ANIMAL DIVERSITY-I- NON-CHORDATA

Programme	B.Sc. Zoology				
Type of Course	Major				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total hours
	4	3		2	75
Pre-requisites	+2 /VHSC Biology or equivalent online courses				
Course objectives	The student develops understanding of the diversity, structural organization, complexity, characteristic features, economic and evolutionary importance of non-chordates of various animal phyla and will be able to perform simple dissections in order to study its characteristic features.				

Course outcome (CO)

CO	CO statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the importance of the diversity of non-chordates living in varied habits and habitats.	U	F&C	Short answer, Paragraph questions
CO2	Understand evolutionary history and relationships of different non-chordates	U	F&C	Short answer, Paragraph, Essay type questions
CO3	Outline the classification and compare the specified protists, acoelomates, pseudocoelomates and coelomates non-chordate phyla.	U	F&C	Short answer, Paragraph type questions
CO4	Critically analyze the organization, complexity and characteristic features of non-chordates of various animal phyla.	An	F&C	Short answer, Paragraph, Essay type questions
CO5	Explain the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.	U	F&C	Short answer, Paragraph type questions
CO6	Perform the mounting of specialized organs of selected non-chordates and dissections of selected specimens by standard laboratory protocols and prepare report on field study	Ap	C&P	Practical lab exams, Viva- voce, report writing

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Module 1: Protists to Animals (10 hrs) (Out of 70: 15marks)

Unit 1: Five Kingdom Classification of Living Organisms (1 hr)

Brief description of Five kingdom classification. Mention Cavalier-Smith's eight kingdom classification also.

Unit 2: Concept of Classification of Animals (2 hrs)
Classification based on number of cells, tissue or organ system level of organization, and development of germ layers. Evolution of symmetry, and segmentation, homology and analogy of organs and their origin, Acoelomate, Pseudocoelomate, and Coelomates; Protostomia and Deuterostomia.
Unit 3: Classification of Kingdom Protista (3 hrs)
General characteristics features and classification of Kingdom Protista down to phyla.[*Salient features of the major groups of protists given below with short notes on theexamples cited*]

Phylum Rhizopoda: *Entamoeba*
Phylum Dinoflagellata: *Noctiluca*
Phylum Apicomplexa: *Plasmodium*
Phylum Parabasilia: *Trichomympha*, and
Phylum Ciliophora: *Vorticella*.

Unit 4: Type: *Paramecium*(4 hrs)
Morphologyand structural organization [as revealed by compound microscopy], Nutrition, Locomotion and Reproduction; Conjugation in detail.

Module II: Kingdom Animalia: Non-chordata-Acoelomates and Pseudocoelomates (10hrs) (18marks)

Salient features and Classification down to classes of major phyla (Porifera, Cnidaria, Ctenophora, Platyhelminthes and Nematoda). [*Habits, habitat, morphology, functional anatomy and life history of representative types (wherever specified) and classification of each phylum down to classes, except otherwise mentioned, and listed examples. Study of animal diversity with typical examples from each class, with emphasis on ecological– and adaptive features, economic importance and such other points of biological interest expected. Only very brief account of each example is to be studied.*]
Unit 1: Phylum Porifera (2 hrs)
Salient features of the Phylum, Classification down to classes and Distinguishing features (any three) of each class.

Class Calcarea (=Calcispongiae)
Class Demospongiae
Class Hexactinellida (=Hyalospongiae).
Eg. *Leucosolenia* from Calcarea (Brief description only).

Mention Amphiblastula, Parenchymula, and gemmule.
Give an account on canal system (Asconoid, Syconoid, Leuconoid and Rhagonoid).
Unit 2: Phylum Cnidaria (4 hrs)
Salient features of the Phylum, Classification down to classes and Distinguishing features (any three) of each class.

. Class Anthozoa
Class Hydrozoa
Class Scyphozoa.
Egs. *Physalia* from Hydrozoa and *Madrepora* from Anthozoa (Brief description only).

Type: *Obelia* - Morphology and metagenesis.
Polymorphism in Cnidaria with special reference to siphonophores.
Unit 3: Phylum Ctenophora (1hr)
Unique features of the Phylum
eg. *Pleurobrachia* (Brief description only).
Mention cydippid larva
Unit 4: Phylum Platyhelminthes (1 hr)
Salient features of the Phylum, Classification down to classes and Diagnostic features (any three) of the following classes

Class Turbellaria

Class Trematoda
Class Cestoda
Eg. *Dugesia* from Class Turbellaria (Brief description only)

Unit 5: Super-phylum Aschelminthes (1 hr)

Phylum Nematoda

Salient features of the Phylum, Classification down to classes and Distinguishing features (any three) offollowing classes

Classes Enoplia
Class Chromadorea
Eg. *Ascaris* from Class Chromadorea

Unit 6: Pseudocoelomate Minor Phyla (1 hr)

Salient features of the following pseudocoelomate minor phyla:
Phylum Gastrotricha (eg. *Chaetonotus)*
Phylum Rotifera(*eg. Brachionus)*.

Module III: Kingdom: Animalia: Non-chordata- Coelomates (15 hours) (22marks)

General characteristics and Classification down to classes of the coelomate phyla of non-chordates (Annelida, Onychophora, Arthropoda, Mollusca, Echinodermata and Hemichordata). [*Habits, habitat, morphology, functional anatomy and life history of representative types (wherever specified) and classification of each phylum down to classes, except otherwise mentioned, and listed examples. Study of animal diversity with typical examples from each class, with emphasis on ecological and adaptive features, economic importance and such other points of biological interest expected. Only very brief account of each example is to be studied.*]

Unit 1: Phylum Annelida (2 hrs)

Salient features of the Phylum, Classification down to classes and Distinguishing features (any three) of following class.

