



CIRCULAR NO.SU/Sci. & Tech./Colleges./NEP/16/2023

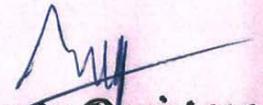
It is hereby inform to all concerned that, the syllabi prepared by the Board of Studies & Ad-hoc Boards and recommended by the Dean, Faculty of Science & Technology, the Hon'ble Vice-Chancellor has accepted **the following curriculum of All Post Graduate Degree Courses as per Norms of National Education Policy - 2020 under the Faculty of Science & Technology run to the Affiliated Colleges, Dr.Babasaheb Ambedkar Marathwada University** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

Sr.No.	Syllabi of Affiliated BAMU, Aurangabad.	Semester
1.	M.Sc.Zoology	Ist and IInd Semester
2.	M.Sc.Microbiology	Ist and IInd Semester
3.	M.A/M.Sc.Mathematics	Ist and IInd Semester
4.	M.Sc.Geology	Ist and IInd Semester
5.	M.Sc.Biophysics	Ist and IInd Semester
6.	M.Sc.Bioinformatics	Ist and IInd Semester
7.	M.Sc. Information Technology	Ist to IVth Semester
8.	M.Sc.Computer Science	Ist to IVth Semester
9.	M.Sc.Botany	Ist and IInd Semester
10.	M.Sc.Environmental Science	Ist and IInd Semester

This is effective from the Academic Year 2023-24 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus, ★
Aurangabad-431 004. ★
REF.NO.SU/NEP/2023/ 8752-60 ★
Date:- 08.08.2023. ★


Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

- 1] **The Principal of all concerned affiliated Colleges, Dr. Babasaheb Ambedkar Marathwada University,.**
- 2] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

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- 1] **The Director, Board of Examinations & Evaluation, Dr.BAMU,A'bad.**
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Dr . BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD



FACULTY OF SCIENCE & TECHNOLOGY

2 Years P.G. Programme

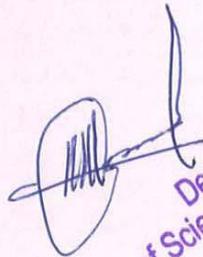
Course Structure & Curriculum

AS PER NEP-2020

Subject: Zoology

Course structure for M.Sc. IST year

**For affiliated colleges.
(Effective from 2023-24)**


Dean
Faculty of Science & Technology
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad

As per NEP 2020

Credit distribution structure for Two Years with Multiple Entry and Exit options –
Class: M.Sc. First Year Semester: Ist Semester

Subject: Zoology

Theory + Practical

Course type	Course Code	Course name	Teaching Scheme (Hrs./ week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Major Mandatory DSC Core Course	ZOO/MJ/-500	Biosystematics and animal diversity.	3	-	3	-	14
	ZOO/MJ/-501.	Biochemistry	3	-	3		
	ZOO/MJ/-502	Ecology(Principle and Practices).	3		3		
	ZOO/MJ/-503	practical based on ZOO/MJ/-500		2	-	1	
	ZOO/MJ/-504	practical based on ZOO/MJ/501	-	2	-	1	
	ZOO/MJ/-505	practical based ONZOO/MJ/ 502	-	2	-	1	
	ZOO/MJ/ 506	practical based Skill/advanced technique	-	4	-	2	
DSE (Choose any one from pool)	ZOO/DSE/-507	Helminthology I	3	-	3	-	4
	ZOO/ DSE /-508	practical based on ZOO/DSE/-507 OR	-	2	-	1	
	ZOO/ DSE /-509	Protozoology-I	3	-	3		
	ZOO/ DSE /-510	practical based on ZOO/DSE/-509 OR	-	2	-	1	
	ZOO/ DSE /-511	Entomology- I	3	-	3		
	ZOO/ DSE /-512	practical based on ZOO/DSE/-511 OR	-	2	-	1	
	ZOO/ DSE /-513	Endocrinology-I	3	-	3		
	ZOO/ DSE /-514	practical based on ZOO/DSE/-513	-	2	-	1	
RM	ZOO/RM/-515	Research Methodology-I (Theory)	4	-	4	-	04
			16	12	16	06	Total Credits-22

Class: M.Sc. First Year , Semester: II Semester
Subject: -Zoology Theory+ Practical

Course Type	Course Code	Course name	Teaching Scheme (Hrs./ week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Major Mandatory DSC	ZOO/MJ/-550	Genetics and Bioinformatics	3	-	3	-	14
	ZOO/MJ/-551	Cell and Molecular Biology	3	-	3	-	
	ZOO/MJ/-552	Immunobiology	3	-	3	-	
	ZOO/MJ/-553	practical based on ZOO/MJ/-550	-	2	-	1	
	ZOO/MJ/-554	practical based on ZOO/MJ/-551	-	2	-	1	
	ZOO/MJ/-555	practical based on ZOO/MJ/-552	-	2	-	1	
	ZOO/MJ/-556	Practical based Skill/Advance technique		4		2	
DSE (any one)	ZOO/DSE/-557	Helminthology-II	3	-	3		04
	ZOO/DSE/-558	practical based on ZOO/DSE/557 OR	-	2	-	1	
	ZOO/DSE/-559	Protozoology II	3		3		
	ZOO/DSE/-560	practical based on ZOO/DSE/559 OR	-	2	-	1	
	ZOO/DSE/-561	Entomology- II	3	-	3	-	
	ZOO/DSE/-562	practical based on ZOO/DSE/-561 OR	-	2	-	1	
	ZOO/DSE/-563	Endocrinology-II	3	-	3	-	
	ZOO/DSE/-564	practical based on ZOO/DSE/-563	-	2	-	1	
OJT/FP	ZOO/OJT/FP/-565	OJT/FP	-	2	-	4	04
			12	12	12	10	Total Credits -22

For practical -- 1 Credit = 30 Clock Hrs.

Total credits for theory = 16 credits

Total credits for Practical = 6 credits

Total Credits = 22 credit

Class: M.Sc. First Year: Zoology First Semester: -

- 1: - DSC- ZOO/MJ/-500 Biosystematics and animal diversity.
ZOO/MJ/-501 Biochemistry.
ZOO/MJ/-502 Ecology (Principle and Practices).
ZOO/MJ/-503 Practical based on Biosystematics and animal diversity.
ZOO/MJ/-504 Practical based on Biochemistry.
ZOO/MJ/-505 Practical based on Ecology (Principle and Practices).
ZOO/MJ/506 Practical based Skilled based Advance technique
- 2: DSE (Choose any one from Pool /Basket)
ZOO/DSE/-507 Helminthology I
ZOO/DSE/-508 Practical based on Helminthology I
ZOO/DSE/-509 Protozoology-
ZOO/DSE/-510 Practical based on Protozoology-I

ZOO/ DSE/-511 Entomology-I

ZOO/DSE/-512 Practical based on Entomology-I
ZOO/DSE/-513 Endocrinology-I
ZOO/DSE/-514 Practical based on Endocrinology-I
- 3: RM-1: ZOO/RM/-515 Research Methodology-I

Second Semester

- 1: DSC- ZOO/MJ/-550 Genetics and Bioinformatics
ZOO/MJ/-551 Cell and Molecular Biology
ZOO/MJ/-552 Immunobiology
ZOO/MJ/-553 Practical based on Genetics and Bioinformatics
ZOO/MJ/-554 Practical based Cell and Molecular Biology
ZOO/MJ/-555 Practical based on Immunobiology
ZOO/MJ/-556 **Practical based** Skilled based technique
- 2: DSE (Choose any one from Pool /Basket)
ZOO/DSE/-557 Helminthology-II
ZOO/DSE/-558 Practical based on Helminthology-II
ZOO/DSE/-559 Protozoology II
ZOO/DSE/-560 Practical based on Protozoology II
ZOO/DSE/-561 Entomology- II
ZOO/DSE/-562 Practical based on Entomology- II
ZOO/DSE/-563 Endocrinology- II
ZOO/DSE/-564 Practical based on Endocrinology- II
ZOO/OJT/FP/-565 OJT/FP

BIOSYSTEMATICS AND ANIMAL DIVERSITY

Total no. of credits- 3

No. of periods per credit- 15

Total No. of contact hours -45

Evaluation: External-60%, Internal-40%

Learning Objectives:

- To give a thorough understanding in the principles and practice of systematic To help students acquire an in-depth knowledge on the diversity and relationships in animal world To develop an holistic appreciation on the phylogeny and adaptations in animals

Learning Outcome:

- The students will learn the basic principle and practices used in systematics.
- The students will learn and understand the diversity in animal world and their adaptations.
- The students will learn about the phylogeny, the tools and salient features of taxonomic publications.

UNIT I BIOSYSTEMATICS

- Hierarchy of categories and higher taxa. Taxonomic Procedures-collection, preservation, curation and process of identification. Three Domain Concept in Systematics, two, five and six kingdom classification.
- Taxonomic Keys, types, use of keys, merits and demerits.
- International Code of Zoological Nomenclature (ICZN), Rules and formation of Scientific names of different taxa. Homonymy and Synonymy.
- **Species concepts** - Nominalistic Species concept, Morphological species concept, Biological species concept, Evolutionary species concept, Phylogenetic species concept and Cladistics

UNIT II LOWER PROTOSTOMES

- Classification and relationship of various phyla
- Acoelomate and Coelomate, Protostomes and Deuterostomes, Bilateria, and Radiata;
- Status of Protista, Parazoa, Onychophora, and Hemichordata;
- Evolutionary advantages. Symmetry, Coelom and Metamerism
- **Protozoa:** General classification, General features and life history of *Plasmodium*.
- **Porifera:** Skeleton, canal system, and reproduction.
- **Cnidaria:** Polymorphism, defensive structures and their mechanism; coral reefs and their formation; General features and life history of *Obelia* and metagenesis.
- **Platyhelminthes:** Parasitic adaptation; general features and life history of *Fasciola* and *Taenia* and their pathogenic symptoms.
- **Nemathelminthes:** General features, life history of *Ascaris*.

