Choice Based Credit System (CBCS)

RAYBURN COLLEGE

(Autonomous, Accredited B++ Grade, 2.96 CGPA out of 4 by NAAC 2023)
Affiliated to M.U: No. MU/1-65/98/CDC/136:07.08.2012.
Recognized by UGC under Section 2(f) & 12(B) of 1956 Act: No.8-29/2015(CPP-I/C):23/04/2015.

DEPARTMENT OF ZOOLOGY

UNDERGRADUATE PROGRAMME

(Courses effective from Academic Year 2024-25)

SEMESTER I

Core Course -I: ZOO 101 - C (Animalia, Non-Chordates I: Protozoa to Nemathelminthes)

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to Animalia, Protista 12 hrs/ 20 marks

General Characteristics of different Phyla of the Kingdom Animalia and Basis of Classification; General characteristics and Classification up to classes for Protista; Study of *Euglena* and *Paramecium.* Life cycle and pathogenicity of *Plasmodium vivax;* Medical importance of protozoans, Mode of Feeding, Locomotion and Reproduction in Protista.

Unit 2: Porifera 9 hrs / 15 marks

Introduction to Parazoa; General characteristics and Classification up to classes; Study of *Sycon* & *Spongilla;* Skeleton & Canal systems in sponges, Economic importance of Sponges

Unit 3: Cnidaria/ Coelenterata, Ctenophora 15 hrs/ 25 marks

Introduction to Metazoa: General characteristics and Classification up to classes; Metagenesis in *Obelia;* Polymorphism in Cnidaria; Morphology & Life Cycle of *Aurelia*; Corals and coral reefs, Structural organization and affinities in Coelenterata. General characteristics and evolutionary significance of Ctenophora.

Unit 4: Platyhelminthes 12 hrs/ 20 marks

General characteristics and Classification up to classes; M o r p h o l o g y , Life cycle and pathogenicity of *Fasciola hepatica, Schistosoma mansoni* and *Taenia solium;* Parasitic adaptations in Platyhelminthes & their medical importance.

Unit 5: Nemathelminthes 12hrs/ 20 marks

General characteristics and Classification up to classes; Morphology, Life cycle and pathogenicity of *Ascaris lumbricoides, Wuchereria bancrofti & Enterobius vermicularis;* Parasitic adaptations in Nemathelminthes

Core Course – I Practical: ZOO 101 - C P

Practical [Credits 2] **30 hrs/50 marks**

1. Study of the whole mounts of *Euglena, Amoeba, Paramecium (including* Binary fission and Conjugation), *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium*/*Adamsia, Pennatula, Fungia, Meandrina, Madrepora, Sycon, Hyalonema, Euplectella, Spongilla, Fasciola hepatica & life cycle stages, Taenia solium and Ascaris lumbricoides*
2. Study of T.S. of *Sycon,* L.S. of *Sycon,*T.S. of *Metridium*/*Adamsi*
3. Examination of pond water collected from different places to observe diversity in Protista
4. Study of adult and its life stages of a Nematode or a trematode (Slides/microphotographs)

5. To submit a Project Report on any related topic on the life cycle of any one parasite of Protist, Nemathelminthes or Platyhelminthes.

Note: Classification of Animals to be followed from "Barnes, R.D. (2006). *Invertebrate Zoology*, VII Edition, Cengage Learning, India"

Examination evaluation Structure:

1. Museum Specimen: 3 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 15 marks
2. Study of Sections (Slides): 1 number/ 3 marks (Identification with reasons = 1 + 2 = 3)
3. Life cycle stages: 1 number /2 marks (Identification with reason : 1+1=2)
4. Project report: 15 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis. III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity), Advances in Animal diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology) Swayam (MHRD) Portal
- ePG Pathshala (MHRD) Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35

Core Course -II: ZOO 102 - C (PRINCIPLES OF CLASSIFICATION, APPROACHES IN TAXONOMY)

Course Content:

Theory [Credits: 4] 60 hrs/100 marks

Unit 1: Taxonomy – Principles, Common terms, taxonomical characters, types and functions; Nomenclature,
International code of Zoological nomenclature and its recent amendments. 12hrs/ 20 marks

Unit 2: Systematics, Zoological Classification – Kinds (Phenetic, Natural, Phylogenetic, Evolutionary & Onmispective), Linnean hierarchy. 12 hrs / 20 marks

Unit 3: Concept of Species – Typological, Biological, Nominalistic, Evolutionary & recognition; Difficulties in the application of different Species concepts. 12 hrs / 20 marks

Unit 4: Taxonomical publications, Taxonomic collection, Techniques of preservation, Process for identification of Specimens. 12 hrs/ 20 marks

Unit 5: Recent trends in modern taxonomy: different approaches (Morphological, Cytological, Biochemical, Numerical, Molecular etc.) 12 hrs / 20 marks

Core Course – I Practical: ZOOI02-C P (Principles of Classification, Approaches in Taxonomy)

Practical [Credits 2] 30 hrs/50 marks

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1. Recent classification of animals with help of museum specimens.
2. Identification of animal species with the help of taxonomic keys, e.g., insect fauna up to order; fish fauna up to families; identification of earthworm etc
3. Methods of taxonomic collection and preservations.
4. Morphological variations in animal phyla.
5. Methods of key preparation
6. Biosystematic position of specimens: 1. Phylum protozoa to echinodermata 2. Cyclostomata to mammals
7. Studies of life cycle and morphology of selected specimens.
8. Morphometric measurements of some available specimens.

Examination evaluation Structure:

1. Museum Specimen: 5 Numbers/each 5marks (Identification =1, Classification= 2, Characters = 2) Total = 25 marks
2. Preparation of Keys from Characters of Selected Specimen provided. (5 marks)
3. Life cycle stages: 2 number /3 marks (Identification with reasons: 1 + 2 = 3)
4. Note Book: 7 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Ernst Mayr (1991): Principles of Systematic Zoology. Tata Mc Graw Hill Publishing Co. Ltd., USA: New Delhi
- Kapoor, V.C (1998): Principles and Practice of Animal Taxonomy. Science Publisher
- Kapoor, V.C (2008): Theory and Practice of Animal Taxonomy. Oxford & IBH Publishing Co. Pvt Ltd
- Blackwelder, R.E. (1967): Taxonomy. John Willey & Sons Inc., New York
- Simpson, G.G. (2012): Principles of Animal Taxonomy, Scientific Publisher (India)
- Dalela, R.C. and Sharma, R.S. (2017): Animal Taxonomy and Museology. Jai Prakash Nath & Co., Meerut

Online Tools and Web Resources:

- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity), Advances in Animal diversity , Systematics and Evolution (https://swayam.gov.in/courses/5300zoology) Swayam (MHRD) Portal
- ePG Pathshala (MHRD)Module 184 of the paper on taxonomy https://epgp.inflibnet.ac.in/ahl.php?csrno=35

Skill Enhancement Course (SEC) - I: ZOO 103 - S (Apiculture)

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit1: Biology of Bees 10 hrs/ 15 marks

History, Systematics and biology of Honey Bees, different species of honey, distribution & occurrence of Honey bees in North East India, Polymorphism, Social Organization of bee colony, behavioural patterns (Bee dance, swarming), Dispersal and foraging methods for Pollen and Nectar collection.

Unit 2: Rearing of Bees 10 hrs/ 15 marks

Apiculture practices, rearing methods, Artificial bee rearing (Apiary), Beehives- Newton and Langstroth; Bee Pasturage; Selection of bee species for Apiculture, Bee keeping equipment,
Methods of extraction of Honey (Indigenous and Modern) and processing; Apiary management- Honey flow period and Lean period

Unit 3: Bee Economy, Diseases and Enemies 3 hrs/ 20 marks

Bee Products (Honey, Bees Wax, Propolis, Royal jelly, Pollen etc.) and their uses; Properties of Honey and economic values, Modern methods in employing artificial beehives for cross pollination in horticultural gardens. Bee diseases, control and preventive measures, Enemies of bees.

Skill Enhancement Course (SEC) Practical - I: ZOO 103 – SP (Apiculture)

Practical [Credit: 2] 30 hrs/ 50 marks

1. Study of the life history of a common honey bee - Egg, larva, pupa, adult (queen, drone, worker) from Photograph or preserved specimen.
2. Study of natural bee hive and identification of queen cells, drone cells and brood
3. Study of morphological structures of honey bee through permanent slides/photographs- mouth parts, antenna, wings, legs (antenna cleaner, mid leg, pollen basket), sting apparatus.
4. Permanent/temporary mount of antenna cleaner, mid leg and pollen basket.
5. Study of artificial hive (Langstroth/Newton), its various parts and beekeeping equipment.
6. Visit to an apiary/honey processing unit/Institute and submission of a report.