Class Polychaeta
Class Oligochaeta
Class Hirudinea.

Egs. *Neanthes* (Life cycle and development, Heteronereis) from Class Polychaeta; *Megascolex*fromClass Oligochaeta (Brief description only) and *Hirudinaria* fromClass Hirudinea (brief description with parasitic adaptations).

Unit 2: Phylum Onychophora (1 hr)

Distribution, peculiarities and affinities of *Peripatus.*

Unit 3: Phylum Arthropoda (6 hrs)

Salient features of the Phylum, Classification down to classes and Distinguishing /identifying/Diagnostic features (any three) of following classes.

Class Trilobita
Class Merostomata
Class Crustacea
Class Insecta
Class Arachnida
ClassChilopoda
Class Diplopoda.

Egs. Class Merostomata – *Limulus*; Class Arachnida – *Heterometrus (=Palamnaeus), Heteropoda*, mention ticks and mites*;* Class Crustacea –*Sacculina, and Eupagurus;* Class Chilopoda – *Scolopendra;* Class Diplopoda – *Spirostreptus;* Class Insecta – *Lepisma, Mantis, Troides minos* (Southern Birdwing butterfly), *Papilio buddha* (Malabar Banded Peacock), Mosquitoes (*Culex, Anopheles, Aedes*), *Apis* [Brief description only].

Type: *Penaeus* - Morphology, digestive system, excretory system, nervous system, sense organs (statocyst, compound eye in detail), reproductive system and development (details of larval stages not expected).

Unit 4: Phylum Mollusca (2 hrs)

Salient features of the Phylum, Classification down to classes and Distinguishing features (any three) of following classes.

ClassAplacophora
Class Polyplacophora (=Amphineura)
ClassMonoplacophora
ClassGastropoda
Class Bivalvia (=Pelecypoda)
Class Scaphopoda
Class Cephalopoda (=Siphonopoda)
Egs. (Brief descriptions only) Class Polyplacophora – *Chiton;* Class Gastropoda – *Turbinella;* Class Bivalvia – *Perna;* Class Cephalopoda – *Sepia*.

Unit 5: Phylum Echinodermata (2 hrs)

Salient features of the Phylum, Classification down to classes and Distinguishing features (any three) of following classes.

Class Crinoidea
Class Asteroidea
Class Ophiuroidea
Class Holothuroidea
ClassEchinoidea.
Egs. *Holothuria* from Class Holothuroidea (Brief description only); Mention Evisceration.
Echinus from Class Echinoidea (Brief description only). Mention Aristotle's lantern.

Water vascular system of Starfish in detail.

Unit 6: Phylum Hemichordata (1 hr)

Balanoglossus: Salient features

Unit 7: Coelomate minor phyla (1hr)

Salient features of the following Coelomate minor phyla

Echiura(eg. *Bonellia)*
Phoronida (eg. *Phoronis)*

Module IV: Economic, Ecological and evolutionary importance of non-chordates (10 hrs). (15marks)

Unit 1. Evolutionarily significant Non-chordates (2 hrs)

Larval forms Mention Cydippid, Trochophore, Nauplius, Zoea, Megalopa, Glochidium, Veliger, Bipinnaria, Brachiolaria, Echinopluteus, Ophiopluteus and Tornaria. (Structural details not expected). [Emphasis on adaptations, distribution and survival as well as phylogenetic significance]

Living fossils – *Limulus, Nautilus*; Extinct forms - Trilobites.

Unit 2. Economically important Non-chordates (5 hrs)

Pollination by insects (especially honeybees)
Vermiculture (Role of earthworms in nutrient recycling and vermiculture**)**
Pearl formation in bivalves
Spider silk and web formation
Edible molluscs
Harmful forms – *Teredo*, Any one Insect pest

Unit 3. Ecological indicators and adaptations (3 Hrs)

Coral reefs (Coral reef ecosystems, bleaching and sustainable reef management)
Mention ecological indicators -*Tubifex, Chironomus*
Parasitic adaptions in helminthes

Module V: Practicals - Non chordata [1 Credit; 30 Hours]

[Students are expected to make sketches/photographs with notes, while they study the specimens in the laboratory/field itself. The record must carry sketches/photographs/copy of printed figures with notes of all specimens, mountings and dissections. Emphasis must be on scientific accuracy and not on beauty of sketches.]