UNIT III HIGHER PROTOSTOMES

- **Annelida:** Coelom and metamerism; General characters and Reproduction in Earthworm.
- **Arthropoda:** Crustacean parasites, vision and respiration in arthropods (Prawn, cockroach, and scorpion);
- Reasons for the success of Arthropods.
- **Mollusca:** Feeding, respiration, locomotion, general features and life history of *Pila*; Torsion, and detorsion in gastropods.

UNIT IV LOWER DEUTEROSTOMES

- **Echinodermata:** Feeding, respiration, locomotion, larval forms, general features, and life history of *Asterias*.
- **Protochordata:** General features and life history of *Branchiostoma* and *Herdmania*.
- General classification of Agnatha and Gnathostomes
- **Pisces:** Respiration, locomotion, and migration. Structural and Functional adaptations of fishes

UNIT V HIGHER DEUTEROSTOMES

- **Amphibia:** General classification, paedomorphosis.
- **Reptilia:** Skull of reptiles and its importance in biosystematics, the status of *Sphenodon* and crocodiles.
- **Aves:** Orders under class Aves. General Classification, flight adaptation, migration.
- **Mammalia:** General classification, general features of egg-laying mammals, pouched-mammals, aquatic mammals and primates.

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- Young, J.Z. 1950. Life of Vertebrates. Clarendon Press, Oxford, UK.

BIOCHEMISTRY

Total no. of credits- 3

No. of periods per credit- 15

Total No. of contact hours -45

Evaluation: External-60%, Internal-40%

Learning Objectives:

- To understand the chemical nature of life and life process To provide an idea on structure and functioning of biologically important molecules To generate an interest in the subject and help students explore the new developments in biochemistry

Learning Outcome:

The students will learn the basic structure, reactions of the biomolecules.

- The students will learn the distribution of these biomolecules in animals and their role in The students will learn the general major metabolic pathways and lesser known life processes. pathways, in relation to metabolic diseases.

UNIT 1 :

A. Structure of atoms, molecules and chemical bonds and forces.

B. Stabilizing interactions

1. Van der Waals,
2. Electrostatic,
3. Hydrogen bonding (ex. water)
4. Hydrophobic interaction.

C. Principles of biophysical chemistry

1. pH and pKa
2. buffer, (Henderson and Hasselbalch equation) and its biological importance.
3. Reaction kinetics,
4. Colligative properties
5. Water: structure, solvent properties, biological importance.

UNIT II : Composition, structure and function of biomolecules

D. Carbohydrates –

1. Classification and nomenclature of carbohydrates-
2. Structure of Monosacharides, Disacharides, Polysacharides, Starch, Glycogen, Cellulose and Chitin
3. Importance of carbohydrate in metabolism.

E. Lipids:

1. Classification of lipids: simple, compound and derived lipids.
2. Biological importance of lipids.
3. Biologically important steroids-cholesterol, Vitamin D, Bile acids

F. Proteins :

1. Structure, classification and Properties of amino acids.
2. Conformation of proteins-chemical bonds involved.
3. Primary structure of protein (e.g insulin).

4. Secondary structure-alpha helix, Collagen helix, Beta Pleated sheet, Ramachandran angles and Ramachandran map.
5. Tertiary structure-e.g. Myoglobin.Quaternary structure-e.g. Haemoglobin..

G. Nucleic acids

1. Structural organization of DNA(Watson-Crick model).
2. Characteristic features of A,B,Cand ZDNA.
3. Structural organization of tRNA;
4. Protein-nucleic acid interaction.
5. denaturational and renaturation of DNA
6. Biological roles of nucleotides and nucleic acids.

H. Vitamins. Structure, classification and function.

UNIT III: Enzymes

I. Classification (L.U.B.system) enzymes

1. Enzyme specificity.
2. Mode of action of enzymes.
3. Formation of enzyme substrate complex.
4. Lowering of activation energy.
5. Theories of active site
6. coenzymes,
7. iso-enzymes

J. Enzyme kinetics:

1. Michaelis-Menten equation.
2. Km value and its significance.
3. Enzyme velocity and factors influencing enzyme velocity.
4. Kinetics of enzyme inhibition, suicide inhibition and feedback inhibition.
5. Enzyme regulation: Allosteric regulations -Key enzymes, Covalent modification.
6. Enzyme engineering.

UNIT IV:

K. Major metabolic pathways –

1. Glycolysis-Fate of pyruvate.
2. Citric acid cycle and its significance - Central role of citric acid cycle.
3. Oxidative and substrate level phosphorylation.

L. Glycogen metabolism-

1. Glycogenesis and its regulation
2. Glycogenolysis and its regulation
3. Gluconeogenesis (From amino acid and lactate)

M. Inborn errors associated with carbohydrate metabolism.

1. Glycogen storage diseases,
2. Lactose intolerance,
3. Galactosuria.

UNIT V: Metabolism of Proteins and Lipids

N. Metabolism of Proteins

1. **Amino acid Metabolism-**
2. Deamination, Transamination and Trans-deamination.
3. Formation and disposal of ammonia.
4. **Urea cycle. Fate of carbon skeletons of aminoacids:**
5. Glucogenic, ketogenic, partly glucogenic and ketogenic with examples.

6. Synthesis of biologically significant compounds from different amino acids with special reference to Glycine, Glutamic acid, Phenylalanine, Tyrosine and Tryptophan.

O. Metabolism of Lipids:

1. Beta oxidation.
2. **Metabolism of cholesterol:** synthesis and its regulation and biosynthesis of triglycerides:
3. **Metabolism of ketone bodies:** Ketogenesis, Ketolysis, Ketosis.
4. **Major and minor nutrients:** Role of Calcium, Phosphorus, Magnesium, Sodium, Potassium, Chloride, Sulphur and Iron.
5. **Free radicals and antioxidants:** Generation of free radicals, Reactive oxygen species, Free radical scavenger systems, Lipid peroxidation and Preventive antioxidants.

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ECOLOGY: PRINCIPLES AND PRACTICES

Total no. of credits- 3

No. of periods per credit- 15

Total No. of contact hours -45

Evaluation: External-60%, Internal-40%

Learning Objectives:

- To provide an understanding on the basic theories and principles of ecology
- To help study various disciplines in ecology
- To learn current environmental issues based on ecological principles
- To gain critical understanding on human influence on environment Learning outcome
- The students will learn the theories that govern the principles of ecology.
- The students will learn the various aspects of ecology, and their immediate
- Practices in day to day life. The students will learn the environmental issues at local, national and global level.
- The students will understand the how the human influence and living deteriorate
- The environment and will understand about the sustainability.

UNIT I : Ecology and Environment & Ecosystem-Structure and Function

A. Physical Environment-biotic and abiotic interactions.

B. Concept of Homeostasis:

C. Concepts of habitats:

1. host as habitat, niche,
2. niche width and overlap,
3. fundamental and realized niche,
4. resource partitioning,
5. character displacement.
6. Ecosystem and Landscapes,
7. pathways in ecosystem,

D. Energy in the environment : Laws of thermodynamics, Cybernetic nature of ecosystem, and Gaia hypothesis

E. Energy flow in the ecosystem: Primary productivity, Biomass and productivity measurement.

1. Food chain,
2. food web,
3. trophic levels.
4. Ecological efficiencies,
5. Ecological pyramids,

F. Biogeochemical cycles- patterns and types (CNP).

UNIT II:

G. Population Characteristics

1. Types of Population
2. Features of Population

- 2.1. Size and Density
- 2.2. Dispersion
 - 2.2.1. Spatial Distribution
 - 2.2.2. Temporal Distribution
 - 2.2.3. Dispersal

H. Population Growth

- 1. Processes governing growth of population :
 - Natality
 - Mortality
 - Immigration
 - Emigration
- 2. Growth Models
 - Exponential model
 - Logistic Model

I. Population Regulation

- 1. Population Growth forms
 - J-shaped populations growth forms
 - S-shaped populations growth forms
- 2. r & K selected Populations
 - Features of r & K selected species
- 3. Population Growth Regulation
 - Density dependent regulation
 - Density independent regulation
- 4. Population Fluctuations
 - Types of fluctuations
 - Population fluctuations & Species Conservation

J. Population structure:

- 1. aggregation,
- 2. Allee's principle,
- 3. isolation,
- 4. dispersal and territoriality.

K. Population interactions:

- 1. types,
- 2. positive and negative,
- 3. interspecific and intraspecific interactions
- 4. Ecological and evolutionary effects of competition.

L. Concept of community - community structure and attributes, ecotone and edge effect.

M. Development and evolution of the ecosystem, concept of climax.

UNIT III: Resource Ecology

N. Natural Resources:

- 1. Soil-soil formation,
- 2. physical and chemical properties of soil.
- 3. Significance of soil fertility.
- 4. Impact of mining on environment;

O. Forest resources- deforestation, forest scenario of India.

P. Aquatic resources-

1. Freshwater and water scarcity,
2. water conservation measures - case studies from India:

Q. Wetlands and its importance-

1. international initiatives for wetland conservation;
2. Ramsar sites.
3. Sand mining and its impacts.
4. Wetland reclamation- causes and consequences.