Examination evaluation Structure:

1. Identification & Character of Slides/ Specimen: 6 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3)

2. Project report: 15 marks (Subject content, Presentation, Diagrams/Photos)
3. Note Book: 7 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Singh S. (1962): Beekeeping in India, Indian Council of Agricultural Research, New Delhi.
- Mishra, R. C. (1995): Honeybees and their Management in India. Indian Council of Agricultural Research, New Delhi.
- David, B.V. and Anathakrishnan, T.N. (2004): General and applied entomology. Mc Graw Hill education (India) Pvt Ltd., New Delhi
- Davis, B.V. and Ramamurthy, V.V. (2013): Elements of Economic Entomology. Namrutha Publication, Chennai
- Gupta, J. K. (2016): Apiculture, Indian Council of Agricultural Research, New Delhi • Prost, P. J. (1962): Apiculture. Oxford and IBH, New Delhi.
- Rahman, A. (2017): Beekeeping in India. Indian Council of Agricultural Research, New Delhi

Online Tools and Web Resources:

- (https://www.ecornell.com/certificates/beekeeping/master-beekeeping/)
- Beekeeping (https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)
- Swayam (MHRD) Portal Vocational Beekeeping (https://swayam.gov.in/courses/5844-vocational-beekeeping
- Apiculture - an overview/ Science Direct Topics. https://www.Sciencedirect.com

Skill Enhancement Course (SEC) -I: ZOO 103 - S (Aquarium Fish Keeping)

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction, Biology of Aquarium Fish 12 hrs/20 marks

Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fish , biology (Breeding, Feeding economic importance etc.) , sexual dimorphism of Fresh water and marine aquarium fish such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish

Unit 2: Food and Feeding of Aquarium Fish 6 hrs/10 marks

Use of live fish feed organisms (Advantages and disadvantages of live food), Use of formulated feeds, Types of formulated feed, Formulation and preparation of feed, Advantages and disadvantages of formulated feed

Unit 3: Fish Transportation and Maintenance of Aquarium 12 hrs/20 marks Live fish transport (Capture and Pre-transport maintenance, capture and handling techniques); Fish packing and transport (Closed and open transport system, Preparation for packaging, Procedure for packaging, Precautions, Post transport maintenance) General handling techniques. General aquarium maintenance - budget for setting up an Aquarium Fish Farm as a cottage industry.

Skill Enhancement Course (SEC) Practical-I: ZOO 103 - SP (Aquarium Fish Keeping)

Practical [Credit: 2] 30 hrs/ 50 marks

1. Study of different species of Aquarium fish and biology (Breeding, Feeding economic importance etc.) of exotic and endemic fish.
2. Study of sexual dimorphism of fresh water and marine aquarium fish (Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish, Butterfly fish)
3. Type, composition and formulation of fish feed (using Pearson Square Methods)
4. Construction and maintenance of Glass Aquarium and Filter System using indigenous Locally available materials.
5. Monitoring of aquarium water quality (temperature, pH, dissolved oxygen, carbon dioxide, ammoniacal N-load) through titrimetric methods.
6. To write a project proposal for setting up a small aquarium fish keeping as a cottage industry to a funding agency for self-employment of youths or for helping poor farmers; after visiting any farm/enterprise.

Examination evaluation Structure:

1. Identification & Character of Specimen: 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks
2. Monitoring of Water quality : procedure & result – 10 marks
3. Project proposal: 15 marks (Subject content, Presentation, Diagrams/Photos)
4. Note Book: 6 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Dawes, J. A. (1984) The Freshwater Aquarium, Roberts Royee Ltd. London.
- Gunther, A. (1980) An Introduction to the Study of Fishes. A and C. Black Edinburgh.
- Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan publication Corp, India.
- Pandey, K and J.P. Shukla (2013) Fish and Fisheries. Rastogi publication

Skill Enhancement Course (SEC) - I: ZOO 103 - S (Poultry Farming)

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Poultry Industry and Diversified Poultry 12 hrs/20 marks

Importance; present status and future prospects of poultry industry; classification of chicken; introduction to ducks, geese, quails, guinea fowls and turkey; improved varieties of chicken; economic aspects of ratites, emu and ostrich

Unit 2: Feeds additives and formulation 6 hrs/10 marks

Feeds: definition; antibiotics; anti-oxidants-their roles in nutrition; supplements used; good quality feed ingredients, cost, availability, storage, etc.; mixing of feeds, different mills used (Hammer, mixture, pellet); premix preparation, raw materials, feed mill operation.

Unit 3: Scientific Poultry Keeping, Diseases 12 hrs/20 marks

Modern breeding; egg and meat production; hatchery managements; farm equipment for broilers rearing; brooding system; multiple batch system; water and feed management; sanitation litter management; performance indices and records. Diseases – types, symptoms, prevention and control. Vaccination program.

Skill Enhancement Course (SEC) Practical - I: ZOO 103 - SP (Poultry Farming)

Practical [Credit: 2] **30 hrs/ 50 marks**

1. Demonstration of breeds of chicken, Ducks, Geese, Turkeys, Quails, Guinea Fowls, Ratite etc.
2. Nutrient required in poultry name of feed ingredient, nutritive value in term of C.P% and M.E in k.cal/kg of feeds like animal source, plant source synthetic source
3. Estimation of protein in a given sample by Kjeldal flask method.
4. Preparation of feed (Selection of ingredient, feed formulation, grinding, mixing).
5. Faecal sample examination and identification of parasites, isolation of disease causing organism.
6. Project work on Broiler management and report submission.

Examination evaluation Structure:

1. Identification & Characters of different breeds of Poultry birds (live/Photo) : 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks
2. Monitoring of Nutritive value, Protein content: procedure & result – 5 marks
3. Faecal sample examination: Identification of Parasites with reasons & drawing of diagram (1 + 2 + 3 = 6)
2. Project Report: 15 marks (Subject content, Presentation, Diagrams/Photos)
3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Reference Books:

- Nadam, R. (2015): Handbook of Poultry farming and feed formulations. Anmol publications Pvt Ltd.
- Das *et al*. (2021); Text book on Poultry management. Narendra Publishing house **Online Tools and Web Resources: https://www.growelagrovet.com http: //www.asci-india.com https://dahd.nic.in**

SEMESTER II

Core Course -III: ZOO 201 - C (Non-Chordates II: Annelida to Echinodermata, Minor phyla)

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to Coelomates, Annelida 12 hrs/ 20 marks

Evolution of coelom and metamerism. General characteristics and Classification up to classes for Annelida; Digestion, Excretion and Reproduction in Annelida, Trochophore larva – structure & affinities.

Unit 2: Arthropoda 12 hrs/ 20 marks

General characteristics and Classification up to classes, Structural organization in different classes, Mouth parts of Insects, Vision and Respiration in Arthropoda; Metamorphosis in Insects; Social life in bees and termites, Larval forms of Crustacea and Insecta.

Unit 3: Onychophora, Mollusca 12 hrs/ 20 marks

General characteristics and Evolutionary significance of Onychophora, General characteristics and Classification up to classes of Mollusca; Structural organization in Pelecypoda, Gastropoda and Cephalopoda, Respiration in Mollusca; Torsion and detorsion in Gastropoda; Structure and affinities of Neopilina, Pearl formation in bivalves

Unit 4: Echinodermata 12 hrs/ 20 marks

General characteristics and Classification up to classes; Protective mechanisms in echinoderms (Dermal skeleton, evisceration, autotomy); Water-vascular system in Asteroidea; Larval forms in echinoderms.

Unit 5:, Minor Phyla 12 hrs/ 20 marks

Introduction to minor phyla. Distinguishing characters and examples of Nemertinea, rotifera, Acanthocephala, Sipunculida, Echiurida, Bryozoa (ectoprocta), Brachyopoda, phoronida etc.

Morphology, Nervous system, Reproductive system in *Acanthocephalus* sp. External features, musculature, digestive system, life cycle of a typical Rotifer.

Core Course –III Practical: ZOO 201 - CP (Non-Chordates II: Annelida to Echinodermata, Minor phyla)

Practical [Credits: 2] **30 hrs/50 marks**

1. Study of *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria,* Trochophore larva
2. Study of T.S. through pharynx, gizzard, and intestine of earthworm
3. Study of *Limulus*, *Palamnaeus, Palaemon, Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta,* termites, *Apis*, *Musca,* Crustacean larvae , *Peripatus,*

Chiton, Dentalium, Pila, Doris, Helix, Unio, Patella, Ostrea, Pinctada, Sepia, Octopus, Nautilus, Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria, Antedon

4. Dissection of digestive, reproductive and excretory system of Cockroach.
5. Dissection of digestive and nervous system of *Pila*.
6. Dissection of digestive and nervous system of *Nereis*. (*Subject to UGC guidelines)
7. Temporary mounts of *Obelia* colony; Ovary, Spermatheca 7 septal nephridia of Earthworm; Parapodia of Nereis; Mouth parts of Cockroach, house fly & mosquito; Radula of *Pila*; whole mounts of *Daphnia, Cyclops*.
8. Submit a Project Report on field study of the social behaviour of any insect (bees/termites/ants/wasps) or behavioural pattern of earthworm in nature.

Examination evaluation Structure:

1. Museum Specimen: 5 Numbers/each 4 marks (Identification =1, Classification= 1, Characters = 2) Total = 20 marks
2. Dissection & display (one system) (7 + 3 = 10)
3. Preparation of a temporary mount (5 marks)
4. Project report submission (3 marks)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 7 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
  *Note: Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India"
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

- Swayam (MHRD) Portal
- Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
- Advances in Animal Diversity, Systematics and Evolution
- (https://swayam.gov.in/courses/5300-zoology)

Core Course -IV: ZOO 202 - C (Animal Physiology, Endocrinology)

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Physiology of Digestion 12 hrs/ 18 marks

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

Unit 2: Physiology of Respiration and Coordination of Nerve 13 hrs/ 22 marks

Histology of respiratory tract; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide; Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration. Structure of neuron, Resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission, Neuromuscular junction; Physiology of hearing and vision

Unit 3: Physiology of Urinogenital System & Muscular System 10 hrs/ 20 marks

Structure of kidney and its functional Unit; Mechanism of urine formation; Regulation of water balance, micturition; Regulation of salt, acid-base balance; Physiology of male and female reproduction.

Muscle types, Ultrastructure of muscle, Sliding filament theory of Muscle contraction, Role of Calcium ion in muscle contraction, Characteristics of muscle twitch; Motor unit, Summation and tetanus

Unit 4: Physiology of Circulatory system 13 hrs/ 20 marks

Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Kininogen Kinin system, Fibrinolytic system. Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses; Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Peripheral circulation, Blood group and Rh factor, Blood pressure and its regulation.