MANDATORY EXPERIMENTS

1. Study of the following specimens:
   - *a. Protists: Noctiluca, Entamoeba, Trichonympha, Paramecium [any 2]*
   - *b. Poriferans: Leucosolenia / Scypha / Spongilla*
   - *c.Cnidarians: Sedentary hydrozoans: Obeliacolony / Obelia medusa*
     - *Pelagic hydrozoans: Physalia*
     - *Pelagic scyphozoan: Aurelia/ Rhizostoma*
     - *Common anthozoans: Adamsia, Madrepora, Fungia, Tubipora, Gorgonia [any 2]*
   - *d.Helminths: Platyhelminths: Free living flat worm: Bipalium / Dugesia*
     - *Parasitic flat worms: Fasciola/Taenia solium*
     - *Aschelminths: Parasitic round worms: Ascaris/Ancylostoma*
   - *e. Annelids: Polychaetes: Neanthes, Aphrodite, Chaetopterus, Arenicola [any 1]*
     - *Common earthworm: Megascolex / Pheretima*
     - *Leech: Hirudinaria, Heamadipsa, [any 1]*
   - *f. Arthropods: Items of evolutionary / taxonomic importance - Limulus / Streptocephalus*
     - *Common fouling barnacle – Lepas / Balanus*
     - *Parasitic crustaceans– Sacculina / Cymathoa*
     - *Crustacean of the sandy shore– Emerita / Albunea*
     - *Symbiotic crustacean - Eupagurus*
     - *Economically important crustacean - Penaeus*
     - *Vectors – Cyclops, Aedes, Musca, Xenopsylla [any 2]*
     - *Insect pests – Lepisma, termite queen, Pest of paddy, Pest of coconut, Pest of mango, pest of stored grains [any 4]*
     - *Aquatic insects – Belostoma / Nepa / Ranatra*
     - *Predatory insect - Dragonfly / Ant-lion / Mantis*
     - *Insect which camouflages - Carausius / Phyllium*
     - *Common myriapods – Scolopendra / Scutigera / Julus / Spirostreptus*
     - *Common arachnids – Palamnaeus / Buthus / Spider / tick / mite [any 2]*
   - *g. Molluscs: Inter tidal molluscs – Chiton, Patella, Haliotis, Aplysia [any 1]*
     - *Ornamental gastropods – Cypraea, Murex, Turbinella [any 1]*
     - *Poisonous gastropod – Conus*
     - *Pelecypods of economic importance – Perna, Pinctada, Teredo [any 2]*
     - *Scaphopod - Dentalium*
     - *Cephalopods of economic/evolutionary importance - Sepia, Loligo, Octopus, Nautilus [any 2]*
   - *h. Echinoderms: Antedon, Asterias, Ophiothrix, Cucumaria, Echinus [any 2]*
   - *i. Hemichordate: Balanoglossus*
   - *j. Onychophora: Peripatus*
   - *k.* Minor phyla: *Phoronis / Bonellia / Chateonotus / any other specimen*
2. Mounting of Earthworm setae in situ
3. Mounting of Prawn appendages

4. Dissection of Prawn to display Nervous system

Of the remaining experiments any 4 can be selected by the Institution from the following list. Two experiments other than the listed should be selected by the Supervising teacher and introduced to the students.

5. Honeybee: mounting of Mouth parts
6. Dissection of Earthworm: Alimentary canal
7. Cockroach: Salivary apparatus
8. Cockroach: Nervous system
9. Examination of pond water collected from different places for diversity in Protista.
10. Metamorphosis in Insects (rearing of an insect [*Drosophila* / Mosquito] to view the various life stages).
11. Plant bug: Mounting of Mouth parts
12. Mosquito: Mounting of Mouth parts

Field Study: Visit to any **field/ecosystem** in the local body (within Panchayat/Corporation) to create awareness of local biodiversity richness of non-chordates and prepare a local biodiversity register with geo-tagged photographs of minimum 20 specimens belonging to any 3 or more non-chordate phyla studied.

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Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1		3					3						
CO 2		3					3						
CO 3		3					3						
CO 4					3						3		
CO 5		3					3						
CO6				3	2	3		2	3				3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Assignment	Practical exam	End semester exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓
C05	✓	✓		✓
CO6	✓		✓	✓

CELL BIOLOGY & GENETICS

Programme	B.Sc. Zoology				
Type of Course	Major				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total hours
	4	3		2	75
Pre-requisites	+2 /VHSC Biology or equivalent online courses				
Course objectives	The course develops an understanding in the cellular organization, gene concept and hereditary principle, etc.				

Course outcomes (CO)

CO	CO statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Illustrate the life cycle of cells, aging of cells, apoptosis and its deregulation in diseases such as cancer.	U	F&C	Short answer, Paragraph, questions
CO2	Describe the ultrastructure and important functions of plasma membrane as well as membraned and non-membraned cell organelles	U	F&C	Short answer, Paragraph, Essay type questions
CO3	Explain chromosomal inheritance, Mendel's contributions, allelic and non-allelic interactions, structure & classification of human chromosomes	U	F&C	Short answer, Paragraph, Essay type questions
CO4	Distinguish genes; gene types, gene bank, gene cloning, gene mapping, genome sequencing and different modes of inheritance	U	F&C	Short answer, Paragraphtype questions
CO5	Perform experiments like, staining of epithelial cells, blood cells, chromosomes of onion and drosophila.	Ap	C&P	Practical lab exams, Viva- voce, report writing
CO6	Conduct surveying to find out the intensity of occurrence of various genetic traits in local population.	Ap	C&P	Viva – Vove, report writing

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Module 1: Cell - life cycle (12 Hrs) (Out of 70: 15marks)

Unit 1: Cell theory and cell cycle: (4 Hrs)-. Cell Theory. Phases of cell cycle - G1, S, G2 and M phases – Check points; G0 phase. Cell division: Mention different types of divisions such as Amitosis, Mitosis and Meiosis and Cleavage.

Unit 2: Interphase nucleus (3 Hrs) - General structure; mention nucleo-cytoplasmic index; ultrastructure of nuclear pore complex (NPC); Nucleoplasm - Composition and function; Nucleolus - Structure, composition, nucleolar organizer, nucleolar cycle and functions of nucleolus.