R. Depletion of resources and impacts on quality of life.

S. Energy Resources –

1. solar, fossil fuels, hydro, tidal, wind, geothermal and nuclear. Energy use pattern in different parts of the world.
2. recent issues in energy production and utilization;
3. Energy audit,
4. Green technology and sustainable development.

T. Ecosystem monitoring-

1. GIS,
2. Role of remote sensing in ecology,
3. GPS and its application;
4. EIA- tools and techniques,
5. Ecosystem Modelling (Brief account only).

UNIT IV: Applied Ecology:

U. Environmental Pollution mitigation at international level,

1. International protocols,

V. Waste management:

1. Concept of waste
2. types and sources of solid wastes including e-waste;
3. Environmental biotechnology and solid waste management-
4. aerobic and anaerobic systems.
5. Concept of bioreactors in waste management.
6. Liquid wastes and sewage.

W. Bioremediation: need and scope of bioremediation in cleaning up of environment.

1. Phytoremediation,
2. bio-augmentation,
3. biofilms,
4. biofilters,
5. bioscrubbers and trickling filters.

X. Radiation Biology:

1. Natural and man-made sources of radioactive pollution;
2. radioisotopes of ecological importance;
3. effects of radioactive pollution;
4. nuclear disasters(two case studies),

5. Disposal of radioactive wastes.
6. Weak radiation LF-EMF.

UNIT V:

Y. Biogeography and Conservation:

1. Major terrestrial Biomes,
2. bio-geographical zones of India;
3. Western Ghats and its significance,
4. Hot-Spots in India

Z. Restoration Ecology:

1. need and policies, case studies and success stories - global and national:
2. Global environmental problems and debates - past and present:
3. Participatory resource management, community reserves, sacred groves, bio villages.

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ZOO/MJ/503

Practical based on ZOO/MJ/500

(Biosystematics and Animal Diversity)

1. Museum specimen study of different groups of Invertebrates .
2. Museum specimen study of different groups of Vertebrates
3. Terrestrial ecosystem (Vegetation studies)- Abundance, Frequency, Density, Relative Diversity, Dominance, Rounkers Biological Spectrum, Index of dominance etc.
4. Method of plankton collection, plankton identification and quantification from river or stream or lake water.
5. Method of collection, preservation and identification of zooplankton.
6. Composition assessment of taxonomical diversity or biodiversity in habitat from local Grassland, Terrestrial and wetland.
7. Composition assessment of taxonomic diversity/biodiversity from different ecosystems.
 - a. Species diversity indices.
8. Relative density, relative frequency and relative abundance of species.
9. Method of collection, preservation and identification with keys from different group of organism like parasite, etc.
10. Method of collection, preservation and identification with keys from different group of organism like insects, birds and fishes etc.
11. Construction of taxonomic Key from the character in an animal group.
12. Construction of Phylogenetic tree from the characters of an animal group.
13. Study of larval forms in crusteceans /coelenterates/helminths(from permanant slides)
14. Visit to any biodiversity center / spots and submission of report.

ZOO/MJ/-504

Practical based ZOO/MJ/-501 (BIOCHEMISTRY)

1. Preparation of Acid and Alkali solutions
2. Preparation of acid base titration.
3. Preparation of Buffers of known pH, buffering capacity.
4. Qualitative test for Carbohydrates.
5. Qualitative test for lipids.
6. Preparation paper model of DNA.
7. Estimation of Amino acid (Tyrosine)
8. Estimation of Protein by Lowry's method.
9. Estimation of Carbohydrates by Anthrone reagent method. (Glycogen)

10. Separation of amino acids by paper chromatography.
11. Separation of Proteins by Gel electrophoresis.
12. Study of factors affecting enzyme activity (Substrate concentration, pH, Temperature and Inhibitors)
13. Isolation of Casein protein from the milk.
14. Determination of isoelectric pH of Casein.

ZOO/MJ/-505

Practical based on ZOO/MJ/-502

(ECOLOGY: PRINCIPLES AND PRACTICES)

1. Study of ecosystem biodiversity of local area.
2. Estimation of DO/ BOD
3. Estimation of hardness of water sample. (Total, Sodium and Potassium hardness.)
4. Estimation of Salinity /Nitrates and phosphates from a given water sample.
5. Biomass analysis in a given ecosystem.
6. Species diversity in community and its measurement- Alpha diversity- Simpsons diversity index, Shannon index, Fisher alpha, Beta diversity- Sorensen's similarity index, Whittaker's index, Evenness, Gamma diversity, Guild and its functioning in the community.
7. Productivity estimation in given ecosystem (Primary and Secondary) 8. Study of efficiency of sampling method.
9. Study of air quality and aerobiology in given area. 10. Toxicology- Principles, toxicants- types, dose and effects, toxicity of heavy metals
11. Measuring ecotoxicity using a lettuce seed assay.
12. Estimation of various physical parameters of water (SSP, Turbidity, TDS etc).
13. Visit to any biodiversity centre /National park/Sanctuary and submission of report.

Practical

ZOO/MJ/-506-Skill/ Advanced technique

ZOO/DSE/-507 Helminthology I

Total no. of credits- 3

No. of periods per credit- 15

Total No. of contact hours -45

Evaluation: External-60%, Internal-40%

Course Objectives

This course is designed to teach students

1. The basic concepts of Helminthology.
2. Basic information and the major types of important cestodes & Trematodes.
4. By studying this course students will develop the ability to collect, identify important cestodes and Trematodes, from locally available hosts.
5. To develop the experts in the field of Helminthology.

Learning Out come

The student will learn about the phylogeny, and importance of the helminthic parasites in control of disease.

The student will learn and understand how helminthes survive in human body.

The student will learn the skill to identify the helminth parasites.

Unit I Introduction, history and scope of Helminthology.

1. General organization and Classification of Platyhelminthes up to order level.

Cestodes (Cestodarians and Eucestodes), Trematodes (Monogenea, Aspidobothria and Digenea)

2. Functional anatomy of Reproductive system.

- a. Trematodes (Digeneans)
- b. Cestodes (Pseudophyllideans & Cyclophyllideans).
- c. Egg shell formation, chemistry of egg shell formation, factors influencing embryonation & hatching.

Unit II :

1. Intramolluscan stages and their effect on molluscan hosts, Effect on foot, haepatopancreas, Reproductive system and general metabolism.
2. Various types of Cercaria.
3. Different types of larvae in cestodes and their pathogenicity.
4. Holdfast organs with its adaptations in cestodes.

Unit -III:

1. Life cycle patterns of Digenetic Trematodes
 - a. Single intermediate host life cycle.
 - b. Two intermediate host life cycles
2. Life cycle patterns in Cestodes
 - a) No intermediate host life cycle
 - b) Single intermediate host life cycle
 - c) Two intermediate host life cycles.

Unit -IV.:

Geographical distribution, habitat, morphology (Structure) life cycle, pathogenicity, diagnosis, treatment & prevention of the following types

- a) Monogenea: *Polystoma integrimum*
- b) *Aspidobothria: Aspidogastar conchicola*
- c) Digenea : 1. *Paragonimus westermani* 2. *Fasciolopsis buski* 3. *Gastrodiccoides hominis*.

Unit- V

Geographical distribution, habitat, morphology (Structure) , life cycle, pathogenicity, diagnosis, treatment and prevention of the following type.(Cestodes)

- 1) *Amphilina*
- 2) *Diphyllobothrium latum*
- 3) *Dipylidium caninum*
- 4) *Echinococcus granulosus*
- 5) *Taenia saginata*

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2. The Biology of animal parasites, Cheng T.C. (1964)-Saunders International Student Edition.
3. The Invertebrates Vol II, McGraw Hill, New York.- Dawes B. (1946).
4. Text book Medical Parasitology Jaypee Brothers, - Medical Publishers, New York. – Panikar C.K.J(1988)
5. The Parasitology of Trematodes Oliver and Boyd Ltd. Edinburgh – Smyth J.D (1977)
6. Parasitology (Protozoology and Helminthology) –Sood Pamnik (1993) CBS Publication and Distribution, Delhi.
7. Human helminthology Manual for Clinical, Sanitarians Medical Zoologists – Faust, Emerest Carol.
8. Systema Helminthum Vol. IV Monogenea and Aspidobothria – Yamaguti S.(1963) Inter- Science Publishers, London. , Vol. II Cestoda. – Satyu Yamaguti (1959)
- 9.Synopsis of Digenetic Trematodes of Vertebrates – Yamaguti S. (1971) Vol. I & II Keigaku Publishing Co., Tokyo, Japan.
- 1) The Invertebrates Vol.II – Hyman L. H.
- 2) The Trematode – Dausese B
- 3) Text book of medical Parasitology – Dey
- 4) Text book of medical Parasitology – Sawitz
- 5) Parasitology – Nobel and Nobel
- 6) General Parasitology – Cheng
- 7) Clinical Parasitology – Craig Faust
- 8) Applied Parasitology – Hiware, Jadhav and Mohekar
- 9) Biochemistry of parasitism – Von Brand
- 10) The Physiology of Cestodes. – J.D Smyth
- 11) Helminth, Arthropod and Protozoa of domesticated animal –Solbsy E.J.W
- 12) Practical exercise in Parasitology – Halton, Behave, Marshall.
- 13) Parasitology (Protozoology and Helminthology) –Chatterjee K. D. (1969)
- 14) The advances in the Zoology of tapeworm from Wardle and Mcleod (1952)
- 15) Modern Parasitology – Cox
- 16) Essential Parasitology –Schimdit
- 17) Parasitism – Cameron
- 18) Animal Parasitism – Read
- 19) Parasitism and Symbiology – Read

ZOO/ DSE /-509

Protozoology-I

Total no. of credits-3

No. of periods per credit- 15

Total No. of contact hours -45

Evaluation: External-60%,Internal-40%

Course objective:

This course is designed to teach students-

1. The basic concepts of Protozoan systematic
2. To study systematic of Subkingdom Protozoa. 3. To study biological importance of free living Protozoa.
3. To study methodology of collection and identification of free living protozon. 5. To study culture methods of free living protozoa.