Unit 5: Endocrine System 12 hrs/ 20 marks

Definitions of Endocrine glands and neurosecretory cells; Functions, hormones secreted by the endocrine glands- pineal, hypothalamus, pituitary, thyroid, thymus, parathyroid, pancreas, adrenal, testis, ovary and their physiological actions; Regulation of their secretion; Mode of hormone action-Signal transduction pathways for steroidal and non-steroidal hormones. Introductory ideas on the miscellaneous hormones secreted by gastrointestinal system, Kidney, Placenta and heart.

Core Course -IV practical: ZOO 202 – C P (Animal Physiology, Endrocrinology)

Practical [Credits: 2] **30 hrs/50 marks** Practical -

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
2. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres, Nerve cells
3. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
4. Demonstration of technique of microtomy to have hands-on experience and learning of the technique.
5. Enumeration of red blood cells and white blood cells using haemocytometer
6. Estimation of haemoglobin using Sahli's haemoglobinometer
7. Preparation of haemin and haemochromogen crystals
8. Interpretation of recording of frog's heart beat (*in situ*) under normal and experimental conditions (effects of acetylcholine, atropine and epinephrine) Subject to UGC guidelines) .

9. Recording of blood pressure using a sphygmomanometer
10. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney

Examination evaluation Structure:

1. Enumeration of RBC/ WBC/ Estimation of Haemoglobin: 10 marks (Procedure & result = 7 + 3=10)
2. Identification of slides/ spot identification: 7 numbers/ 21 marks (Identification with reasons = 1 + 2 = 3)
3. Preparation of a temporary mount and diagram (5 + 2 = 7 marks)
4. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 7 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Tortora, G.J. and Grabowski, S. (2006). Principles of Anatomy & Physiology. XI edition. John Wiley & Sons
- Vander, A., Sherman, J., and Luciano, D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, Mc Graw Hills
- Ganong, W.F. (2019) Review of Medical Physiology. 26th Edition, Mc Graw-Hill
- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd/W.B. Saunders Company
- Marieb, E.N. (1998) Human Anatomy and Physiology. IV Edition, Addison Wesley Longman Inc.

Online Tools and Web Resources:

- e portals like SWAYAM and http://nsdl.niscair.res.in

Skill Enhancement Course (SEC) - II: ZOO 203 – S (Sericulture)

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Sericulture; Systematics and Biology of Silkworm 12 hrs/ 20 marks

Sericulture: Definition, history and present status; Silk route; Silk varieties, usage, export values, employment opportunities; Types of silkworms, Distribution and races; Univoltine and multi voltine races, Exotic and indigenous; Mulberry sericulture; Non-mulberry Sericulture, Eri, Muga, Tassar. Life cycle of *Bombyx mori, Eri, Muga, Antheraea proyli.*

Unit 2: Rearing of Silkworms 12 hrs/ 20 marks

Selection of mulberry variety and establishment of mulberry garden, Rearing house and rearing appliances, Disinfectants: Formalin, bleaching powder, RKO Silkworm rearing technology: Early age and Late age rearing, Types of mountages, Harvesting and storage of cocoons, Cocoon drying,

Post- harvest technology- Silk reeling, re reeling, Dyeing ,weaving, bundling and packing,

Unit 3: Pests and Diseases 6 hrs/ 10 marks

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Diseases of silkworm, Causal factors: Bacteria, Viruses, Fungus, Protozoan, Parasitoides; Control and prevention of pests and diseases.

Skill Enhancement Course (SEC) Practical - II: ZOO 203 – SP (Sericulture)

Practical [Credits: 2] 30 hrs/ 50 marks

1. Study of the life cycle of different species of silk moths - *Bombyx mori, Philosamia ricini, Antheraea proyli/Antheraea mylitta, Antheraea assamensis* and silk secreted by them.
2. Study of the sexual dimorphism in caterpillar, pupae and adults of *Bombyx mori.*
3. Study of the structure of silk gland of mulberry silk worms through dissection .
4. Study of rearing house and different appliances used in rearing of mulberry silk worms.
5. Study of the different disinfectants used in silkworm rearing houses.
6. Study of different types of mountages from specimen/photographs.
7. Analysis of silk fibre quality- Visual examination, thickness, purity.
8. Study of the parasites and predators of silk worms and their control- Uzi fly, Dermestid beetle, Vertebrates.
9. Study of silkworm diseases and their control- Pebrine, Flacherie, Grasserie, Muscardine.
10. Submission of a report on visit to a 'Sericulture Institute'/'Various Sericulture Centres in Manipur.

Examination evaluation Structure:

1. Identification & Characters of different Silkworms (live/ Preserved specimen /Photo) : 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks
2. Identification of appliances used for Silkworm rearing & silk threads– 3 numbers/ 9 marks (Identification = 1, Reason = 2)
3. Dissection and display of Silk gland. 7 marks (Dissection = 4, Display = 3)
4. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Manual on Sericulture (1976); Food and Agriculture Organisation, Rome
- Ullal, S.R. and Narasimhanna, M.N. (1987): Handbook of Practical Sericulture; 3rd Edition, CSB, Bangalore
- Yonemura, M. and Rama Rao, N. (1951): A Handbook of Sericulture. I. Rearing of silkworms. Government Branch Press, Mysore.
- Ananthanarayanan, S. K. (2008): Silkworm Rearing. Daya Publishing House Aruga, H. (1994). Principles of Sericulture. CRC Press

- Sathe, T. V. and Jadhav, A. (2002): Sericulture and Pest Management. Daya Publishing
- House Yup-Lian, L. (1991): Silkworm Diseases. Food and Agricultural Organization.

Online Tools and Web Resources:

- Silkworm crop protection (https://swayam.gov.in/courses/152-silkworm-crop-protection)
- Sericulture (http://csb.gov.in/silk-sericulture/sericulture/)
- http://csb.gov.in/publications/videos/
- http://www.fao.org/3/x2099e/x2099e02.htm

Skill Enhancement Course (SEC) -II: ZOO 203 – S (Vermicomposting)

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Vermiculture, role & types of Eartworms. 12 hrs/ 20 marks

Introduction to vermiculture, definition, classification, history, economic importance and values in maintenance of soil structure. Role of vermiculture in biotransformation of residues, types of worms – local and exotic, usefulness of different species.

Unit 2: Biology of Earthworm, Pests & Diseases 6 hrs/ 10 marks

Biology of *Pheretima posthuma*: taxonomy, anatomy, physiology and reproduction including fecundity and annual reproduction potential. Pests and diseases of earthworms & preventive measures.

Unit 3: Vermicompost preparation & Physico-chemical parameters 12 hrs/ 20 marks

Physico-chemical parameters of vermicompost, different methods of vermicomposting – small, largescale bed farming, pit methods, limiting methods in vermicomposting. Extraction, harvesting, processing, packaging, transport and storage of vermicompost.

Skill Enhancement Course (SEC) Practical -II: ZOO 203 – SP (Vermicomposting)

Practical [Credits: 2] 30 hrs/ 50 marks

1. Identification and Classification of earthworms
2. External morphology of earthworms
3. Dissection and internal anatomy of earthworms
4. Study of habit and habitat of earthworms
5. Establishment of vermicomposing units using locally available resources
6. Vercompost production, harvesting and packaging

7. Study of cocoon and vermicast
8. Study of pests and diseases of earthworms
9. Visit to a local Vermicomposting Unit & submission of report.

Examination evaluation Structure:

1. Identification & Characters of different Earthworms (live/ Preserved specimen /Photo): 3 numbers/ 3 marks (Identification with reasons = 1 + 2 = 3 each). Total = 9 marks
2. Identification of appliances used for Vermicomposting – 3 numbers/ 9 marks (Identification = 1, Reason = 2)
3. Dissection and display of internal organs of Earthworm. 7 marks (Dissection = 4, Display = 3)
4. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- NPCS Board of Consultants & engineers (2004): The complete technology book on Vermiculture and Vermicompost …….vermicompost production. Asia Pacific Business Press Inc.
- Panda, H (2022): The complete technology book on Vermiculture and vermicompost (earthworm) with manufacturing process, Machinery equipment, details & layout. Asia pacific Business Press Inc.
- Ismail, S.A (2005): The earthworm Book. Other India Press, Goa
- Julka, J.M. (1993): Earthworm resources and Vermiculture. ZSI, Calcutta

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Online Tools and Web Resources:

https://cals.ncsu.edu
https://www.vermico.com
https://www.researchgate.net
https://icar-nrri.in **http://agricoop.nic.in**

Skill Enhancement Course (SEC) -II: ZOO 203 – S (Organic Farming)

Course Content:

Theory [Credits: 2] 30 hrs/ 50 marks

Unit 1: Introduction to Organic farming 12 hrs/ 20 marks

Components and Principles of Organic farming: Definition - Scope - principles and concepts; History of organic farming - global scenario. biodiversity: importance and measure to preserve biodiversity - pre requisites for Organic farming. Soil organic carbon: status and improvement strategies; Prospects and problems in organic farming.

Unit 2: Organic sources; Soil, Crop, Weed, Pest & disease management 12 hrs/ 20 marks

Organic sources of Nutrients: Organic sources of nutrients- manures and other inputs - on farm and off farm sources - organic waste recycling - methods - Soil and crop management - inter cropping, crop rotation, green manures, cover crops, mulching - bio fertilizers. Soil, Nutrient, Water, Weed, Pests and disease management: Non-chemical weed management methods: preventive, physical, cultural, mechanical and biological measures - Bio-intensive pest and disease management.

Unit 3: Indigenous technical Knowledge, Crop production standard & Certification.

6 hrs/ 10 marks

Indigenous Technical Knowledge (ITK) in organic agriculture - scientific rationale, Certification of label Organic certification: NPOP guidelines, Certification agencies in India, crop production standards, Quality considerations, labelling and accreditation process, marketing and export opportunities.