Unit 3: Chromosomes (2 Hrs) -A typical chromosome structure, Euchromatin and heterochromatin. Human Karyotype.; Nucleosome organization and higher order structures; Endomitosis; Giant chromosomes - (Polytene chromosomes, Lamp brush chromosomes) structure and significance.;
Unit 4: Ageing, Apoptosis and Cancer (3 Hrs) -. Theories of Ageing. Mechanism of apoptosis and its significance. Characteristics of cancer cells; causes of transformation. Types of cancer.

Module 2:. Cell organelles (11 Hrs) (22marks)
Unit 1: Plasma membrane (3 Hrs) - Chemical composition and structure (unit membrane concept and fluid mosaic model).; Modifications of the plasma membrane – microvilli, desmosomes, nexuses, tight junction and gap junction.
Functions: trans-membrane transport mechanisms – diffusion, osmosis, active transport, ion transport (channels), co-transport, bulk trans-membrane transport – exocytosis, endocytosis.
Unit 2: Mitochondria (1 Hrs) - Ultra-structure and Functions of mitochondria; Biogenesis and dynamic nature of mitochondria.
Unit 3: Lysosomes and GERL (2 Hrs) - Lysosomes - Structure and function; polymorphism in lysosomes, lysosomal enzymes.; GERL- Golgi body – Endoplasmic Reticulum – Lysosome complex
Unit 4: Centrosome and Cytoskeleton (2 Hrs) - Location, ultrastructure, biochemical composition and functions of microfilaments, intermediate filaments and microtubules. Centrosome cycle.
Unit 5: Ribosomes (1 Hrs) - Ultra structure and functioning
Unit 6: Cytoskeleton. Microtubules, Microfilaments and Intermediate filaments (2 Hrs)

Module. 3 Factors of Inheritance (12 Hrs) (16marks)
Unit 1: Introduction to inheritance (2 Hrs)- Nature vs nurture. Mendelian inheritance and Non-Mendelian inheritance (in brief)
Unit 2: Concept of gene (4 Hrs) - Gene structure; Pseudogenes; Modifying genes; Housekeeping genes and luxury genes, Complementary genes, Polymeric genes and Duplicate genes with examples. Gene mapping and genomic sequencing. Genbank, gene cloning. Expression and penetrance. Pleiotropy.

Unit 3: Mutations (3 Hrs) - Chromosome mutations: numerical (euploidy and aneuploidy) and structural changes (deletion, duplication, insertion, inversion, translocation).
Gene mutations: types. Point mutation and frameshift mutations. Mutagenesis- Natural and artificial mutagenesis, Mutagenic agents: a) UV radiation and ionizing radiation b) Base analogues, alkylating and intercalating agents.

Unit 2: Alleles, isoalleles and pseudoalleles (3 Hrs) -Allelic interactions: codominance and incomplete dominance with example. Non-allelic interactions: Epistasis: dominant and recessive epistasis Multiple alleles (ABO blood group system and coat colour in rabbits)
.
Module. 4 Linkage, Recombination and modes of Inheritance (10 Hrs) (17marks)
Unit 1: Linkage and Recombination (6 Hrs) - Definition and characteristics of linkage groups, Morgan's work on Drosophila. Types of linkage: complete and incomplete with examples; Crossing over and recombination; Linkage map and Map Distance (brief).
Sex-Linked Characteristics: Types of sex-linkage - X linked characters - Colour blindness and haemophila in humans, holandric genes – hypertrichosis.
Sex-Influenced and Sex-Limited Characteristics with examples
Unit 2: Modes of inheritance (4 Hrs)
Autosomal dominant inheritance, autosomal recessive inheritance and X-linked inheritance. Multifactorial inheritance (in brief).

Module 5: PRACTICALS (1 CREDIT, 30 Hrs)
MANDATORY EXPERIMENTS

1. To study the effect of isotonic, hypotonic and hypertonic solutions on RBCs.
2. Mitosis: Identify stages in onion (*Allium cepa*) root meristem by squash preparation.
3. Study of inheritance of human traits using pedigree charts.Widow's peak, attached ear lobe, dimple in chin, hypertrichosis, Blood groups, Eye colour
4. Study through photographs of Karyotype (Human, Drosophila) and sex linked inheritance - Haemophilia and Colour blindness (Ishihara Chart).

From the remaining 6, four experiments can be selected by the teacher; Two more experiments (not included in the list) are to be designed by the teacher

5. Study of the polytene chromosome of *Drosophila melanogaster* using salivary gland cells of 3rd instar larva (Demonstration).
6. Cytochemically demonstrate presence of DNA in cheek cells or onion peel using Feulgen reagent.
7. Study of diversity of eukaryotic cells. Methylene blue staining of buccal epithelium, striated muscle cells.
8. Genetic problems on Monohybrid, dihybrid crosses; blood groups; sex-linked inheritance. incomplete dominance (One problems each).
9. Observation of Barr body in buccal epithelial cells or drumstick in WBC
10. Study of different stages of meiosis in grass hopper testes

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Online Sources

1.https://onlinecourses.swayam2.ac.in/cec24_bt04 (Cell biology 5 credits)
2.https://onlinecourses.nptel.ac.in/noc24_bt18 (Cell biology 2 credits)
3. https://onlinecourses.swayam2.ac.in/cec24_bt12 (Genetics 4 credits)

Mapping of COs with PSOs and POs :