Learning Out come :

The students will learn the economic importance of protozoans, their systematics, and techniques To identify.

The students will learn the different culture methods.

UNIT I

1. Classification of Protozoa up to order level
2. Factors influencing Growth of Protozoa
 - i.Balanced growth..
 - ii.Non balanced growth

UNIT II

Ecology of free living Protozon

- i. Marine Protozoa
- ii. Planktonic protozoa
- iii. Soil protozoa
- iv. Protozoan blooms

UNIT III

- 1).Nutrition in Protozoa
- 2) Methods of feeding
 - a.Filter feeding b. Raptorial feeding c. Diffusion feeding
- 3) Nutritional requirements

UNIT IV

- i. Metabolism in Protozoa
- ii. Carbohydrate and Respiratory metabolism
- iii. Nitrogen metabolism
- iv. Lipid metabolism

UNIT V

- i. Heredity in Protozoa

- ii. Bi-parental reproduction
- iii. Uni-parental reproduction
- iv. Mating types in ciliates

Reference Books

Aikwa and Sterling- Intracellular parasitic protozoa
Baker- Parasitic Protozoa
Chandler and Read- An introduction to parasitology
Chatterjee- Parasitology
Thomas C. Cheng – General Parasitology
Corliss-The ciliate protozoa
Dogiel – An Introduction to Protozoology
Horare- Trypanosome of mammals
Faust, Rusell and Jung-Clinical Parasitology
Hall-Protozoology
Kudo- Protozoology
Levine- An introduction to protozoa parasites of domestic animals and of man
Meanwell- An introduction to protozoa
Richardson and Kendal-Veterinary protozoology
Calkins- Protozoa in biological research
Thomas and Cheng –Research in ProtozoologyI-IV
Florkin and Scheer-Chemical Zoology volume I
Tayler and Baker- Cultivation of parasites in vitro

ZOO/ DSE /-511

Entomology I

Total no. of credits-3

No. of periods per credit- 15

Total No. of contact hours -45

Evaluation: External-60%,Internal-40%

Course Objective: 1. To develop a strong foundation in entomology, including understanding of the importance of insects to human society.

2. To familiarize the students with insects for their external and internal features.

3. To review important areas in insect biology such as morphology, physiology, ecology, behaviour, genetics, phylogeny, ontogeny and population biology.

4. To develop a sufficient background for those students who wish to study more advanced entomological topics.

Learning Outcome:

- The students will learn in depth the morphology and structure of insects.
- The students will get knowledge about different physiological adaptations, physiological processes in different orders of insects.

Unit I:

1. Introduction to Entomology

2. Insect morphology, segmentation and tagmosis

3. Head – Structure of definitive insect head

4. Structure and types of antennae

5. Structure and types of mouth parts

6. Thorax – Segmentation, Wings – Origin, Structure, venation, modifications

7. Leg – General structure, types of legs

8. Abdomen – Segmentation, Appendages

Unit II:

1. Integument, Cuticle – Structure, moulting, sclerotization

2. Digestive System – Structure of alimentary canal and associated digestive glands and physiology of digestion

3. Respiratory System – Respiratory Structures and mechanism of respiration in terrestrial and aquatic insects.

Unit III: 1. Circulatory System – Structure, Haemocoel, the dorsal vessel, accessory pulsatile organs, Haemolymph – chemical composition, Haemocytes – structure and types, mechanism of circulation.

2. Excretory System – Structure of Malpighian tubules, Physiology of excretion and osmoregulation.

Unit IV: 1. Nervous System – Central nervous system, Physiology and neuro-biochemistry

2. Sense Organs – Compound eyes, Chemoreceptor, Mechanoreceptors

3. Effector organs – Sound producing organs, Light producing organs

Unit V: 1. Reproductive system – Male and female reproductive system, fertilization and development

2. Endocrine system – Structure and mode of action of hormones in metamorphosis.

3. Ectohormones – Pheromones, Sex pheromones and defensive mechanism.

Reference Books: 1. The insect structure and function, 4th Edition 92008. Chapman R. F, Publisher – Cambridge University Press, London.

2. General Textbook of Entomology, 10th Edn., (1977) Imms A. D, Richard O. W. and Devis R. G (Eds.) 1: Chapman & Hall, London

3. General Entomology, 2nd edition (1973) Mani M. S, Oxford & IBH Publishing Company, Delhi.

4. Modern Entomology, 1st edition (1997) D. B. Tembhare, Himalaya Publishing House, Delhi

5. Principles of Insect Morphology (1973). Snodgrass R. E, Publisher – Tata McGraw Hill, Bombay.

Additional Reference Books: 1. The Principles of Insect Physiology, 2nd edition (2007). Wigglesworth, V. B. Publisher – English Language Book Society and Methuen and Co. Ltd.

2. The Insect: Structure, Function and Biodiversity (2004). Ambrose D. P, Publisher – Kalyani Publications, New Delhi.

3. Introduction to Insect Biology & Diversity. Daly H. V., J. T. Doyen & P. R. Ehrlich (1981): International Student Edn. McGraw Hill , Kogakusha, Japan.

4. Insects: Textbook of Entomology, Evans E. H. (1984): Addison – Wesley, London.

5. Insects Physiology, Henning W. (1981): Wiley – Innerscience Publ., John Wiley & Sons, Chichester, England.

6. Journal and Internet resources

ZOO/DSE/-513

Endocrinology-I

Total no. of credits- 3

No. of periods per credit- 15

Total No. of contact hours -45

Evaluation: External-60%, Internal-40%

Course objective :

1. To learn the basic information of the various endocrine glands/tissue, particularly in invertebrates
2. To learn the neuroendocrine system and their hormones.
3. To learn physiological interaction of endocrine hormones and their regulation by environmental factors in invertebrates.

Learning Outcome

1. The student will understand the basic structure of endocrine glands in invertebrates.
2. The students will learn the structure of neuroendocrine gland and their hormones.

Unit-I Endocrine mechanisms in Annelida

1. Neuroendocrine system in annelids.
2. Growth and regeneration in Polychaetes.
3. The control of epitoky and relationship between gametogenesis and epitoky.
4. Growth and reproduction in Oligochaetes.
5. Endocrine control of gametogenesis in polychaetes.

Unit-II Endocrine mechanism in Mollusca.

1. Neurosecretion in Lamellibranches.
2. Hormones and reproduction in Gastropoda.
3. Hormones and reproduction in Cephalopoda.
4. Role of hormones in osmotic and ionic regulation in Gastropoda.

Unit-III Endocrine mechanism in insecta.

1. Neuroendocrine system in insecta.
2. Role of hormones in growth and metamorphosis in insects.
3. Moulting in adult insects and mode of action on developmental hormones in insects
4. Reproductive system and endocrine control of oocytes development in insects.

Unit-IV Endocrine mechanism in Crustacea

1. Neuroendocrine system in crustacea
2. Moulting cycle and role of hormones in moulting in crustacean.
3. Sexual differentiation and role of hormone in gonadal activity in crustacean.
4. Colour change and its hormonal control in crustacean.

Unit-V Neuroendocrine mechanisms in Echinodermata.

1. Histomorphology of radial nerve neurosecretory system in starfish.
2. Neurosecretory hormones and control of reproduction in Echinodermata.
3. Hormone types and their chemical nature in echinoderms.

References

1. Highnam K.C. and Hill L: The comparative Endocrinology of Invertebrates.
2. Adiyodi and Adiyodi: Reproductive Biology of invertebrates Vol. I & II.
3. Lauffer H. and Downer R.C.H. Endocrinology of selected invertebrates Types.
4. Journals and Internet resources.
5. Boolootian R.: Physiology of Echinodermata.

Reference Book

1. Patil Meena: Neurobiology and Electrophysiology of Decapod.
2. Crustacean Lockwood ,A.P.M. : Aspects of Physiology of Crustacea.
3. Novak, U.J.A. : Insect hormones.
4. Rock stein M. : The physiology insect Vol.I.
5. Wilbur K.M. and Young ,C.M. Physiology of Mollusca Vol.I and II Mill P.J. Physiology of Annelida.

ZOO/DSE/-508

Practicals based on ZOO/DSE/507 (Helminthology I)

1. Examination and survey of host(vertebrates) for parasitic collection
2. .Collection of trematodes and cestodes from various host.
3. .Preservation, staining and mounting of collected trematodes & cestodes and preparation of their permanent slides (At least 10 from cestodes and 10 from trematode).
4. Identification of parasites from the prepared slides.
5. Study of different trematode and cestodes from permanent slide (At least 10 from cestodes and 10 from trematode).
6. .Study of hold fast organs in helminths.
7. Examination of fecal samples for ova.
8. Study of different larvae of helminth parasites (from permanent slides)
9. .Collection and examination of molluscan hosts for larvae of trematode.
10. .Study of effect of helminth parasites(histopathology) on the host tissue
 - a. micro technique.
11. Submission: At least five permanent slides to be submitted at the time of practical examination.