Skill Enhancement Course (SEC) Practical -II: ZOO 203 – SP (Organic Farming)

Practical [Credits: 2]

30 hrs/ 50 marks

1. Study on different Soil types and Soil conditioners (lime, dolomite, gypsum, slag, organic manure etc.).
2. Preparation of FYM/ Compost
3. Preparation of Seed bed (wet seed bed, Dry seed bed, manuring, soil treatment), Sowing, raising of seedlings, weeding, Watering.
4. Soil testing using laboratory method or Soil testing Kits, Calculation of different Fertilizers required for Crops as per Soil test result.
5. Identification of different Pests, Physiological disorders of Plants and control measures using eco friendly approaches.
6. Familiarization of Farm equipments and Implements
7. Visit to an organic Village within Manipur and observe the methods followed, Submission of a report.

Examination evaluation Structure:

1. Identification different Soil types. 2 numbers / 6 marks (Identification = 1, Reason = 2)
2. Identification of appliances / farm equipments/ implements & drawing (1 number / 6 marks) (identification = 1, drawing = 5)
3. Testing of Soil.(13 marks) (Testing = 5, Procedure = 5 , Result = 3)
4. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Panda S.C. 2018. Soil Management and organic farming. Agrobios
- Dahama, A.K.2009. Organic farming for sustainable agriculture, Agrobros publishers.

- SP. Palaniappan and K Annadurai. 2008. Organic Farming: Theory and Practice. Scientific Publishers.
- Panda, S.C. 2012. Principles and Practices of Organic Farming. Agribios (India), Jodhpur.
- Gehlot, D. 2010. Organic Farming- Components and Management. Agribios (India), Jodhpur.
- Dushyant Gehlot . 2010. Organic farming: Components and management. Agrobios (India), Jodhpur.
- Ranjan Kumar Biswas.2014. Organic farming in India. N.D. Publishers. New Delhi.

Online Tools and Web Resources:

http://ecoursesonline.iasri.res.in

/ www.ifoam.org www.apeda.org

SEMESTER III

Core Course -V: ZOO 301 - C (Diversity of Chordates I: General organization of Chordates: Hemichordata to Pisces)

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to Chordates 12 hrs/ 20 marks

Comparison of Chordates & non-Chordates; General characteristics and outline classification of Chordates; Advancement of Chordate over other Phyla. Dipleurula concept and the Echinoderm theory of origin of chordates.

Unit 2: Protochordata 12 hrs/ 20 marks

General characteristics of Hemichordata, Urochordata and Cephalochordata; Structure & Life Cycle of *Balanoglossus, Herdmania, Amphioxus;* Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata.

Unit 3: Origin of Vertebrates 12 hrs/ 20 marks

Phylogeny or evolutionary history of Vertebrates: Salient features of Vertebrates, Diversity of Vertebrates; Comparative account between Protochordates & Vertebrates; Distinctive features of Poikilothermic & Homeothermic Vertebrates.

Unit 4: Agnatha 12 hrs/ 20 marks

General characteristics and classification of cyclostomes up to Class; Structure & Life cycle of *Petromyzon* & *Myxine*; Features & significance of the Extinct first Jawed Vertebrates.

Unit 5: Pisces 12 hrs/ 20 marks

General characteristics of Chondrichthyes and Osteichthyes, Classification up to order ; Types of Scales, Fins; Hypophysis & its role in induced breeding; Parental care; Migration, Osmoregulation and Swim bladder in Fish.

Core Course – V Practical: ZOO 301-C P

Practical [Credits 2] **30 hrs/ 50 marks**

.

1 Protochordata: *Balanoglossus, Herdmania, Branchiostoma,* Colonial Urochordata, Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules

2 Agnatha: Petromyzon, Myxine

3 Fish: Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas, Flat fish

4 Power point presentation on study of any two animals from two different classes by students

Examination evaluation Structure:

1 Museum Specimen / Slides: 3 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 15 marks

2 Power point presentation : 20 marks (Subject Knowledge, Presentation / delivery, Communication)

3 Note Book:5 marks (Based on the neatness, inclusiveness, overall presentation)

4 Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Young, J. Z. (2004). The Life of Vertebrates. III Edition, Oxford university press.
- Parker T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates.VII Edition, Volume II
- Pough H. (2018). Vertebrate life X Edition, Pearson International.

Online Tools and Web Resources:

- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-course-biology science/v/crash-course-biology-123
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/

Core Course -VI: ZOO 302 - C (Diversity of Chordates II: General organization of Tetrapods: Amphibia to Mammalia)

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Amphibia 12 hrs/20 marks

Origin of Tetrapoda (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Distinctive characters of Apoda, Urodela & Anura; Neoteny & Paedogenesis; Parental care in Amphibians; Defensive mechanisms in Amphibians.

Unit 2: Reptilia 12 hrs/20 marks

General characteristics and classification up to order; Affinities of *Sphenodon*; External features of *Calotes versicolor* & *Uromastix hardwickii*; Poison apparatus and biting mechanism in snakes; Difference between Venomous and non – venomous Snakes.

Unit 3: Aves 12 hrs/20 marks

General characteristics and classification up to order; *Archaeopteryx*- a missing link; Types of feathers , their roles and types of Beaks; Distinctive characters between flightless & Flying birds; Flight mechanism & adaptations; Perching mechanism and migration in birds; **Unit 4: Mammals (Prototheria & Metatheria)** 12 hrs/20 marks

General characters and classification of Mammals up to order; Distinctive characters of Prototheria and Metatheria; Affinities of Prototheria with Reptiles & Birds; Affinities of Metatheria with Prototheria & Eutheria ; Significance of marsupium or abdominal pouch; Adaptive radiation with reference to locomotory appendages.

Unit 5: Mammals (Eutheria) 12 hrs/20 marks

General characters and classification up to order; Adaptations in Toothless, Aquatic, Flying & Fossorial mammals; Types of Feet; Adaptive convergence in Mammals; Dentition in Mammals.

Core Course – VI Practical: ZOO 302-C P

Practical [Credits 2] 30 hrs/50 marks

.

1. Study of Museum Specimen/ Models :

   Amphibia: *Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra*
   Reptilia: *Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus*
   Aves: Study of six common birds from different orders. Types of beaks and claws
   Mammalia: *Sorex,* Bat (Insectivorous and Frugivorous), *Funambulus, Loris, Herpestes, Erinaceous.*
2. Study of Weberian ossicles of *Mystus*, pecten from fowl head and brain of fowl.
3. Power point presentation on study of any two animals from two different classes by students.

Examination evaluation Structure:

1. Museum Specimen: 3 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 15 marks
2. Power point presentation: 20 marks (Subject Knowledge, Presentation / delivery, Communication)
3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Young, J. Z. (2004). The Life of Vertebrates. III Edition, Oxford university press.
- Parker, T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates. VII Edition, Volume II
- Pough, H. (2018). Vertebrate life X Edition, Pearson International.

Online Tools and Web Resources:

- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-coursebiology-science/v/crash-course-biology-123
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/

Core Course -VII: ZOO 303 - C (Fundamentals of Biochemistry)

Course Content:

Theory [Credits: 4] 60 hrs/100 marks

Unit1: Thermodynamics& Bioenergetics: 12 hrs/20 marks

Acid-Base regulation & Disorders, Energy flow, Principles & Laws of Thermodynamics, Biochemical energetics, Redox reaction, Electron transport system, ATP synthesis, Fermentation as an anaerobic respiration, Energy yielding compounds, Chemical bonding : Covalent bond, Ionic bond, Hydrogen bonds, Van der Waal's bond, Electrostatic bond, Peptide bond.

Unit 2: Carbohydrates 12 hrs/20 marks

General Structure and Biological importance of Carbohydrates-reducing and non-reducing sugars: monosaccharides, disaccharides, polysaccharides and Glycoconjugates, Biochemical Processes: - Glycolysis, Glycogenesis, Glycogenolysis, Gluconeogenesis, Citric acid cycle, Hexose monophosphate shunt.

Unit 3: Proteins & Lipids 12 hrs/20 marks

Structure, Classification and General properties of - amino acids; Proteins and Lipids. Physiological importance of essential and non-essential α-amino acids. Protein folding, Ramachandran plot, . Levels of organization in protein motifs, folds and domains; Denaturation; Transamination & deamination, Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids; β - Oxidation.

Unit 4: Nucleic Acids 12 hrs/20 marks

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids; Cot Curves: Base pairing, Denaturation and Renaturation of DNA; Types of DNA and RNA, Complementarity of DNA, Hypo-Hyperchromicity of DNA, DNA replication (models & mechanism)

Unit 5: Enzymes 12 hrs/20 marks

Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis- Menten equation, Concept of Km and Vmax, Line weaver- Burk plot; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme reaction. Vitamin – types & functions, Vitamin as a cofactor/ Coenzyme.

Core Course –VII Practical: ZOO 303 – C P

Practical [Credits: 2] 30 hrs/ 50 marks

1. To understand the preparation and roles of two important biological buffer systems: phosphate and bicarbonate; Preparation of buffers and determination of pH.
2. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
3. Quantitative Tests: Determination of Ascorbic acid – DCPIP method OR Estimation of Calcium–Titrimetric method.
4. Paper chromatography of amino acids.
5. Action of salivary amylase under optimum conditions.
6. Effect of pH, temperature and inhibitors on the action of salivary amylase.