	PSO 1	PS O2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1		3					3						
CO 2		3					3						
CO 3		3					3						
CO 4		3					3						
CO 5				3	3				3				
CO6						3		2	2			2	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Quiz / Assignment/ Discussion / Seminar
Exam
Project/Practical
Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Assignment	Practical exam	End semester exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓
C05			✓	✓
CO6		✓	✓	✓

BASICS IN AQUACULTURE AND FISHERY SCIENCE PRACTICES

Programme	B.Sc. Zoology				
Type of Course	Major				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total hours
	4	3		2	75
Pre-requisites	+2 /VHSC Biology or the following online courses 1. https://onlinecourses.swayam2.ac.in/cec21_bt01/preview 2. https://elearning.fao.org/course/view.php?id=579 3. https://www.classcentral.com/classroom/youtube-aquaculture-types-of-culture-systems-179652 4. https://fisheries.tamu.edu/training-online-courses/				
Course objectives	The student develops understanding and knowledge about different aquatic culture species, culture methods and aquaculture systems. Student develops skill in developing aquaculture systems				

Course Outcomes (COs)

CO	CO statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify and describe major commercially important aquaculture species of India and the basic principles of aquaculture and culture methodologies of fishes and shellfishes.	U	F&C	Short answer, Paragraph, questions
CO2	Describe the concepts of pond culture, pen culture, cage culture and other advanced culture systems	U	F&C	Short answer, Paragraph, questions
CO3	Explain different types of tools used in fishing and resource utilization.	U	F&C	Short answer, Paragraph questions
CO4	Manage induced breeding of fish and hatchery technology; fish disease diagnosis	Ap	C&P	Short answer, Paragraph, Essay questions
CO5	Develop expertise in setting up and maintenance of different types of aquaculture systems in commercial level.	Ap	C&P	Practical lab exams, Viva- voce, report writing
CO6	Prepare field reports on visiting aquaculture systems, fish processing centers and fish landing centers	C	M&P	Viva- voce, report writing

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Module 1: Unit 1: Introduction to Aquaculture (6hrs) (Out of 70: 6marks)
Unit 1. Aquaculture – Definition. Criteria for selection of species for aquaculture. Commercially important aquaculture species in India. Freshwater, Brackish and Marine finfish and shellfish species. Brief account of classification of aquaculture based on: Environment – Freshwater, brackish water and mariculture.

Module 2: Culture Techniques and breeding(12hrs) (20marks)
Unit 1: Culture techniques (3 hrs): pond aquaculture, cage culture, pen culture, raft culture, pole culture, rack culture and long line culture. Number of species – Mono culture and poly culture.
Unit 2: Type of culture and breeding (9 hrs): Brief account on prawn culture, shrimp culture, edible oyster culture, lobster culture, mussel culture, pearl culture, pisciculture etc. Important cultivable species in India, seed collection, spawning and larval rearing, induced breeding. Mudbanks of Kerala coast.

Module 3: Aquaculture systems(17hrs) (22marks)
Unit 1: Aquaculture (8 hrs): Principles of Aquaculture, Site selection, Surveying, Pond preparation-Layout of a farm. Weed eradication, Water quality requirements, Selection of candidate species (indigenous/exotic). Live feed culture, Feed formulation.
Unit 2: Culture and breeding of finfishes (9 hrs): Carps, Air breathing fishes, Catfishes, Tilapia, Etroplus. Broodstock management, seed production, larval rearing, growout technology, types of hatcheries, design; feed management, harvesting and marketing.

Module4: Fishing resources and management (10hrs) (22marks)
Unit 1: Fishing crafts and gears (4 hrs): Mention Catamaran, Canoes and dug-out-canoes. Gillnet/drift gillnet, purse-seines, harpoon, Chinese dipnets, echo sounders, sonar, remote sensing. Prohibited fishing practices, trawl ban, impacts of trawling.
Unit 2: Fish diseases, spoilage and preservation (6 hrs): Biochemical changes, spoilage, use of ice, freezing, canning, dehydration, salting and smoking. Fish and Shell fish diseases (Bacterial, fungal, viral). Cryopreservation of fish germplasm, semen bank and preservation media.

Module 5: Practicals – 30 hrs; 2hrs per week; Credit – 1
Experiments1-4 are mandatory; from the remaining 6, four experiments can be selected by the teacher; Two more experiments (not included in the list) are to be designed by the teacher.

1. Identification of culturable species.
2. Identification of aquatic weeds, pests and predators.
3. Feed formulation and preparation for cyprinids, catfishes, prawns, etc.
4. Preparation of field study report after visiting, hatchery and farm/ fish processing plants,/ice plant and fish landing centre/ institutes like CMFRI/ CIFNET/ KUFOS (Maximum **TWO** days)
5. Collection and preservation of crustaceans, molluscs, fishes and other aquatic organisms
6. Identification of fishing crafts(models, charts, pictures can also be used)
7. Making of culture devices: rafts for mussel culture, happa for fish culture etc. (models can be made)
8. Water quality analysis of aquaculture systems (pH, salinity, dissolved Oxygen, BOD etc.,)
9. Culturing of any commonly available culture fishes in synthetic tanks, ponds etc.
10. .Identification of Fish and shell fish diseases

Virtual lab:
1. https://blue-cloud.d4science.org/web/aquacultureatlasgeneration
2. https://www.aquaexcel2020.eu/virtual-laboratory

3. https://www.aquafeed.com/regions/europe/new-virtual-fish-laboratory-open-for-use/