ZOO/DSE/-510

Practical based on ZOO/ DSE /-509

Protozoology-I

1. Collection, observation in living condition-fixation, staining and identification of protozoa from different habitats.
 - a. Marine Protozoa
2. Collection, observation in living condition-fixation, staining and identification of Planktonic protozoa.
3. Collection, observation in living condition-fixation, staining and identification of Soil protozoa.
4. Study of population density of ciliates in fresh water.
5. Study of ecological factors in relation to freshwater ciliates.
 - a. Oxygen b. Carbon dioxide
 - c. pH .d. Oxidized organic matter
6. Study of different protozoans
7. Study of cyclosis in Paramecium.
8. Study of contractile vacuole to observe excretion and osmoregulation.
9. Submission of slides.

ZOO/DSE/-512

Practical based on ZOO/ DSE /-511 Entomology-I

1. Study, mounting and sketching of types of mouth parts, antennae
2. Study, mounting and sketching of wings, legs.
3. Study, mounting and sketching of genitalia of various insects.
4. Dissections of Digestive system of five available/ at least 3 insects.
5. Dissections of Reproductive system of five available/ at least 3 insects.
6. Dissections of Nervous system of five available/ at least 3 insects.
7. The Study and preparation of permanent slides of any five organs of at least 2 insects.
8. Estimation of enzyme activities of Amylase, Invertase, Lipase & Protease in the alimentary canal / midgut of cockroach.
9. Detection of uric acid as an end product of excretion in any terrestrial insect.
10. Study of types and Total count of haemocytes in haemolymph of any one insect.
11. Determination of role of insect hormones in the pupation of insect larvae by ligature technique.
12. Study of eggs, larvae and pupae / nymph of any one insect.

ZOO/DSE/514

Practical based on ZOO/DSE/513 (Endocrinology-I)

1. Histomorphological study of neuroendocrine system in various invertebrates (Annelids, Mollusca Arthropoda etc) (At least 10 Slides)
2. Dissection of nervous systems in different invertebrates (Leech, Crab, Cockroch. etc)
3. Histological preparation of slides of neuroendocrine centers (at least 5)
4. Effect on brain removal on oxygen consumption in leech.
5. Effect of background on integument chromatophores of the freshwater prawn, *Caridina/Macrobachium*.
6. Effect of eyestalk removal on oxygen consumption of freshwater crab/prawn.
7. Effect of eyestalk removal on blood glucose level in crab/prawn.
8. Effect of eyestalk removal on chromatophores in relation to background adaptation in *Cariadina/Macrobacrium*

ZOO/RM/-515

RESEARCH METHODOLOGY

Total no. of credits – 4

No. of periods per credit – 15

Total No. contact hours – 60

Evaluation: External – 60%, Internal – 40%

Objectives:

- To understand some basic concepts of research and its methodologies
- Identify appropriate research problem and parameters
- Prepare a project proposal
- To organize and conduct research in a more appropriate manner
- Write a research report/ proposal and thesis.

UNIT I

I. Science / Life Sciences and concept of Research

Basic concepts-Knowledge, Information and Data-Science, Pseudoscience. Life Science-Definition, Laws, Characteristics. Scientific temper, Empiricism, Rationalism and Units of measurements. Basic concepts of research -Meaning, Objectives, Motivation and Approaches. Types of Research (Descriptive /Analytical, Applied/ Fundamental, Quantitative/Qualitative, Conceptual/ Empirical. Research methods versus Methodology, Research and scientific method. Research Process.

II. Research Formulation and design

Research formulation -Observation and Facts, Prediction and explanation, Induction, Deduction. Defining and formulating there search problem, Selecting the problem and necessity of defining the problem. Literature review-Importance of literature reviewing in defining a problem, Critical literature review, Identifying gap areas from literature review.

Hypothesis -Null and alternate hypothesis and testing of hypothesis -Theory, Principle, Law and Canon. Research Design-Basic principles, Meaning, Need and features of good design, Important concepts. Types of research designs. Development of are search plan-Exploration, Description, Diagnosis, Experimentation, determining experimental and sample designs. Data collection techniques.

III. Scientific Documentation and Communication

Scientific writing begins with a question. Scientific writing in computer age, Communication channels – informal and formal, compilations, Use of internet, Difference between subject directories and search engines, emails, Use of word processing to write more effectively, Revising with word processors. Writing of the first draft- Content, matters dealing with authorship, copy right. Standard structure- Introduction, Materials and Methods, result, Discussion and conclusion. The title, references, Abstract and summary. Title page, key words, and acknowledgement. Project proposal writing, Research report writing (Thesis and dissertations, Research articles, Oral communications). Presentation techniques - Assignment, Seminar, Debate, Workshop, Colloquium, Conference.

VI. Information Science, Extension, Ethics and Text , Tables and English language

Sources of Information -Primary and secondary sources. Library-books, journals, periodicals, reference sources, abstracting and indexing sources, Reviews, Treatise, Monographs, Patents. Internet-Search engines and software, Online libraries, e-Books, e-Encyclopedia, TEDTalk, Institutional Websites. Intellectual Property Rights - Copy right, Designs, Patents, Trademarks, Geographical indications.

Safety and precaution-ISO standards for safety, Lab protocols, Lab animal use, care and welfare, animal houses, radiation hazards.

Extension: Lab to Field, Extension communication, Extension tools. Bioethics: Laws in India, Working with man and animals, Consent, Animal Ethical Committees and Constitution.

References

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Class: M.Sc. First Year , Semester: II Semester Subject: -Zoology

ZOO/MJ/-550

Genetics and Bioinformatics

Total no. of credits – 3

No. of periods per credit – 15

Total No. of contact hours – 45

Evaluation: External – 60%, Internal – 40%

Learning Objectives:

- To understand basic unit cell and the molecular biology of the cellular function.
- To understand the protein secretion and sorting within the cell and laws of cell division and their regulation.
- To understand the central dogma of molecular biology.

Learning Out come

- The student will learn about the cell and cellular function at molecular level.
- The student will learn about the protein secretion, sorting and arranging the protein to different cell organelle.
- The student will learn in detail the central dogma of molecular biology in Prokaryotes and Eukaryotes.

GENETICS

UNIT 1: Molecular organization of chromosomes.

- Genome size and C -value paradox,
- Structure of eukaryotic chromosomes- nucleosome model,
- Chromosome condensation, - euchromatin and heterochromatin,
- Repetitive nucleotide sequences in eukaryotic genomes.
- Kinetics of renaturation, Cot and Cot curve repetitive sequences.
- Mini and micro satellites, Molecular structure of centromere, and telomere.
- Polytene chromosome and lampbrush chromosome.
- Chromosome banding techniques.

UNIT II: Gene Fine structure

- Evolution and concept of gene function and structure.
- The definition of gene. The standard genetic code, redundancy and wobble.
- DNA structure- alternate forms of Double Helix,
- Gene Synthesis (in vitro synthesis) – works of Khorana and Kornberg, Modern finding on the nature of gene.
- Interrupted genes in eukaryotes, Exons and Introns -R loops, significance of introns.
- Genes within genes (overlapping genes) Bacteriophage phi X174.

- Transposable elements in Bacteria-IS elements, Composite transposons, Tn3 elements, medical significance.
- Transposable elements in Eukaryotes - P elements, Retro-transposons, Significance of transposons.

UNIT III:

- Extension of Mendellian principles;
 - a. incomplete dominance,
 - b. co- dominance.
 - c. Multiple alleles
 - d. Linked genes
 - e. Gene action, - penetrance and expressivity,
 - f. gene interactions- epistasis, pleiotrophy, genomic imprinting, phenocopy.
- Chromosome theory of heredity, Linkage and recombination of genes in a chromosomes,
- Crossing over as the physical basis of recombination, Stern's Experiments;
- Molecular mechanisms of recombination (Holliday model), Gene conversion,
- Recombination mapping with two point and three point test cross in *Drosophila*. Coincidence and interference.

BIOINFORMATICS

Unit IV: Scope and Data bases

- Bioinformatics, scope and applications.
- Biological data bases- Primary data bases
- Nucleotide sequence data bases; Gen Bank , EMBL, DDBI ; DDBJ;
- Protein sequence data base, SWISSPROT, PIR,;
- Structure data bases; PDB,NDB;
- Secondary data bases,; PPROSITE,PFAM,CATH;
- Composite databases, OWL; Literature data base;
- Pub Med; Data base searching – Entrez; Database sequence submission-BankIt.

Unit V Sequence analysis

- Types of sequence alignment,
- Methods of sequence alignment,
- Scoring schemes,
- Gaps and gap penalties,
- Construction of phylogenetic trees.
- Structural genomics, functional genomics, comparative genomics,
- Data mining in proteomics, Microarray, significance of proteomics and drug design.

