae, Cerambycidae)
 - 10.4.9 Lepidoptera (Noctuidae, Sphingidae, Bombycidae, Nymphalidae, Pieridae, Papilionidae, Pyralididae and Saturniidae)
 - 10.4.10 Hymenoptera (Ichneumonidae, Chalcididae, Braconidae, Vespidae, Apidae, Formicidae)
 - 10.4.11 Diptera (Tipulidae, Chironomidae, Culicidae, Muscidae, Tabanidae, Tachinidae, Drosophilidae, and Bombyliidae)
- 10.5 Study of the different types of adaptation found in insects
- 10.6 Summary
- 10.7 Terminal Questions and Answers

Unit 03: Applied entomology exercise

- 11.1 Objectives
- 11.2 Introduction
- 11.3 Pests of fruits, Vegetables & Stored grains
- 11.4 Study of the structure of Beehive
- 11.5 Bioassay studies on Insects using some Contact Poisons
- 11.6 Study of the Life Cycles of some important Insect Pests
- 11.7 Study of Pollinators Insect Species and their Host Plant
- 11.8 Identification and study of Taxonomic Status of Insect and their Host Plant used in various economic practices: Apiculture, Sericulture and Lac culture
- 11.9 Summary
- 11.10 Terminal Questions and Answers

Unit 04: Insect Ecology Exercise

- 12.1 Objectives
- 12.2 Introduction
- 12.3 Exercises on Insect Behaviors
- 12.4 Insect Plant Interactions and Bee Plant of Local Area
- 12.5 Study of habitat quality effect on Insect Assemblage

Course IV: Project Work (Entomology) (MSZO613)

1. Ancestry and Evolution.
2. Collection mounting and Presentation of Insect.
3. Classification of Insect up-to Order.
4. Insect pest of cereals (Wheat, Maize, Rice etc.)
5. Pest of Stored Grains.
6. Pest of Vegetables.
7. Pest of Fruits.
8. Apiculture, Sericulture, Lac Culture etc.
9. Economic Importance of Insect.
10. Integrated Pest Management.