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Online Sources

1. https://www.tandfonline.com/journals/brfs21
2. https://www.fisheries.noaa.gov/topic/aquaculture/science-&-technology

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3					3						
CO 2		3					3						
CO 3		3					3						
CO 4				3	3				3				3
CO 5				3	3						3		
CO6					3-	3							3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Quiz / Assignment/ Discussion / Seminar
Exam
Project/Practical
Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Assignment	Practical exam	End semester exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓
CO5			✓	✓
CO6	✓			✓

ANIMAL DIVERSITY-II-CHORDATA

Programme	B.Sc. Zoology				
Type of Course	Major				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total hours
	4	3		2	75
Pre-requisites	+2 /VHSC Biology or equivalent online courses: 1. https://www.acsebooks.com/product-ungulate-animals-pdf-ebook-6155.aspx 2. https://www.su.se/english/search-courses-and-programmes/bl7034-1.413080#:~:text=Animal%20Diversity%20%E2%80%94%20Vertebrates%20is%20an,main%20points%20of%20the%20course 3. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/225/ANIMAL DIVERSITY 22				
Course objectives	The student develops understanding of the general characteristics and classification of Phylum Chordata, analyze the salient features of ***Hoplobatrachus tigerinus*** (Indian Bullfrog) with emphasis on selected systems, create awareness in the significance of conservation of chordates and will be able to perform simple dissections in order to study its characteristic features.				

Course Outcomes (COs)

CO	CO statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Enumerate the salient features and examples of Phylum Chordata	U	F & C	Oral exams, Quizzes, Written exams
CO2	Describe the classification principles vertebrates within Phylum Chordata, with emphasis on Pisces, Amphibia, Reptilia, Aves, and Mammalia	U	F & C	Oral exams, Written exams
CO3	Analyze the anatomical and physiological adaptations of various vertebrate groups to their environments	An	F & C	Assignments, Written exams
CO4	Explain identification keys for distinguishing between venomous and non-venomous snakes	U	F C & P	Assignments, Practicals, Written exams
CO5	Appreciate the biodiversity of vertebrates, with a focus on indigenous species and their conservation	E	F C& P	Practical sessions, Case studies, Field trips
CO6	Conduct field study and prepare report; contribute towards the preparation of Local Biodiversity register	C	F C P &M	Field study report,Oral presentations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

MODULE I. Protochordates to Tetrapods (11 hours) (Out of 70: 15marks)

Unit 1. Introduction to Chordata (1 hour)

Chordate characters (fundamental, general and advanced); chordates versus non-chordates; Outline the classification of Phylum Chordata down to classes.

Unit 2. Subphylum Cephalochordata and Subphylum Urochordata (3 hours)

General characteristics and classification of sub-phylum Cephalochordata up to Classes

Class Leptocardiie.g. *Branchiostoma*

General characteristics and classification of sub-phylum Urochordata up to Classes Ascidiacea, Thaliacea and Larvacea

Class Ascidiaceae.g. *Ascidia*– Retrogressive Metamorphosis, Mention neoteny and paedogenesis

Class Thaliaceae.g. *Salpa*

Unit 3. Subphylum Vertebrata Division I – Agnatha (1 hour)

Characteristics and classification down to classes eg. *Petromyzon,*mention Ammocoetes larva

Unit 4. Subphylum Vertebrata Division II – Gnathostomata Superclass Pisces (6 hours)

Classification of fishes down to subclasses, Salient features of the following extant groups

Class Chondrichthyes

Subclass Selachii e.g. *Scoliodon,* mention Mermaid's Purses

Subclass Holocephali e.g. *Chimaera*

Class Osteichthyes

Subclass Sarcopterygii e.g. *Latimeria*

Subclass Actinopterygii e.g. *Sardinella*, *Etroplus suratensis*

MODULE II. Subphylum Vertebrata – Superclass Tetrapoda – I (11 hours) (18 marks)

Unit. 1. Class Amphibia (4 hours)

Type: ***Hoplobatrachus tigerinus*** (Indian Bullfrog)

Morphology, skeletal system (exclude skull bones), digestive system, respiratory system, circulatory system, excretory system and reproductive system

Unit 2. Classification of Amphibia (3 hours) Classification down to orders, Characteristic features of the following extant examples

Order Gymnophiona e.g., *Ichthyophis*

Order Caudata (=Urodela) e.g, *Andrias davidianus* (Chinese Giant Salamander), Mention the three Indian species of *Tylototriton (T. verrucosus,T.himalayanus and T.* zaimeng), *Ambystoma*, mention Axolotl larva

Order Anura e.g., *Rhacophorus*

Unit. 3. Class Reptilia (4 hours)

Classification of class Reptilia down to orders and salient features of thefollowingorders (onlyextant forms)

Subclass Anapsida

Order Testudines e.g., *Geochelone elegans*

Subclass Diapsida

Order Rhynchocephalia e.g., *Sphenodon*

Order Squamata Suborder Lacertilia e.g., *Chamaeleozeylanicus*

Suborder Ophidia e.g., *Hydrophis, Lycodonaulicus*

Order Crocodilia e.g., *Gavialis gangeticus*

Mention Arribada.Mention Polyvalent Snake Antivenoms.