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Bioinformatics

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- Krane, D.E. and M.L. Raymer. 2006. *Fundamental concepts of Bioinformatics*. Pearson Education, New Delhi
- Lesk A. M, 2005. *Introduction to Bioinformatics*. Oxford Press, New Delhi
- Pengcheng Fu and Sven Panke, (Eds.) 2009. *Systems Biology and Synthetic Biology*. John Wiley & Sons, Inc. NJ, USA
- Tisdall J. D, 2001. *Beginning Perl for Bioinformatics*. O'Reilly Media Inc. CA, USA
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ZOO/MJ/-551

Cell and Molecular Biology

Total no. of credits – 3

No. of periods per credit – 15

Total No. of contact hours – 45

Evaluation: External – 60%, Internal – 40%

Learning Objectives:

- To understand basic unit cell and the molecular biology of the cellular function.
- To understand the protein secretion and sorting within the cell and laws of cell division and their regulation.
- To understand the central dogma of molecular biology.

Learning Out come

- The student will learn about the cell and cellular function at molecular level.
- The student will learn about the protein secretion, sorting and arranging the protein to different cell organelle.
- The student will learn in detail the central dogma of molecular biology in prokaryotes and Eukaryotes.

Unit 1 Introduction of cell:

A. Cellular Organelle: Structure and function in detail of the following

1. Cell wall (Gram positive and Gram negative)
2. Plasma membrane
3. Endoplasmic reticulum
4. Ribosomes (Subunits in prokaryotes & eukaryotes)
5. Golgi bodies,
6. Lysosomes,
7. Peroxisomes,
8. Mitochondria: (Oxidative phosphorylation and Chemiosmotic theory)
9. Nucleus and Nucleolus.

B. Cytoskeleton

1. Intermediate filaments,
2. Microtubules,
3. Actin filaments,
4. cilia and centrioles,
5. Organization of cytoskeleton.

C. Cell- cell communication:

1. Cell junctions and its types
2. extracellular matrix,
3. Cell adhesion,

4. cell matrix adhesion,
5. collagen the fibrous protein of the matrix,
6. non collagen components of the extra cellular matrix.

UNIT II:

D. Cell growth and Division

1. Overview of the cell cycle and its control,
2. The molecular mechanism for regulating mitotic and meiotic events,
3. Amitosis,
4. cell cycle control, Checkpoints in cell cycle regulation.

E. Cell to cell signaling,

1. overview of the extracellular signaling,
2. Identification of cell surface receptors,
3. G- protein coupled receptors, and their effectors,
4. second messengers,
5. enzyme linked cell surface receptors,
6. interactions and regulation of signaling pathways.

UNIT III :

F. Chromosome structure – in prokaryotes and eukaryotes

G. Chromatin structure-

1. The Nucleosome Model –
2. Histones, Non histones proteins ,
3. euchromatin, heterochromatin, (Lyon hypothesis (X Chromosome inactivation)
4. constitutive and facultative heterochromatin,

H. Regulation of chromatin structure

1. Structure of DNA
2. Replication of DNA-
3. Prokaryotes DNA replication.
4. Eukaryotic DNA replication.
5. Mechanism of DNA replication,
6. Enzymes and accessory proteins, involved in DNA replication,

UNIT IV : Transcription

I. Prokaryotic transcription :

1. Regulation in Prokaryotes – Lac operon
2. Initiation, elongation, and termination of transcription

J. Eukaryotic transcription

1. General and specific transcription factors,
2. Regulation in Eukaryotes
3. Initiation, elongation, and termination of transcription,
4. capping, polyadenylation, Splicing, editing,
5. mRNA stability,
6. RNA interference,

K. Translation :

1. Genetic code

L. Prokaryotic Translation :

1. special features of Prokaryotic translation.
2. The translation machinery: Initiation , elongation and termination
3. Polyribosomes

Unit V:**M. Eukaryotic translation**

1. The translation machinery: mechanisms of chain initiation, elongation, and termination,
2. regulation of translation
3. co and post translation modifications of proteins,

N. Protein targeting :

1. Translational modifications in the ER,
2. Protein sorting in the Golgi bodies,
3. Traffic in the endocytic pathways,
4. Exocytosis.
5. Protein synthesis and targeting of-
 - a. Secretory proteins
 - b. mitochondrial proteins

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- Watson,J.D.,Baker,T.A.,Bell,S.P.,Gann,A.,Levine,M.andLosick,R.2009.*MolecularBiology of the Gene*.Pearson.

ZOO/MJ/-552

Immunobiology

Total no. of credits – 3

No. of periods per credit – 15

Total No. of contact hours – 45

Evaluation: External – 60%, Internal – 40%

Learning objectives:

1. To inculcate knowledge about immunobiology
2. To understand the aspects of human immunology such as antigens, antibodies, B and T lymphocytes and different cells of the immune system
3. To extend the knowledge about immune systems of the body and immune system in invertebrates and their association with vertebrate system

Learning outcome

By the end of the course students will be able to :

1. Explain the tissues, cells and molecules involved in host defense mechanisms
2. Understand the types of immunity, interaction of antigen, antibodies, complement and other immune components.

UNIT I: Innate immunity

1. Barriers that provide immunity

- Physical,
- Physiological barrier- Anatomic and chemical basis of inflammation
- Cellular barrier – different types of cell involved in innate immunity
- Cytokines

2. Types of molecular patterns on pathogen

- DAMPs
- PAMPs

3. Pattern recognition receptors : Structure and types.

- **Toll-like receptors (TLRs)** - TLR-4 Recognition, Bacterial Lipopolysaccharides (LPS), Activation of NF κ B, AP-I, and IR5 Transcription factors by TLRs.
- **-NOD Like Receptors** as sensors and Bacterial infection and cellular damage, NLRP in cell death and inflammation
- **-RIG Like receptor** in type-1 Interferon production and Proinflammatory cytokines.

UNIT II : Adaptive Immunity:

- **Components of adaptive immune system:**
- **Organs of immune system**
- **Cells of immune system** Lymphoid cells, Myeloid cells
- **Mechanism of adaptive immunity :**
 - Primary immune response

- Secondary immune response -- Humoral immune response, cell mediated immune response

- **Characteristics of Adaptive Immunity:**

- Antigenic Specificity
- Diversity
- Immunologic memory
- Self/non-self recognition

UNIT III : Antigen recognition by B cell and T cell Receptor :

- Structure and function of typical antibody molecules,
- Structure and function of T-Cell receptors
- antigen antibody interaction
- antigen recognition by B cells
- Antigen recognition by T-Cells,
- activation and differentiation of B cells and T cells
- Antigen Processing and presentation

UNIT IV : Development of Immune cells

- Development of B and T lymphocyte,
- Receptor diversity in B and T lymphocytes
- Primary immunoglobulin gene rearrangement,
- T-cell receptor gene rearrangement,
- Structural variation in immunoglobulin constant regions.
- Positive and negative selection of T cells
- Major Histocompatibility Complex and its function.

Unit V : The immune system in health and diseases

- Immunodeficiency diseases ,
- Evasion and subversion of immune defenses
- Non IgE and IgE mediated allergic defenses and effector mechanism
- Non IgE mediated allergic diseases
- Autoimmune disease and pathogenic mechanisms
- Transplant rejection

Reference book:

1. Kuby Immunology -RA Goldsby ,Kinote TJ,Osborne BS,4th Ed.W.H Freeman and company,New York.
2. Janeways Immunobiology-Murphy,K.Weaver,C. 9th Ed. Garland and Science.Taylor and Francis Group.
3. Text book of immunology-Riott
4. Fundamental Immunology -Coleman, Lombard, Sicard Wm Brown Publishers.
5. Understanding Immunology-Peter wood .Pearson Education.

PRACTICALS

ZOO/MJ/-553

Practical based on ZOO/MJ/-550 Genetics and Bioinformatics

Genetics and Bioinformatics (Any 8)

1. Determination of blood groups and suggestions on Medico legal problems regarding the parentage disputes using blood groups.
2. Problems based on interaction of genes
3. Culture of *Drosophila melanogaster* and study of its life cycle stages
4. Mutant studies in *Drosophila*.
5. Identification of blood group, a case study of multiple alleles.
6. Chironomous larva – Giant Chromosomes
7. Study of gene frequency using PTC tests (taster and non – tasters)
8. database search and data retrieval-using NCBI, SWISS-PROT, PDB, Expasy.
9. Methods of sequence alignment-BLAST and Clustal W.
10. Phylogenetic tree using PHYLIP.
11. Gene Prediction using GENSCAN/GRAI.
12. Protein structure visualization using RASMOL.

ZOO/MJ/-554

Practical based on ZOO/MJ/-551 Cell and Molecular Biology

1. Preparation of different cell types as hepatocytes/ parenchymal cells
2. Study of tumor and cancerous cell (Use permanent slides)
3. Study of Stages of Mitosis (permanent slides)
4. Study of Stages of Meiosis (permanent slides)
5. Squash preparation of grasshopper testis to study meiotic stages.
6. Determination of mitotic index in the squash preparation of onion root tip. Effect of drugs on cell division (Colchicine or any other inhibitor)
7. Study of mitochondria by vital staining technique.
8. Fulgen reaction- Staining of DNA.
9. Micronuclei test.
10. Induction of puff and study of puffing pattern.
11. Study of polytene chromosomes.
12. Preparation of Microtome section, spreading.
13. Histochemical staining of carbohydrates (PAS), Protein (Bromophenol blue), lipids (Sudan Black), DNA (Fuelgen stain).