Examination evaluation Structure:

1. Experiment on preparation of one biological buffer/ Quantitative tests of functional groups in carbohydrates, proteins and lipids. 10 marks (Procedure=5,Experiment=3,Result=2)
2. Determination of Ascorbic acid – DCPIP method OR Estimation of Calcium–Titrimetric method / Action of salivary amylase under optimum conditions or Effect of pH, temperature and inhibitors on the action of salivary amylase. 10 marks (Procedure = 5, Experiment = 3, Result = 2)
3. Paper chromatography of amino acids. 12.5 marks (Procedure= 7, Experiment = 3.5, result = 2)
4. Note Book: 7.5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry. V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition, International Edition, The McGraw - Hill Companies Inc.
- Lehninger, A.L, Nelson, D.L & Cox, M.M (2008). Principles of Biochemistry. W.H. Freeman & Co,N.Y.
- Devlin, T.M (2011). Text book of Biochemistry with clinical correlation. John Wiley & Sons
- Weil, T.M (1990). General Biochemistry. New Age International Ltd.

- Stryer Lupert (2002). Biochemistry. W.H. Freeman & Co, N.Y.

Suggested Reading:

- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry. II Edition, BIOS Scientific Publishers Ltd., U.K.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene. VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

Online Tools and Web Resources:

- CEC Gurukul (www.cec.nic.in)
- https://www.youtube.com/user/cecedusat/featured.
- National Institute of Science Communication and Information Resources (NISCAIR) (http://www.niscair.res.in/) and National Science Digital Library (NSDL) (www.nsdl.niscair.res.in).
- National Digital Library of India (NDL India; https://ndl.iitkgp.ac.in/).

SEMESTER IV

Core Course –VIII: ZOO 401 - C (Paleozoology, Zoogeography, Evolution)

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Paleozoology 12 hrs/20 marks

Definition of Paleozoology, Geological time scale and associated fauna; Fossils and Fossilization, types of Fossils, trace fossils, living fossils; Missing link – *Archaeopteryx*; Dating of Fossils; Significance of Fossils.

Unit 2: Zoogeography 12 hrs/20 marks

Definition of Zoogeography, Zoogeographical regions of the World with characteristic fauna. Wallace line; Marine realm, its divisions and characteristics; Tectonic plate & Continental drift; brief account of the Biogeography of India – Western Ghats & Himalayan region.

Unit 3: Barriers , Distribution & Speciation 12 hrs/20 marks

Barriers – types and significance, Species concept; Speciation & its types; significance of Speciation; inheritance of acquired modifications in speciation; Continuous, Cosmopolitan, Discontinuous, Bipolar & Isolated distribution. Adaptive radiation; Role of hybridization.

Unit 4: Evolution I: 12 hrs/20 marks

History of evolution of animals, origin of life, Evidences of evolution, Theories of evolution, modern concept of organic evolution, Hardy- Weinberg law, Genetic drift /Sewall – Wright effect.

Unit 5: Evolution II : 12 hrs/20 marks

Role of mutation in evolution, Variation, Natural selection – Directional, Stabilizing and Disruptive types. Isolating mechanism and their role in evolution, Coevolution – Parasite host coevolution, Evolution of Horse & Man. Introductory idea on Evolutionary Genomics.

Core Course –VIII Practical: ZOO 401 – C P

Practical [Credits: 2] **30 hrs/ 50 marks**

1. Study on Fossils of different Organisms.
2. Model preparation on different forms of organic evolution using diagrams/ paper models.
3. Study of living Fossils using Museum specimen / Photographs (*Limulus*, *Balanoglossus*, *Ornithorhynchus*, *Nautilus*, *Peripatus*, *Myxine*, Komodo Dragon)
4. PowerPoint presentation on any topic under Paleozoology, Zoogeography or evolution.

5. Documentary Film show on Paleozoology, Zoogeography or evolution / Visit to Zoological Park or Sanctuary or Biodiversity Park, report preparation and Submission.

Examination evaluation Structure:

1. Fossil display & identification: 15 marks (5 nos. x 3 marks) (Identification = 1, Characters = 2).
2. PowerPoint presentation: 15 marks (Subject knowledge, Presentation, Communication)
3. Field visit report or Film show report: 5 marks (based on inclusiveness and overall presentation)
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Lull, R.S. (2022). Organic evolution. Creative media partners, USA
- Futuyama, D.J. (1979). Evolutionary Biology. Oxford Univ. Press
- Mark, K.P & Futuyama, D.J. (2017). Evolution. Sinauer
- Mark Ridley (2004). Evolution (Third edition). Blackwell Publishing
- Raup,D.M. & Stanley,S.M. (2004).Principles of Paleontology 2nd Edition. W.H. Freeman
- Foote,M and Miller,A.I. (2007). Principles of Paleontology. 3rd edition. W.H. Freeman
- Darlington, P.J (1957 republished June 1980). The Zoogeography: The geographical distribution of animals. Wiley Publ.,New York
- Beddard, F.E. (2008). A text book of Zoogeography. Biblobazaar
- Ward,D.J. (2021). Fossils Smith Sonian Handbooks.

Online Tools and Web Resources:

***** Digitized version of Evolutionary Biology by Futuyama, D.J (2010), SWAYAM, NISCAIR, NSDL resources.

Core Course –IX: ZOO 402 - C (Histology & Comparative Anatomy of Vertebrates)

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Histology 12hrs/ 20 marks

Basic principles of histological techniques, Microscopic anatomy of the following organs of a Mammal: Skin, Stomach, Intestine, Pancreas, Liver, Lungs, Kidney, Spinal Cord, Heart, Arteries, Veins, Capillaries, Lymph nodule, Spleen, Testis and Ovary.

Unit 2: Integumentary System & Skeletal System 12hrs/ 20 marks

Structure and derivatives of integument, functions of skin. Basic plan and comparative accounts of bones of skull, girdles, ligaments and limbs. Structure of a typical vertebra, Jaw suspension, Visceral arches.

Unit 3: Digestive System & Respiratory System 12hrs/ 20 marks

Comparative account of the Alimentary canal and associated glands, dentition. Comparative account of Skin, gills, lungs and air sacs; Accessory respiratory organs.

Unit 4: Circulatory System & Urinogenital System 12hrs/ 20 marks

General plan of circulation, Comparative account of heart and aortic arches. Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

Unit 5: Nervous System, Sense Organs & Endocrine glands 12hrs/ 20 marks

Nervous system : Comparative account of brain; Autonomic nervous system, Spinal cord, Cranial nerves in mammals ; Sense organs : Classification of receptors; Brief account of visual and auditory receptors in man. Endocrine glands: Comparative account of Pituitory, Thyroid, Adrenal, Pancreas and Gonads.

Core Course –IX Practical: ZOO 402 – C P

Practical [Credits: 2] 30 hrs/50 marks

1 Study of placoid, cycloid and ctenoid scales of fish through permanent slides/photographs / Fresh preparations.

2 Study of different types of feathers of birds.

3 Disarticulated skeleton of Frog, *Varanus*, Fowl, Rabbit (Skull, Limb bones, Vertebral Column, Sternum, Girdles, Ribs).

4 Mammalian skulls (Model): One herbivorous and one carnivorous animal.

5 Study of digestive, circulatory and urinogenital system of frog/rat through videos or dissection or through virtual dissections.

6 Study of anatomical details of any two organs (brain, heart, lung, kidney, eye and ear) through videos.

7 Project on modifications in skeletal structures/GI tract/Respiratory organs in vertebrates.

Examination evaluation structure:

1. Preparation and display of Fish Scale: 10 marks (Experiment = 3, Procedure = 3, Diagram = 3, Result = 1).
2. Dissection of digestive, circulatory and urinogenital system of frog/rat through dissection or through virtual dissections. 10 marks (Experiment / Display = 3, Procedure = 3, Diagram & labelling = 4,).
3. Specimen identification (Feathers / Disarticulated skeleton) : 15 marks (3 nos. x 5 marks) (Identification = 1, Characters = 4)
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr, R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
- Leiem, C.F., Bermis W.E, Walker and W.F, Grande, L. (2001). Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.
- C.K Weichert and W. Presch (1970). Elements of Chordate Anatomy, IV Edition, McGraw-Hill.
- Pough.H. (2018). Vertebrate Life. X Edition. Pearson International.
- Gartner,L.P (2015). Textbook of Histology.Elsevier Health Sciences

Online Tools and Web Resources:

- SWAYAM (Functional anatomy and regulation of vision, hearing, taste, smell and touch, Link - https://www.swayamprabha.gov.in/index.php/program/upcoming/9).
- SWAYAM (Structure of heart), Link- https://www.swayamprabha.gov.in/index.php/program/archive/9.
- COURSERA (PALEONTOLOGY: Early vertebrate evolution, Link – https://www.coursera.org/learn/early-vertebrate-evolution).

Core Course – X: ZOO 403 - C (Ecology and Biodiversity)

Course Content:

Theory [Credits: 4] 60 hrs / 100 marks

Unit1: Introduction to Ecology 9 hrs/ 15 marks

Definition, history and scope of ecology, ecological principles, biotic and abiotic factors (major environmental factors) influencing various ecosystems, concept of limiting factors – Liebig's law of minimum, Shelford's law of tolerance, concept of habitat and Niche, Niche breadth and Niche overlap, fundamental and realized Niche.

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Unit 2 Ecosystem 15 hrs/ 25 marks

Concept of ecosystem, Structure & function of ecosystem, major ecosystem, Men made ecosystem, agro- ecosystem, Food chain & energy flow, Primary and secondary production of ecosystems, Biosphere & Biome, Ecological pyramids and Ecological efficiencies, Nutrient and biogeochemical cycle with one example e.g. Nitrogen cycle . Greenhouse gases and global warming, Acid rain, Ozone layer destruction. Southern Oscillation (ENSO), Effect of climate change on public health

Unit 3: Population 15hrs/ 25 marks

Unitary and Modular Populations, Unique and group attributes of Population :- Density, Demography, Natality, Mortality, Life tables, Fecundity tables, growth models, survivorship curves, Variations in natural Population, age ratio, Sex ratio, dispersal, dispersion; Carrying capacity. Biotic potential, Exponential and logistic growth, equation and patterns, r and k strategies; Population regulations, Density – dependent and independent factors; Gauss's principle with laboratory and field examples; Lotka - Volterra equation for competition and predation; Functional and numerical responses.