MODULE III. Subphylum Vertebrata – Superclass Tetrapoda – II (10 hours) (15marks)

Unit 1. Class Aves (2 hours)

Classification of class Aves down to orders and salient features of thefollowingorders (onlyextant forms)

Subclass Archaeornithes

Order Archaeopterygiformes e.g., *Archaeopteryx*

Subclass Neornithes

Super order Palaeognathae

Orders Casuariiformes, Dinornithiformes, Rheiformes, and Struthioniformes

Order Struthioniformes e.g., *Struthio* and

Order Dinornithiformes e.g., *Apteryx*

Unit 2. Super order Neognathae (3 hours)

Order Galliformes e.g., *Pavo cristatus*
Order Coraciiformes e.g., *Merops orientalis*
Order Bucerotiformes e.g., *Ocyceros griseus*
Order Cuculiformes e.g., *Eudynamysscolopaceus*
Order Psittaciformes e.g., *Psittaculakrameri*
Order Columbiformes e.g., *Columba livia*
Order Falconiformes e.g., *Falco peregrinus*
Order Accipitriformes e.g., *Accipiter badius*
Order Strigiformes e.g., *Tyto alba*
Order Passeriformes e.g., *Pycnonotus jocosus*
Order Charadriiformes e.g., *Tringa*
Order Sphenisciformes e.g., *Aptenodytes*

Unit 3. Class Mammalia (5 hours)

Classification of class Mammalia down to orders and salient features of theorders cited with specified examples

Subclass Prototheria

Order Monotremata e.g. *Ornithorhynchus, Tachyglossus*

Subclass Theria

Order Marsupialia e.g. *Macropus*
Order Edentata e.g. *Myrmecophaga*
Order Pholidota e.g., *Manis*
Order Lagomorpha e.g. *Lepus nigricollis.* Mention dentition in rabbit.
Order Rodentia e.g. *Funambulus*
Order Chrysochloridea e.g., Golden mole of Africa
Order Dermoptera e.g., *Cynocephalus*
Order Soricimorpha e.g. *Crocidura.* Mention discovery of *C. narcondamica*
Order Erinaceomorpha e.g., *Paraechinusnudiventris*
Order Chiroptera e.g. *Pteropus giganteus, Latidenssalimalii*

Order Primates	e.g. *Hylobates*
Order Carnivora	e.g., *Vivericula indica*
Order Cetacea	e.g. *Balaenoptera*
Order Artiodactyla	e.g. *Bos gaurus, Sus scrofa cristatus*
Order Perissodactyla	e.g., *Rhinoceros*
Order Sirenia	e.g. *Dugong*
Order Proboscidia	e.g. *Elephus maximus indicus.* Mention *Loxodonta.*
Order Pholidota	e.g., *Manis*
Order Hyracoidea	e.g., *Dendrohyrax* (Tree hyrax)
Order Tubulidentata	e.g., *Orycteropus* (Aardvark)

MODULE IV. Ecologically, Economically and Evolutionarily significant chordates (13 hours) (22marks)

Unit 1. Ecologically important chordates from Kerala

Sub-terranean fishes from Kerala:

Mention *Pangiopathala, Kryptoglanisshajii, Horaglanis populi, Monopterus, Rakthamichthys indicus, Aenigmachannagollum*

Endangered and Threatened Amphibians

Diversity of bush frogs, dancing frogs and night frogs in Western Ghats

Mention the Indian sanctuaries with Amphibians as flagship species -- Jore Pokhri Wildlife Sanctuary –*Tylototritonverrucosus (*Himalayan Newt); Mathikettan Shola National Park – *Melanobatrachus indicus* (Galaxy Frog)

Reptilia from Kerala

Contributions of Padmashree Rhomulus Whitaker in Reptile Conservation

Common venomous and non-venomous snakes of Kerala: a] *Python molurus*b] *Ptyas mucosa*] *Gongylophis* (= *Eryx*) *conicus*d] *Indotyphlopsbraminus*e] *Bungarus caeruleus* f] *Naja naja*g] *Daboia russellii*h] *Ophiophagus hannah*

Identification key for venomous and non-venomous snakes

Endemic birds of the Western Ghats

Myophonushorsfieldii (Malabar Whistlingthrush), *Leptocoma minima* (Crimson-backed Sunbird), *Anthusnilghiriensis* (Nilgiri Pipit), *Chrysocolaptes socialis* (Malabar Flameback)

Endemic/Endangered Mammals from Kerala *Macaca silenus* (Lion-tailed macaque), *Niligiritragus hylocrius* (Nilgiri Tahr), *Martes gwatkinsii* (Niligiri marten)

Unit 2. Economically important chordates

Ornamental fishes from Kerala ---Denison's barb/ Miss Kerala --*Sahyadriadenisonii,* Rosy barb–*Pethiaconchonius*, Honey gourami -*Trichogasterchuna*, Indian glassy fish—*Parambassisranga,* Yoyo loach–*Botiaalmorhae*

Dolphin echolocation and biosonar technology

Unit 3. Evolutionarily significant chordates

Affinities and systematic position of Cephalochordata

Neoceratodus, Protopterus, Lepidosiren

Nasikabatrachussahyadrensis

Mention the extinct subclasses Euryapsida, Parapsida and Synapsida (mammal- like reptiles) and mention the origin of mammals from synapsids

Rediscovery of *Rhinoptilusbitorquatus* (Jerdon's Courser) and *Athene blewitti* (Forest owlet)

Recent Extinctions: Passenger Pigeon [*Ectopistesmigratorius*), Dodo [*Raphus cucullatus*], Pink-headed Duck [*Rhodonessacaryophyllacea*], Elephant Bird [*Aepyornis*].