ZOO/MJ/-555

Practical based on ZOO/MJ/-552 Immunobiology

1. To study the immunological techniques. (Cell culture, ELISA, Flow cytometry)
2. To study the different cells of immune system (by permanent slide/charts)
3. To determine the blood groups of given blood samples by slide agglutination, technique.
4. Blood group antigen and research system
5. Blood cell count
6. To perform double immunodiffusion (DID) by using Outherlony's method.
7. To carry out Immuno-electrophoresis..
8. To determine haemocytes from cockroach hemolymph.
9. To determine the activity of Phenol oxidase in haemolymph of cockroaches
10. To study the immunodeficiency diseases.

Practical.

ZOO/MJ/-556- Skill/ Advance technique

ZOO/DSE/-557

Helminthology-II

Total no. of credits – 3

No. of periods per credit – 15

Total No. of contact hours – 45

Evaluation: External – 60%, Internal – 40%

Learning Objectives: This course is designed to teach students

Basics information & major types of important helminth parasites(Animal & plant Nematodes).
To understand the phylogeny, the biology and applied aspects of helminthes parasites in disease and plant parasites.

Students will develop the ability to collect, identify important Nematodes and Plant Nema from locally available hosts.

To prepare the experts in the field of Nematology.

The role of helminthes parasites in burden of disease.

Learning Out come

The student will learn about the phylogeny , and importance of the helminthic parasites in control of disease.

The student will learn and understand how helminthes survive in human body by manipulating the surface coat.

The student will learn the skill to identify the plant nematodes and control measures in agricultural productivity.

UNIT-I

1. General organization of Animal nematodes.
- 2 Phylogeny of the nematodes and related groups. .Burden of helminthes disease worldwide and in India. Economic importance.
- 3 Nematode ultra structure – Body wall of nematodes: cuticle, Epicuticle (Hypodermis), muscle layer, Hydrostatic skeleton, Nervous system.

Cephalic sense organs : Amphids, labial and cephalic papillae, Structure of lips and cephalic papillae. Caudal sense organs– caudal papillae, plasmids. Spicules.

UNIT- II Digestive system – the stomodeum (foregut), The intestine (midgut), the Proctodeum (hind gut), Structure of stoma, its variations on esophagus and its associated glands.

Feeding and nutrition in Nematodes. Essential foods, blood feeding by Hookworms and other nematodes.

Secretary / excretory system,

Reproductive system in male, female, fertilization, development and hatching of eggs.

Moulting and Development in nematodes.

UNIT- III

1. Different life cycle patterns in Nematodes.
2. Morphology, life cycle, pathogenicity, Epidemiological biology, clinical pathology, immune response, diagnosis, treatment, pharmacotherapy, immunotherapy control and prevention of following types.

- a. *Strongyloides stercoralis* b. *Wuchereria bancrofti*
 c. *Trichinella spiralis* d. *Trichuris trichura*

Unit IV Nematodes as plant parasite,

- 1 Introduction , General organization and Outline classification of plant parasitic Nematodes.
2. Feeding habits and modifications in anterior region.
- 3 Reproductive systems of plant parasitic nematodes .
4. Ecology of nematodes population dynamics, the threshold levels, nematode survival

UNIT-V

1. Symptoms of damages caused by nematodes, nematode injuries to plants (above ground. below ground)
2. Controlling nematode diseases of plants (Cultural, biological, chemical, physical, legislative)
3. Life cycle studies of followings ---
 a. Root knot Nematodes (*Meloidogyne*) b. Citrus Nematodes (*Tylenchulus*) c. Bud and leaf Nematodes (*Aphelenchoides*) d. Seed gall Nematodes (*Anguina*)

References

1. Bird AF, Bird J (1991) The structure of nematodes, vol 2. Academic press, San Diego
2. Blaxter ML, Robertson WM (1998) The cuticle. In: Perry RN, Wright DJ (eds) The Physiology and biochemistry of free-living and plant-parasitic nematodes. CAB International, New York, pp 25–48
3. Gardner S (2001) Worms, Nematoda. In: Levin SA (ed) Encyclopedia of biodiversity. Academic Press, University of Nebraska, Lincoln
4. Lewbart G (2011) Nematodes, Nervouse system In: Invertebrate Medicine, 2nd (edn). John Wiley & Sons
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6. Mehlhorn H (2016) Encyclopedia of parasitology, vol 3. Kluwer Academic Publishers, Great Britain
7. Mehlhorn H (1988) Parasitology in Focus . Springer –Verlag , Berlin.
8. Brown, R.H. and Kerry, B.R (1987). Principles and practice of Nematode control in crops. Academic Press, Sydney.
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12. Stirling, G.R. (1991). Biological control of plant-parasitic nematode CAB International Slough, U.K.
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14. Sood Pannik (1993) Parasitology (Protozoology and Helminthology) - CBS Publication and Distribution, Delhi.
15. Hiware, Jadhav and Mohekar Applied Parasitology
 Solbsy E.J.W(1982) Helminth, Arthropod and Protozoa of domesticated animal , London
- 16 Parasitology - Nobel and Nobel
18. An introduction to Nematodology - Chitwood
19. Organization and Biology of nematodes -Crool
20. Physiology of nematodes - Lee
21. Plant parasitic nematode - Parmonove
22. Principal of Nematodology - Throne
23. Plant Nematodology - Jenkins and Taylo

ZOO/DSE/-559

Protozoology II

Total no. of credits – 3

No. of periods per credit – 15

Total No. of contact hours – 45

Evaluation: External – 60%, Internal – 40%

Learning Objectives:

1. To understand the genetics, nutritional and parasitic adaptation in human or in other vertebrates.
2. The students will also study the geomedical aspects of protozoan's.

Learning outcome:

1. The student will understand the genetics, and the nutritional requirements and general Organization of protozoan's.
2. The students will understand the genetics of the common parasites like trypanosomes and Plasmodium.
3. The student will learn about the metabolic adaptation.

UNIT I

Genetics of protozoa

Trypanosome- diploidy and sexual stages, chromosome number, survival in blood stream by coat changing. (Shedding). Molecular structure of the surface coat. Mechanism of variable surface glycoprotein et VSG)

Plasmodium: Chromosome size. Diploid and haploid stages, and meiosis, chromosome size polymorphism. Evolutionary relatedness of plasmodium sp by comparative DNA analyses. Importance of cloning genes for surface proteins. Cloning of genes, encoding the circum sporozoite protein.

UNIT II Geo medical aspect of parasites

1. Factors influencing the distribution of protozoa.

Climatic and Atmospheric factors, - temperature, humidity, precipitation, and irradiation, and Edaphic Otherfactors-Oxygen, Carbon dioxide, pll, Light, Food, Nutrition

2. Immunity to protozoan parasite-Host reaction, Innate and acquired defense mechanism: Antigen of zooparasites

UNIT III General organization

1. General organization and morphology of the parasitic flagellates occurring in digestive tract of man, i. Retortomonas intestinalis ii. Chilomastix mesnili, ii. Giardia lamblia iv. Trichomonas tenax
2. General organization of the Microspora – Structure of the spore, life cycle of Nosema, Diseases Caused by microspora in fishes and Arthropods.
3. General organization of the Myxospora – structure and development of the spore, Life cycle of Myxobolus, disease caused by Myxospora in fishes. 4 General morphology, life cycle,

transmission and pathology of parasitic Amoebae of man and domestic animals. i. Entamoeba histolytica ii. E gingivalis

UNIT-IV

1. Structure and life cycle pattern of acephaline and cephaline Gregarines.
2. Coccidia of poultry with special reference to the structure, treatment and control. 3. Parasitism, in ciliophora-structure, Life cycle. Pathogenesis and control of
 - I. Balantidium coli
 - II. Ichtiophtherius multifilis

UNIT V

Nutrition in Protozoa

Preferred substrate glucose, aquciation of amino acids, Metabolism in parasitis protozions.

Bioenergetics and the role of oxygen.. energy metabolism in kinetoplastid flagelletes, Aerotelereant Anaerobic protozoans, Malarial parasites.

Reference Books:

1. Mehlhorn H (2008) Encyclopedia of parasitology, vol 3. Kluwer Academic Publishers. Great Britain
2. Mehlhorn (2016) Encyclopedia of parasitology, vol 3. Kluwer Academic Publishers, Great Britain
3. Mehlhorn H (1988) Parasitology in Focus Springer-Verlag. Berlin.
4. S.V.Nikam,T.T.Shaikh ,Protozoology , Oxford publication.

ZOO/DSE/-561

Entomology II

Total no. of credits – 3

No. of periods per credit - 15

Total No. of contact hours – 45

Evaluation: External – 60%, Internal – 40%

Course Objective:

1. To develop a strong foundation in entomology, including understanding of the importance of insects to human society.
2. To familiarize the students with identification of insect pests, vectors and their control methods.
3. To introduce the students with entomological cottage industry.
4. To develop a sufficient background for those students who wish to study more advanced entomological topics.

Unit I: Phylogeny and Classification of Insects

1. Classification of Apterygota orders up to families – Thysanura and Collembola
2. Classification of Pterygota orders up to families – Exopterygota – Odonata, Orthoptera, Mallophaga, Anoplura, Isoptera and Hemiptera.
3. Classification of Pterygota orders up to families – Endopterygota – Coleoptera, Hymenoptera, Neuroptera, Lepidoptera and Diptera.

Unit II: Insect as pest and Vectors

1. Concept of pest: Origin of pest, Classification of Pests.
2. Insect pests of Jowar, Cotton, Sugarcane, Soybean, Vegetables, Fruit Crops, Stored grains, structural pests.
3. Insects as vectors of human pathogens and domestic animals,
4. Study of insect vectors like mosquito, bed bug, flea, body louse, rat flea etc.