Unit 4 : Community 12 hrs/ 20 marks

Community characteristics : Species richness, dominance, abundance; ruderal, competitive & Stress tolerant organisms; Guilds, Ecotone and edge effect, Keystone species, Ecological succession with examples and types, Theories pertaining to climax community, Species interaction.

Unit 5: Biodiversity 9hrs/ 15marks

Biodiversity, types, Concept, Importance of Biodiversity, biodiversity hotspots, Threats to Biodiversity; IUCN Red list, Protected areas: National Parks, Bio reserves and Sanctuaries.

Core Course – X Practical: ZOO 403 – C P

Practical [Credits: 2] 30 hrs/50 marks

1. Determination of minimum size of quadrates necessary for the study of grassland community.
2. Determination of frequency values of grassland species. Classification of species into frequency classes. Comparison of the result with Raunkiaer's standard frequency diagram.
3. Determination of density of different species in a grassland ecosystem.
4. Determination of abundance of different species in a grassland ecosystem.
5. Studies on the population density of insect communities (above ground and below ground)
6. Primary productivity estimation of grassland and aquatic ecosystems by harvest and light bottle method respectively.
7. Temperature measurement of soil, air and water.
8. Measurement of moisture regime of air (relative humidity).
9. Basic physical and chemical properties of soil: pH, Nitrate, Carbonate, etc.
10. Estimation of dissolved Oxygen and carbon dioxide content of water samples.
11. Study of life table and plotting of survivorship curves of different types from the hypothetical / real data provided.

Examination evaluation structure:

1. Experiment on grassland community: 10 marks (Experiment = 4, Procedure = 4, Result = 2).
2. Measurement of temperature/Moisture/Physical and chemical properties. 13 marks (Experiment = 5, Principle & Procedure = 6, Result = 2).
3. Experiments on Primary productivity of aquatic ecosystem/ Estimation of dissolved Oxygen and carbon dioxide content of water samples / life table and plotting of survivorship curves of different types from the hypothetical / real data provided: 12 marks (Experiment = 4, Procedure = 5, Result = 3)

4 Note Book: 5 marks (Based on the neatness, regularity, overall presentation)

5 Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition Brocks/Cole.
- Smith, R.L. (2000). Ecology and Field Biology. Harper and Row Publisher.
- Krebs, C.J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Rickilefs, R.E. (2000). Ecology. V Edition. Chiron Press.

Online Tools and Web Resources:

- e-PG Pathshala, SWAYAM, Coursera,
- BBC, Discovery, National geographic, Science Inside

SEMESTER V

Core Course -XI : ZOO711C (Developmental Biology & Immunology)
Course Content:
Theory [Credits: 4] **60 hrs/100 marks**

Unit 1: Introduction to Developmental Biology 12 hrs/20 marks

Historical perspective and basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division, Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Developmental biology & merits, types of development, Fertilization (External and Internal): mechanism, general sequence & molecular events during fertilization, Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Chemical changes during Cleavage, Types of Blastula; Fate maps.

Unit 2: Embryonic Development 12 hrs/20 marks

Early development of frog and chick up to gastrulation; Embryonic induction and organizers, Fate of Germ Layers; Formation of neural tube, Extra-embryonic membranes in birds; Implantation of embryo in humans, elementary concept of Transplantation, Determination, Competence, embryonic induction and organizers; Placenta (Structure, types and functions of placenta); Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories.

Unit 3: Teratogenesis and overview of Immune system 12 hrs/20 marks

Teratogenesis: Teratogenic agents and their effects on embryonic development; Teratogenesis as an environmental assault on human development;
Overview of Immune system: Historical perspective of Immunology, Early theories of Immunology, Clonal Selection Theory, Cardinal features of vertebrate immune system, Hematopoiesis, Cells and organs of the Immune system. Anatomical barriers, Inflammation, Cell and molecules involved in innate Immunity, Adaptive Immunity (Cell-mediated and Humoral), Passive immunity; Active: Artificial and natural Immunity, Immunological Tolerance.

Unit 4: Antigens, Antibodies, and Immunoglobulins: 12 hrs/20 marks

Structure of antibodies; Functional properties of antibodies. Generation of antibody diversity – molecular mechanism, role of major histocompatibility complex in immune response. Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Structure and functions of different classes of immunoglobulins, Antigenic determinants on Immunoglobulins, Antigen-antibody interactions (Precipitation reactions, Agglutination reactions, Immunofluorescence and ELISA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

Unit 5: MHC, Cytokines, Complement system, Diseases: 12 hrs/20 marks
Structure and functions of Major histocompatibility complex (MHC) molecules (MHC I and II), Endogenous and exogenous pathways of antigen processing and presentation, concept of Cytokines, Properties and functions of cytokines, Complement system, Components and pathways of complement activation, biological consequences of complement activation. Tumor immunology, Immunization, Immunodeficiency diseases – Primary, Combined, severe combined, acquired, secondary immunodeficiency diseases; Hypersensitivity; recent developments in antibodies and immune therapy.

Core Course -XVII Practical : ZOO711CP (Developmental Biology & Immunology)

Practical [Credits: 2] **30 hrs/ 50 marks** Part A

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7-24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19- 72 hours and Stage 24-96 hours of incubation
3. Demonstration of culture of chick embryo from fertilized eggs to study various developmental stages.
4. Study of different sections of placenta (photomicrographs/ slides).

Part B

5. Histological study of spleen, thymus and lymph nodes through slides/photographs.
6. Preparation of stained blood film to study various types of blood cells.

7. Basic patterns of precipitation by Ouchterlony's double immuno-diffusion method.
8. ABO Blood group antigen determination by hemagglutination.
9. Demonstration of: ELISA, Immunoelectrophoresis

Examination evaluation Structure:

1. Identification of Slides with Characters (at least three Characters) : 3 each from Part A & B : 6 (1 + 3) = 24
2. Whole mount of Part A : Characters & Identification (only 2) : (1 + 2) 2= 6
3. Blood smear to show blood components or blood group : Procedure = 3, experiment = 2
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company

Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, International Thompson Computer Press.

Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers. David, M., Jonathan, B., David, R. B. and Ivan, R. (2006). Immunology, VII Edition,M osby, Elsevier Publication.

Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA

Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006). Immunology, VI Edition, W.H. Freeman and Company.

Suggested Reading:

- Abbas, K. Abul and Lechtman H. Andrew (2003) Cellular and Molecular Immunology.V Edition, Saunders Publication.
- Kalthoff, K. (2001). Analysis of Biological Development. II Edition, McGraw Hill Publishers.
- Kenneth Murphy and Casey Weaver (2016). Janeway's Immunobiology, IX Edition, Garland Science
- Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Online Tools and Web Resources:

- https://www.hhmi.org/biointeractive/human-embryonic-development
- https://www.khanacademy.org/science/biology/developmental-biology
- https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm
- https://embryology.med.unsw.edu.au/embryology/index.php/Main_Page
- e-PG Pathshala portal of Government of India: https://epgp.inflibnet.ac.in Fundamentals of immunology; https://www.coursera.org/specializations/immunology.

Core Course -XII: ZOO712C (Cell Biology & Genetics)

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Overview of Cells, Cellular Organelles and Membrane Dynamics 12 hrs/20 marks

Overview of prokaryotic and eukaryotic cell types and their key differences. Comparative structure of plant and animal cells. An overview of structure and function of the following cellular components: Plasma Membrane, Mitochondria, Nuclear Membrane, Cytoskeleton, Endoplasmic Reticulum (ER types), Golgi Apparatus, Lysosomes, Peroxisomes, Mitochondria, Nucleus, Nucleolus, Vacuoles, Chloroplasts, Ribosomes, Centrosomes and Centrioles. Structure and functions of microtubules, microfilaments and intermediate filaments; Transport across membranes: diffusion, osmosis, ion channels; ion pumps, active & passive transport, facilitated transport.

Unit 2: Chromosome Structure & Types, Cell Division and Cell signaling & communication

12 hrs/20 marks

Structure and types of chromosomes, Specialized chromosomes – Polytene and Lamp brush chromosomes, nucleosome organization: DNA – histone complex, higher order chromatin folding. Chromosomal variations and abnormalities. Cell Division: Phases of Mitosis and Meiosis: Key steps and regulation of the processes. Overview of Cell Cycle and mechanisms of cell cycle control. Cell-Cell junctions and general principles of cell communication, Cell adhesion, roles of different adhesion molecules, gap junctions, integrins, neurotransmission & its regulation, Apoptosis.

Unit 3: Principles of Inheritance – Mendelian Genetics 12 hrs/20 marks

Mendelian Genetics: Mendel's laws of segregation and independent assortment. Monohybrid and dihybrid crosses, test crosses, and backcrosses. Concepts of dominance, recessiveness, and codominance. Concept of gene, allele, pseudo allele, multiple alleles. Extensions of Mendelian Genetics: Incomplete dominance, co-dominance, multiple alleles, lethal alleles. Penetrance and expressivity, epistasis, pleiotropy. Sex-linked, sex-influenced, and sex-limited traits. Polygenic Inheritance: Traits controlled by multiple genes (e.g., skin color, height). The role of multiple genes in producing continuous variation in traits.