MODULE V. Practicals- Chordata[1 Credit; 30 Hours]

[Students are expected to make sketches/photographs with notes, while they study the specimens in the laboratory/field itself. The record must carry sketches/photographs/copy of printed figures with notes of all specimens, mountings and dissections. Emphasis must be on scientific accuracy and not on beauty of sketches.]

MANDATORY EXPERIMENTS

1. **Study of the following specimens:**

(Students are expected to identify the specimens by their generic names, respective phyla /classes/ orders)

a. **Cephalochordates:** *Branchiostoma*
b. **Urochordates:** *Ascidia*, *Salpa* (any 1)
c. **Agnathans:** *Petromyzon*, Ammocoetes larva [any 1]
d. **Fishes:**
i) Common elasmobranchs - *Chiloscyllium, Stegostoma, Sphyrna, Pristis, Trygon, Narcine, Astrapes* [any 2]
ii) Common edible fishes (marine) - *Sardinella, Rastrelliger, Cynoglossus, Parastromateus, Trichiurus, Cybium, Thunnus* [any 2]

iii) Common edible fishes (Inland) - *Etroplus, Mugil, Wallagonia, Tilapia, Catla, Cirrhina, Labeo, Cyprinus* [any 3]

iv) Fishes with special adaptive features - *Hippocampus, Belone, Exocoetus, Tetrodon, Pterois, Ostracion, Heteropneustes, Clarias, Anabas, Channa, Echeneis, Antennarius, Anguilla* [any 3]

e. **Amphibians:** Common amphibians - *Duttaphrynus, Euphlyctis, Rhacophorus, Hyla, Ambystoma*, Axolotl larva, *Ichthyophis*/*Uraeotyphlus* [any 3 – one from each order]

f. **Reptiles** :

i) Common lizard - *Hemidactylus, Calotes, Mabuya (Eutropis)* [any 1]
ii) Lizards with special adaptations - *Draco, Chamaeleo, Phrynosoma* [any 2]
iii) Non venomous snakes - *Ptyas, Gongylophis, Lycodon, Indotyphlops*[any 2]
iv) Venomous snakes - *Naja, Daboia, Bungarus, Echis* [any 3]
v) Water snake – *Hydrophis / Enhydris*/ *Xenochrophis*
vi) Arboreal snake – *Dendrelaphis / Python / Ahaetulla*
g. **Birds**:

i) Fossil bird - *Archaeopteryx*
ii) Flightless bird - *Rhea, Struthio* [any 1]
iii) Wetland birds - Waterhen, Duck, Egret, Heron, Ibis, Stork [any 2]
iv) Shore birds – Gulls, Plovers, Terns [any 1]
v) Migratory birds - Pelican, Crane, Flamingo [any 1]
vi) Birds of Prey – Falcon, Eagle, Kite, Shikra, Owl [any 2]
h. **Mammals**:
i) Common insectivore – *Suncus*, Hedgehog [any 1]

ii) Common rodent – *Rattus, Bandicoota, Funambulus* [any 1]
iii) Common bat of Kerala – *Pteropus, Megaderma, Pipistrellus* [any 1]
iv) Small Carnivore – Jungle Cat, *Herpestes*, Civet [any 1]
v) Primate – *Loris* or any other species
2. **Osteology**
a. Frog: Pectoral & Pelvic girdles
b. Rabbit: Skull showing dentition
3. Mounting of Placoid scales of Shark
4. Dissect and display the alimentary canal of Sardine/Mullet
Of the remaining experiments any 4 can be selected by the teacher from the following list. Two experiments other than the listed should be identified by the Supervising teacher and introduced to the students.
5. Mounting of cycloid scales of Sardine/ctenoid scales of Mullet
6. Osteology: Frog: Typical, 8^{th} and 9^{th} Vertebrae
7. Histology: *Branchiostoma* - T. S. through pharyngeal region
8. Key for identification of venomous and non-venomous snakes.
9. Features and adaptations of: duck, parrot, king fisher, owl, kite and wood pecker [sketches/photographs/copy of printed figures of the beaks and feet of 4 birds)

10.Locate the distribution of following animals in the worldmap: Lungfishes, *Sphenodon*, monotremes, marsupials
11. Study on different types of Feather, Structure and Adaptations
12. Morphometric measurements of fishes
13. **Local Biodiversity Record:** Observe birds of the locality in their natural habitat and prepare a field note.

Field Study: Visit to any Hatchery/aquarium, Zoo/Virtual Zoo, Wild life Sanctuary/National park in Kerala to create awareness of biodiversity richness of chordates and prepare a field study report with geo-tagged photographs of minimum 20 specimens belonging to any 2 or more Classes of Phylum Chordata studied.
Suggested Activities

- Awareness on software application SARPA and Snakepedia
- Awareness on software application 'Merlin', 'Kili','Indian birds' and its installation

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Online resources

Sardinella digestive system
https://www.youtube.com/watch?v=r_pSMuE25rw

Virtual tour
https://www.360virtualtour.co/portfolio/google-street-view-of-london-zoo-virtual-tour/

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1		3					3						
CO 2		3					3						
CO 3					3		3						
CO 4		3					3						
CO 5					3				3		2		
CO6		3					3						2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:
Quiz / Assignment/ Discussion / Seminar
Exam
Project/Practical
Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Assignment	Practical exam	End semester exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓
C05			✓	✓
CO6	✓	✓		✓