Unit III: Principles of insect pest control

1. Chemical control: mode of action of insecticide, merits and demerits of chemical control

2. Modern trends in pest control
3. Biological control: Principles, procedure, Biological agents; success and limitations.
 - ii. Autocidal Control – sterile male technique, genetic technique, the pheromonal technique
 - ii. Integrated pest management (IPM) Principles and application.

Unit IV: Sericulture and Lac Culture

1. Mulberry silkworm: life history, silk glands and silk production, silkworm diseases.
2. Lac Culture: Biology of lac insects, lac cultivation and economic importance of lac.

Unit V: Apiculture and Importance of insects

1. Types of honey bees, life cycle, social organization and economic importance of honey wax and apiary products.
2. Other important insects – Insects as pollinators, Insects in research, Butterfly farming, Insects in forensic entomology.

References

1. Applied Entomology, Vol. 1 2nd Edition. (1996). K.P. Srivastava, Kalyani Publishers, New Delhi.
2. Applied Entomology, Vol. 2 2nd Edition, (1996). K.P. Srivastava, Kalyani Publishers, New Delhi.
3. Modern Entomology (2009), D.B. Tembhare, Himalaya Publishing House, Delhi.
4. General and Applied Entomology. 2 edition (2004). David. B.V. and Ananthkrishnan, T.N. Publisher Tata McGraw Hill, New Delhi.
5. General Entomology. 2nd edition (1973) Mani M.S. Oxford & IBH Publishing Company, New Delhi.
6. Applied Zoology, Dr. Waykar B.B., Prashant Publication, Jalgaon.

Reference Books:

1. Applied Entomology, 2nd edition, P. G Fenemore. Alka Prakash, Publisher: New Age International.

ZOO/DSE/-563

Endocrinology- II

Total no. of credits – 3

No. of periods per credit - 15

Total No. of contact hours – 45

Evaluation: External – 60%, Internal – 40%

Course Objective:

- The students will learn about vertebrate hormones and their actions in vertebrates.
- The student will learn about hypothalamic pituitary axis and the various hormones released, their role in sex determination.
- The student will learn about the male and female reproductive endocrinology
- The students will learn about other hormones secreted by other organs- like stomach, intestines, pancreases, etc.

Learning Out come

- The students will understand about the various hormones in vertebrate and their origin and roles.
- The students will understand the role of male and female reproductive hormones.
- The students will understand the hormonal actions and other hormones involved in metabolism and homeostasis.

Unit - I The vertebrate endocrine system

Classes of hormones. Hormone synthesis and control – a general concept. General mechanisms of hormone action. Termination of hormone action. Hormone circulation and metabolism. Plasma membrane hormone receptors, second messengers of hormone action, receptor signal transduction, Multiple membrane messengers, Eicosanoids and hormone action, Cytosolic hormone receptors. Sex determination, differentiation of male and female gonads. Development and differentiation of genital ducts. Gonadal hormone synthesis. Gonadal steroids and brain differentiation.

Unit -II Hypothalamus and Pituitary gland

Structure of Hypothalamus and hypophysiotropins and their functions in brief. Control of Hypothalamo-hypophysial hormone secretion. Histomorphology of pituitary gland, hormones and their functions. Neurohypophysial hormones and their functions. Pars intermedia and role melanotropic hormones.

Hormones of pituitary, - families of pituitary hormones, Growth hormones, prolactin, The glycoprotein hormones, Pro-Opiomelanocortin and melanocortins, Neurophysical hormones, Hypophysiotropic hormones, - thyrotropins releasing hormones, - thyrotropin – releasing hormones, Gonadotropins releasing hormones, (GnRH), corticotropin releasing hormones (CRH) Prolactin release inhibiting Factor (PIF) , prolactin releasing factor (PRF) , MSH – release inhibiting Factor (MIF).

Neurophysical hormones - oxytocin, vasopressin, vasotocin, mode of action, Melanotropic hormones. Control of MSH secretion, - dopaminergic control, Physiological roles.

Unit - III Reproductive Endocrinology

Female Reproductive endocrinology. Pregnancy, Parturition and Lactation mechanisms

Anatomy of female reproductive system and histology of ovary, ovarian cycle and its hormonal control.

Ovarian steroid hormones and their physiological functions. Menstrual cycle in primates and its hormonal basis. Estrus cycle in rat and its hormonal basis. Role of hypothalamic, pituitary and ovarian hormones in pregnancy in mammals. 3. Hormonal mechanism in parturition in mammals. Hormonal mechanism in lactation mammals. Menopause.

Unit - IV Male Reproductive Endocrinology ;

Anatomy of male reproductive system, histology of testis, spermatogenesis; hormones of testis and their functions. Endocrine control of testicular function, GnRH and Pituitary gonadotropins- inhibin, prolactin, Role of androgens, , Spermatogenesis . Estrogen – physiological roles, fertility , male behavior, Epiphyseal fusion , cardiovascular functions.

Unit V : Hormones in homeostasis , Gastro intestinal tract, thyroid and adrenal glands.

Hormonal control of – calcium homeostasis . Parathormone, calcitonin, vitamin D.

Gastro intestinal Hormones- Gastrin, Secretin , cholecystokinin(CCK), Gastric inhibiting peptides, Vasoactive Intestinal Peptide (VIP), Substance P , Somatostatin , motilin. Pancreatic hormones – Insulin and glucagon – physiological action. Thyroid hormone and control of thyroid hormone secretion. Adrenal steroid hormones- Glucocorticoids, Mineralocorticoids, Aldosterone, Renin – Angiotensin system. Neurohormones- Endorphins.

Reference book

1. Hadley , M. E (2004) Endocrinology. Pearson education (Singapore)
2. Norman ,AW, Litwerck, G .(1987) Hormones. Orlando ,FL ; Academic press,
3. Larsen PR, Kronenberg ,HM, Melmed ,S and Polonsky , KS (Ed)(2003) Willams Text Book of Endocrinology , 10th . Ed. Philadelphia, Saunders,

ZOO/DSE/558

Practical based on ZOO/DSE/-557 Helminthology-II

1. Collections of Nematodes from locally available animals
2. Basic techniques of preservation and mounting of Nematodes
3. Identification of collected Nematodes
4. Fecal sample analysis for collection and identification of ova.
5. Study of permanent slides of animal nematodes (At least 8).
6. Study of larva.
7. Collection and identification of Phyto nematode.
8. Techniques of collection, fixation, mounting and preparation of permanent slides of phytonemes.
9. Study of permanent slides of plant nematodes.
10. Submission of permanent slides at the time of examinations.

ZOO/DSE/560

Practical based ZOO/DSE/558(Protozoology II)

1. Classification of parasitic protozoa.
2. Study of ciliates in alimentary canal of vertebrates and invertebrates.
3. Impregnation of ciliates with dry silver nitrate for study of kinetic structure.
4. Study of haemoflagellates from vertebrate blood.
5. Preparation of blood smear, staining and identification of staining of haemosporina.
6. Histopathology of host tissue caused by Apicomplexan parasites.
7. Examination of fecal sample of vertebrate host for oocyst of coccidia.
8. Collection of coccidian oocysts by centrifugation method.
9. Observation of oocysts for sporulation.
10. Study of different mosquito vectors of protozoan parasites.
11. Collection of Myxozoa from fishes.
12. Study of binary fission and conjugation in ciliates

ZOO/DSE/-562

Practical Based on ZOO/DSE/-559 Entomology II

1. Collection, preservation, sketching, identification and classification of insects from Marathwada belonging to orders- Thysanura, Collembola, Odonata, Orthoptera, Mallophaga, Anopleura, Isoptera.
2. Collection, preservation, sketching, identification and classification of insects from Marathwada belonging to orders Hemiptera, Coleoptera, Neuroptera, Hymenoptera. Lepidoptera. and Diptera and insects from Marathwada.
3. Identification damage symptoms, and management practices of pests of Jowar. Cotton, Sugarcane, Soyabean,
4. Identification damage symptoms, and management practices of pests of Vegetables, Fruit Crops. Stored grains.
5. Collection and study of parasitic, predatory and biological control agents.
6. Collection and study of pollinator insects,
7. Collection and study of forensic insects.
8. Study of insect vectors like mosquito, bed bug, flea, body louse, rat flea.
9. Study of silk worm - adult, caterpillar, cocoon and types of silk worms.
10. Study of Indian species of honeybee and Study of life cycle of honeybee.

11. Study of Indian species of *Lacifer lacca* and its life cycle stages.
12. Field visit for demonstration of pest damage/Sericulture farm/Apiculture farm.

ZOO/DSE/-564

Practical based on ZOO/DSE/-560 Endocrinology- II

1. *In situ* demonstration of endocrine glands in rat or by demonstration using visual aids.
2. Histological study of endocrine glands in different vertebrate representatives
3. Anatomical studies of reproductive system in and rat
4. Study of estrous cycle in rat
5. Endocrine gland removal in rat- a) Orchidectomy b) Ovaryectomy
c) Adrenalectomy d) Thyroidectomy
6. Effect of thyroxin on oxygen consumption in fish
7. Chromatophores and colour changes in fish (a) Effect of back ground and (b) Effect of MSH injection.
8. Determination of cholesterol in the adrenal gland of rat.
9. Effect of insulin on blood glucose levels in fish / rat
10. Histological techniques : preparation of permanent slides for histological structure of endocrine glands of rat (at least 5 be submitted)

ZOO/OJT/FP/565 –On job training/Field project