Unit 4: Non-Mendelian & Extra-nuclear Inheritance, Gene Regulation & Epigenetics

12 hrs / 20 marks

Non-Mendelian and Extra-nuclear Inheritance: Cytoplasmic Inheritance and Genomic Imprinting: Maternal effects and genomic imprinting (e.g., shell coiling in *Limnaea*). Organelle Inheritance: Mitochondrial inheritance, antibiotic resistance in *Chlamydomonas*, mitochondrial mutations in *Saccharomyces* and related human disorders. Infective Heredity: Inheritance patterns in *Paramecium*. Prokaryotic and Eukaryotic Gene Regulation: Mechanisms of gene regulation in prokaryotes (e.g., lac operon) and eukaryotes. Epigenetics: DNA methylation, histone modifications, and chromatin remodeling. Epigenetic Control of Gene Expression: Epigenetic mechanisms in development and diseases (e.g., cancer, imprinting disorders). Environmental Influence on Epigenetic Traits: Impact of environmental factors on epigenetic modifications and the heritability of epigenetic traits.

Unit 5: Linkage, Chromosomal Mapping, Mutations, Sex Determination and Quantitative genetics

12 hrs/20 marks

Linkage, Crossing Over, and Chromosomal Mapping. Gene mapping techniques, including somatic cell hybridization. Mutations – physical and chemical mutagens, types of mutations and their detection methods. Chromosomal aberrations. Sex Determination: Genetic and environmental mechanisms of sex determination in *Drosophila* and humans. Dosage compensation mechanisms: X-inactivation in

mammals, hyperactivation of the X chromosome in *Drosophila*. Mechanism of Sex Reversal in Animals such as fish and amphibians and the factors influencing sex reversal. Pedigree analysis, Karyotypes, genetic disorders, polygenic inheritance, heritability and its measurements.

Recommended Books:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). ***Molecular** Biology of the Cell*, 6th Edition. Garland Science, Taylor & Francis Group.
- Becker, Kleinsmith and Hardin (2009): The world of the Cell, VIII Edition. Benjamin Cummings Publishing, San Francisco.
- Cooper,G.M. and Hausman,R.E. (2009): The Cell : A molecular approach, V edition, ASM Press and Sinauer associates.
- Klug, W.S., Cummings, M.R., Spencer, C.A., & Palladino, M.A. (2018). *Concepts of Genetics*, 12th Edition. Pearson Education.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K.

(2016). *Molecular Cell Biology*, 8th Edition. W.H. Freeman & Company.

- Snustad, D.P., & Simmons, M.J. (2015). *Principles of Genetics*, 7th Edition. John Wiley & Sons.
- Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., & Doebley, J. (2020). *Introduction to Genetic Analysis*, 12th Edition. W.H. Freeman & Company.

Suggested Readings:

- De Robertis, E.D.P., & De Robertis, E.M.F. (2018). *Cell and Molecular Biology*, 9th Edition. Lippincott Williams & Wilkins.
- Karp, G. (2018). *Cell and Molecular Biology: Concepts and Experiments*, 8th Edition. John Wiley & Sons Inc.
- Pierce, B.A. (2017). *Genetics: A Conceptual Approach*, 6th Edition. W.H. Freeman & Company.
- Becker, W.M., Kleinsmith, L.J., & Hardin, J. (2018). *The World of the Cell*, 9th Edition. Pearson Education.
- Russell, P.J. (2016). *Genetics: A Molecular Approach*, 3rd Edition. Pearson Education.

Online Tools and Web Resources:

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-coursebiology-science/v/crash-course-biology-123
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/

Core Course – XII Practical: ZOO712CP

Practical [Credits 2] **30 hrs/50 marks**

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
2. Simulation exercises using beads or seeds to study the Mendel's laws and gene interactions.
3. Study of various stages of meiosis.

4. Verification of Mendelian ratios using Chi-square analysis/test, Pedigree analysis.
5. Preparation of temporary stained mount to show the presence of Barr body in human female blood cells/ cheek cells.
6. Linkage maps based on data from conjugation.
7. Cytochemical staining and preparation of permanent slide to demonstrate:
   (a) DNA by Feulgen reaction
   (b) Mucopolysaccharides by PAS reaction
   (c) Proteins by Mercuric Bromophenol Blue/Acid Fast Green.

Examination evaluation Structure:

1. Temporary slide preparation : 2 numbers (Procedure = 05, Slide = 04, Display = 03) Total = 24 marks
2. Identification of Meiotic stages (2 slides) (Identification : 01, Character = 02) Total = 06
3. Cytochemical staining and preparation of permanent slide (Procedure = 03, Display/result = 02) Total = 5 marks
4. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Generic Elective Course (GEC) -III : ZOO703G Fundamentals of Zoology – 3: Protozoa & Phyla of Invertebrates

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit I: Protozoa & Porifera 12 hrs/20 marks

General Characters and different classes of Protozoans with examples, Structure, life Cycle and clinical significance of *Plasmodium* sp. General Characters and different classes of Poriferans with examples, Canal system in Sponges, integumentary system in Sponges.

Unit II: Cnideria & **Platyhelminthes** 12 hrs/20 marks

General Characters and different classes of Cnideria with examples, Polymorphism in Coelenterates, Corals & Coral reef formation; General Characters and different classes of Platyhelminthes with examples, Life cycle of *Fasciola hepatica* and *Taenia solium.*

Unit III: Nemathelminthes & Annelida 12 hrs/20 marks

General Characters and different classes of Nematodes with examples, Life cycle of *Ascaris lumbricoides,* its parasitic adaptation and medical importance. General Characters and different classes of Annelida with examples, Significance of medicinal Leeches.

Unit IV: Mollusca & Echinodermata 12 hrs/20 marks

General Characters and different classes of Mollusca with examples, Torsion in Gastropods. General Characters and different classes of Echinodermata with examples, Water vascular system in Asteroidea.

Unit V: Arthropoda & Hemichordata 12 hrs/20 marks

General Characters and different classes of Arthropoda with examples, metamorphosis in Insects, Economic and medical importance of Insects. General Characters of Hemichordata , Affinities of Balanoglossus with Chordates and non-Chordates.

Generic Elective Course (GEC) -III Practical : ZOO703GP

Practical [Credits 2] **30 hrs/ 50 marks**

1. Identification of slides of Protozoans and museum specimen representing the Invertebrates.
2. Slide making of free living Protozoans / Blood smears to show malarial parasites.
3. Visit on foot to a place near the Institute to get familiarized with different invertebrates available in the area & submission of a report.

Examination evaluation Structure:

1 Slide identification: 2 Numbers/ 4 marks each (Identification =1, Comments = 3) Total = 8 marks

2 Museum Specimen identification: 6 Numbers/ 3 marks each (Identification =1, Comments = 2) Total = 18 marks

3 One slide preparation: 9 marks (experiment and display = 6 marks, procedure = 3 marks)

4 Field report submission: 5 marks (Subject Knowledge, Presentation) 5 Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India. Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Discipline Specific Elective (DSE) Course - I: ZOO701D(a) Wildlife & Bioresource management

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Introduction , evaluation & management of Wildlife 12 hrs/20 marks

Values of wildlife - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies: WCS, CBD, Agenda 21. Habitat analysis: a) Physical parameters: Topography, Geology, Soil and water; b) Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

Unit 2: Management of Habitats , Population estimation 12 hrs/20 marks

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successional process: Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats. Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, and Hair identification; Pug marks and Census methods

Unit 3: Excess population of Wildlife & Protected Areas– Management & Planning 12 hrs/20 marks

Estimation of carrying capacity; Human-wildlife conflict; Eco tourism / wild life tourism in forests; Climax communities: characteristics and theories; Ecology of purterbance. Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth Disease, *Mycobacterium* TB, Bovine and Avian Flu

Unit 4 : Protected areas 12 hrs/20 marks

Biodiversity hotspots, Biosphere reserves, National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India and Management, challenges in Tiger reserve; Brow Antlered Deer conservation & Challenges

Unit 5 : Bioresource 12 hrs/20 marks

Bioresource Concepts and types – Animals, Plants, Cells, Genes, Microorganisms.
Significance of Bioresources and threats faced by them, Insect resources, Fishes and Livestock, Animal products & processing, Biomass, Bioenergy and Biomaterials; basic biomolecules and Water; Antigen & antibodies, Bioremediation.

Recommended Books:

- Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313
- Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK. Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.

Suggested Readings: Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002). The Ecology of Wildlife Diseases. Oxford University Press, Oxford.

- Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.
- Sharma, B.D. (1999). Indian Wildlife Resources Ecologyand Development. Daya Publishing House, Delhi.
- Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.
- Hossetti, B. B. (1997). Concepts in Wildlife Management. Daya Publishing House, Delhi.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4687-july-2018-wildlife-conservation
- https://swayam.gov.in/courses/5364-jan-2019-wild-life-ecology
- https://papaco.org/mooc-on-species-conservation/
- https://www.iucn.org/theme/protected-areas/our-work/capacity-development/moocs
- https://www.zsl.org/united-for-wildlife-free-conservation-courses
- https://wildlife.org/next-generation/career-development/online-courses/

https://www.openlearning.com/umtmooc/courses/wildlife-management

Discipline Specific Elective (DSE) Course –I Practical :
ZOO701DP(a)
Wildlife & Bioresource management

Practical [Credits 2] **30 hrs/50 marks**

1. Identification of mammalian fauna, avian fauna, herpeto-fauna through direct and indirect evidences seen on a field trip to a wildlife conservation site.

2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System,Various types of Cameras and lenses).
3. Familiarization and study of animal evidences in the field: Identification of animals through pug marks, hoof marks, scats, nests and antlers.
4. Demonstration of different field techniques for flora and fauna: PCQM.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
6. Identification of big cats: Lion, tiger, panther, cheetah, leopard and jaguar.
7. A report based on a visit to National Park/Wildlife Sanctuary/Biodiversity Park or any other wildlife conservation site.

Examination evaluation Structure:

1. Identification of Fauna from models/ Pictures/Photos: 5 numbers x 4 marks (Identification=1, Characters=3): Total = 20
2. Identification of pug marks, hoof marks, scats, nests and antlers from models/ Pictures/Photos: 5 numbers x 2 marks (Identification=1, Character=1): Total = 10
3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)
5. Field visit report : 5 marks

Discipline Specific Elective (DSE) Course - I: ZOO701D(b) Integrated Pest management

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to IPM 12 hrs/20 marks

Introduction: Definition and Importance of IPM; Historical development of IPM; Pests definition and categories. Plant pathology, Concept of pest management, Ecological aspects as foundation for IPM; Principles of IPM, mechanical strategy for IPM.

Unit 2: **Components of IPM-I** 12 hrs/20 marks

Economic thresholds, Sampling & monitoring of Pests, Legal approach to IPM, ecological management, diverting pest population away from the crop.; managing insects with resistant plants; history, mechanism of resistance and use of plants as resistant means in pest management.

Unit 3 : **Biological and Genetic control** 12 hrs/20 marks

Biological control; predators, parasitoids and microbes. Merits & demerits of Biological control, Pest management by modifying insect development and behaviour; Sterile insect technique. Sterile Insect release method; Botanical pest management. Genetic control and transgenic plants, insect growth regulators like repellants, attractants, inhibitors etc.

Unit 4: Chemical and Innovative approaches for IPM 12 hrs/20 marks

Chemical means of pest management. Types of Insecticides, adjuvant & formulation, Chemical control with reference to organochloride, organophosphate, carbamates, synthetic pyrethroids ; Pest

management through innovative approaches like biotechnological approach,; Adoption of IPM; pros and cons.

Unit 5: **IPM and sustainable agriculture** 12 hrs/20 marks

Implementation of IPM in cereals (paddy), pulses (pigeon pea and Soybean) and commercial crops (sugarcane), vegetable crops (cabbage and tomato), Pesticide in IPM & Pesticide management, Host plant resistance, Weed management

Recommended Books:

1. Handbook of Integrated Pest Management by Govt. of India Indian Council of Agricultural Research (ICAR).
2. General and Applied Entomology by David B.V and Ananthakrishnan T.N; Tata McGraw Hills, New Delhi.
3. Biopesticides and Pest management by Dhaliwal G.S and Opendro Koul. Kalyani Publishers, New Delhi.

Suggested Readings:

1. A manual of practical Entomology (field and Laboratory guide) by M.M Trigunayat. Scientific publishers (India)
2. Elements of Economic Entomology by David B.V and Ramamurthy V.V. Namrutha publication, Chennai

Online Tools and Web Resources:

1. http://www.eagri.org/eagri50/ENTO232/index.html
2. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=12468

Discipline Specific Elective (DSE) Course –I Practical :
ZOO701DP(b)
Integrated Pest management

Practical [Credits 2] **30 hrs/50 marks**

Examination evaluation Structure:

Examination evaluation Structure

1. Identification of Pest, Parasitoid species. 5x4=20 Mark
2. Pesticide formulation. 5 Mark
3. Submit a report of field visit (Paddy field, Vegetable farm, Fruit Orchard). 10 Mark

6. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
7. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Discipline Specific Elective (DSE) Course - I: ZOO701D(c) Fish & Fisheries
Course Content:
Theory [Credits: 4] **60hrs/ 100 marks**

Unit1: Integrative Fish Taxonomy: Morphological, Anatomical (osteology) and Molecular Approach (Fish DNA barcoding), characteristics of Chondrichthyes & Osteichthyes, dichotomous key, type specimens, invasive species, commercially important endemic and exotic food fishes, ornamental fishes, brackish water and coldwater fishes, hill stream fishes and its adaptive modification, cultivable species of prawn. 12 hrs/20 marks

Unit2: Fish Physiology and biotechnology: Types of scales, modification of alimentary canal based on food and feeding habits, digestion of food, circulation in fish, aquatic respiration, osmoregulation in migratory fishes. Cryopreservation of milt, Hybridization, production of monosex population, transgenic fish: its merits and demerits. Feed biotechnology: Probiotics, single cell proteins, Nutraceuticals. 12 hrs/20 marks

Unit3: Fish reproduction, breeding and seed production: Functional morphology of gonads, types and modes of reproduction, Fecundity, Bundh breeding, induced breeding by using pituitary extract; induced breeding by injecting commercial synthetic hormones, hatcheries: Double-walled hatching hapa, clay pots, glass jars, Chinese circular hatcheries; stages of fish seeds, conditioning, packing, and transport of brood fishes and fish seed.

12 hrs/20 marks

Unit4: Fish farming and ecological parameters: Fish farm construction and layout of different types of ponds; Pre-stocking preparation of Ponds; Post-stocking management. Physico-chemical properties of pond water and soil and their maintenance. Different types of aquaculture systems based on stocking density and management practices. Climate Resilient Aquaculture Technologies: Recirculatory Aquaculture System (RAS), Biofloc, Aquaponics.

12 hrs/20 marks

Unit5: **Fish Nutrition and health; Harvesting & preservation techniques, extension and marketing**: Components of fish feed; principle of fish feed formulation, fish food organisms. Fish diseases: Infectious and Non-infectious Pathogens (bacterial, viral, fungal, protozoan, helminth diseases of fish, nutritional disease). Inland fishing crafts and gears, Spoilage of fish and causative agents, methods of fish preservation and processing, methods of fishery extension, fish marketing channels.

12 hrs/20 marks

Recommended Books:

1. Jhingran, V.G.: Fish and Fisheries of India 3rd. En Today and Tomorrow Book Agency, New Delhi
2. Pillay, T.V.R. 1990: Aquaculture, principles and Techniques. Fishing News Bk. Ltd.
3. Edmonson, W.I.: Freshwater Biology, War and Weipel.
4. Abidi, R.: Fish Pathogen & Diseases in India.
5. Amlacher, E.: Text Book of Fish Diseases.
6. Gupta, S. K. & P.C. Gupta: General and Applied Ichthyology (Fish and Fishery), S. Chand & Co. Ramnagar, New Delhi, 110055.
7. Lagler, K. F., Bardach, J. E., Miller, R. R., & Dora, R. May Passino (1977) Ichthyology.
8. Lucas, J. S., Southgate, P. C., & Tucker, C. S. (Eds.). (2019). *Aquaculture: Farming aquatic animals and plants*. John Wiley & Sons.
9. Hoar, W. S., Randall, D. J., & Donaldson, E. M. (1983). *Fish physiology*. Academic Press.

10. Vishwanath, W. (2021). *Fishes of Eastern Himalayas*. Academic Press.
11. Darshan, A., Abujam S., & Das, D.N. (2019). Biodiversity of Fishes in Arunachal Himalaya. Academic Press.
12. Timmons, M. B., Guerdat, T., & Vinci, B. J. (2018). *Recirculatory Aquaculture System*, 4th Edition, Ithaca Publishing Company LLC.
13. Goddek, S., Joyce, A., Kotzen, B, & Burnell, G.M. (2019). *Aquaponics Food Production Systems.* Springer.
14. Wedmeyer, A.F.S.: Fish Hatchery & Management.
15. Von Brandt's: Fish Catching Techniques of the World. Blackwell Pub.
16. George Borgstrom Elsevier,: Fish as Food, Vol.I & II.
17. Chonder, S. L. (1994): Induced Carp breeding. CBS Publishers & Distributors, New Delhi-110002.
18. Roberts, R. J. (2012). Fish pathology. John Wiley & Sons.
19. Pandey, P. K., Mallik, S. K., & Yumnam, R. (Eds.). (2024). Handbook of Aquatic Microbiology. CRC Press.
20. Biswas, K. P. (1990). A Text Book of Fish, Fisheries & Technology. Narendra Publishing House.
21. Thomas, P.C., Rath, S.C., Mohapatra, K. D. (2013). Breeding and seed production of Fin Fish and Shell fish. Astral publication, Gaya.

Suggested Readings:

1. Piper, R. G., McElwain, I. B., Orme, L. E., McCraren, J. P., Fowler, L. G., Leonard, J. R. (1986). Fish Hatchery Management. US Government Printing Office. 2. Wedmeyer, A.F.S.: Fish Hatchery and Management.
3. Von Brandt's: Fish Catching Techniques of the World. Blackwell Pub. 4. George Borgstrom Elsevier: Fish as Food, Vol. I & II.

Online Tools and Web Resources:

1. Eschmeyer's Catalog of Fishes Online Database (https://www.calacademy.org/scientists/projects/eschmeyers-catalog-of-fishes)
2. Food and Agriculture Organisation of the United Nations (https://www.fao.org/home/en/)
3. Indian Council of Agricultural Research (https://icar.org.in/)

Discipline Specific Elective (DSE) Course –I Practical : ZOO701D(c) Fish & Fisheries
Practical [Credits 2] 30 hrs/50 marks

Examination Evaluation Structure:

1. Identification and classification of endemic food fishes, weed fishes and predatory fishes using morphometric and meristic characters, and taxonomic keys.
2. Identification of exotic invasive fish species using morphometric and meristic characters.
3. Identification of predatory insects and common aquatic weeds in fish pond.
4. Identification of common fish parasites.
5. Fecundity: Estimation the number of eggs by gravimetric and volumetric methods.
6. Water and soil sampling from fish farms. Physico-chemical analysis of water - turbidity, temperature, dissolved oxygen, carbon dioxide, alkalinity, pH, BOD, TAN, Ammonia, TSS
7. Dissection of Weberian Ossicles

8. Study of food and feeding habits of fishes: Bucco-pharynx of economically important fishes, Pharyngeal teeth.
9. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
10. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)