MANIPUR UNIVERSITY

UG COURSE IN ZOOLOGY (NEW)

FIRST YEAR (SEMESTER I & II)

(As per Manipur University Ordinance for Four Year Undergraduate Program 2025 based on NEP – 2020)

For implementation from the year 2025

MANIPUR UNIVERSITY
UG COURSE IN ZOOLOGY
Course Structure (NEW)

(As per Manipur University Ordinance for Four Year Undergraduate Program 2025 based on NEP – 2020)

1.1 Credit distribution for the course

Semester	Course Opted	Course code	Name	Credit
I	Ability EnhancementCourse	**AEC45Z00101(T)25**	Communication Skills	4
	Major-I	**MJC45ZOO101(T)25**	Animalia, Non-chordates: Protozoa to Echinodermata, Minor Phyla	3
	Major -I Practical	**MJC45ZOO101(P)25**	,,	1
	Minor-I	**MNC45ZOO101(T)25**	Fundamentals of Zoology-1 : Non Chordates	3
	Minor-I Practical	**MNC45ZOO101(P)25**	,,	1
	Multidisciplinary Course - 1	**MDC45ZOO101(T)25**	Introduction to Animal diversity - 1	3
	Skill Enhancement Course (SEC)- I	**SEC45ZOO101a(T)25** **SEC45ZOO101b(T)25** **SEC45ZOO101c(T)25**	Aquarium Fish keeping **or** Apiculture **or** Poultry farming	2
	Skill Enhancement Course (SEC)- I Practical	**SEC45ZOO101a(P)25** **SEC45ZOO101b(P)25** **SEC45ZOO101c(P)25**	Aquarium Fish keeping **or** Apiculture **or** Poultry farming	1
	Value added Course (VAC) - I	**VAC45ZOO101(T)25**	As per College preference e.g. NCC/NSS/Solid Waste management/IPR	2
				20
II	Ability Enhancement Course	**AEC45Z00102(T)25**	Academic Writing	4
	Major-2	**MJC45ZOO102(T)25**	Chordates : General organization – Hemichordata to Mammalia	3
	Major-2 Practical	**MJC45ZOO102(P)25**	,,	1
	Minor-2	**MNC45ZOO102(T)25**	Fundamentals of Zoology-2 : Chordates	3
	Minor-2 Practical	**MNC45ZOO102(P)25**	,,	1
	Multidisciplinary Course - 2	**MDC45ZOO102(T)25**	Introduction to Animal diversity - 2	3

	Skill Enhancement Course (SEC)- II	**SEC45ZOO102a(T)25** **SEC45ZOO102b(T)25** **SEC45ZOO102c(T)25** **SEC45ZOO102d(T)25**	Sericulture **or** Vermicomposting **or** Organic farming **or** Fish Farming	2
	Skill Enhancement Course (SEC)- II Practical	**SEC45ZOO102a(P)25** **SEC45ZOO102b(P)25** **SEC45ZOO102c(P)25** **SEC45ZOO102d(P)25**	Sericulture **or** Vermicomposting **or** Organic farming **or** Fish Farming	1
	Value added Course (VAC) - 2	**VAC45ZOO102(T)25**	As per College preference e.g. NCC/NSS/Solid Waste management/IPR	2
				20
Summer Internship in a Research laboratory or a Government Institute outside the College in an area of Zoology. This must be taken up during summer vacation in the first year (i.e. during Semester I and II)				**4**
Exit option with Bachelor's Certificate in Zoology on completion of Courses equal to a minimum of 44 Credits including the Credits for the work-based summer internship.				

N.B.*: Students can earn upto 40 % of the total Credits of a given Semester through online learning Courses offered via SWAYAM or any other platform recognized by the UGC, provided they need to declare their chosen Courses before the semester begins. Only equivalent Credits or those exceeding the Credit allocation in Multidisciplinary Courses (MDC), Ability Enhancement Courses (AEC), Skill Enhancement Courses (SEC) and Value-added Courses (VAC) may be selected.*

For Zoology Students, Multi-disciplinary Course can be selected from other Subjects. Multi-disciplinary Course " Introduction to Animal diversity" must be offered by Students of subjects other than Zoology.

Major -I: MJC45**ZOO101(T)25**

(Animalia, Non-Chordates : Protozoa to Echinodermata, Minor Phyla)

Objective:

The course is aimed with the objective of providing knowledge of the diversity of animal life especially among the non Chordates. It shall provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organization of the animals based on their evolutionary relationships, structural and functional affinities. Morphological and anatomical features of diverse animal groups; their significance and their relationships have been incorporated to create interest among the students to explore the animal diversity in nature. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Outcome:

The outcome expected on completion of Course:

- Having knowledge of systematic position, habitat and structural organization of non-chordates.
- Understand the economic importance of non-chordates, their interaction with the environment, role in the ecosystem, evolutionary history and their relationships.
- Having enhanced knowledge of the said group and communication skills through practical sessions, group discussions, assignments and projects.
- Appreciate the diversity of non-chordates living in diverse habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically think about the organization, complexity and characteristic features of non-chordates.
- Getting familiarized with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

Course Content:

Theory [Credits: 3] 45 hrs/ 100 marks(70 for end exam, 30 for Internal assessment)

Unit 1: Animalia, Non- Chordates : Protista, Porifera 9 hrs/ 14 marks

Characteristics of Animalia and Basis of Classification; Classification & Characters up to Classes for Protista; Life cycle and pathogenicity of *Plasmodium* sp.*;* Mode of Nutrition, Locomotion and Reproduction in Protista. Introduction to Parazoa/ Porifera; General characteristics and Classification up to Classes; Skeleton & Canal systems in sponges, Economic importance of Sponges

Unit 2: Cnidaria, Ctenophora & Platyhelminthes 9 hrs/ 14 marks

Introduction to Metazoa: General characteristics and Classification up to Classes of Coelenterata; Metagenesis in *Obelia;* Regeneration in *Hydra*; Polymorphism in Coelenterata; Morphology, sense organs, reproductive system & Life Cycle of *Aurelia*; Corals and coral reefs, Structural organization and affinities in Coelenterata. General characteristics and evolutionary significance of Ctenophora;

General characteristics and Classification up to Classes of Platyhelminthes; Morphology, Nervous system, Reproductive system, Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*.

Unit 3: Nemathelminthes, Coelomates & Annelida 9 hrs/ 14 marks

General characteristics and Classification up to Classes of Nemathelminthes; Morphology, Life cycle and pathogenicity of *Ascaris lumbricoides;* Parasitic adaptations in Nemathelminthes; Evolution of coelom and metamerism. General characteristics and Classification up to Classes for Annelida; Coelom, Excretion, Nervous systems and Reproduction in Annelida, Trochophore larva – structure & affinities.

Unit 4: Arthropoda, Onychophora & Mollusca 9 hrs/ 14 marks

Structural organization in different Classes of Arthropods, Mouth parts of Insects, Vision and Respiration in Arthropoda; Metamorphosis in Insects; Social life in bees, Larval forms of Crustacea and Insecta. External morphology, Digestive, Reproductive & respiratory systems of *Palaemon* sp. General characteristics and Evolutionary significance of Onychophora, General characteristics and Classification up to Classes of Mollusca; Structural organization in Pelecypoda, Gastropoda and Cephalopoda, Torsion and detorsion in Gastropoda; Structure and affinities of Neopilina, Pearl formation in bivalves

Unit 5: Echinodermata & Minor Phyla 9 hrs/ 14 marks

General characteristics and Classification up to Classes of Echinodermata; Water-vascular system in Asteroidea; Larval forms in echinoderms. Introduction to minor phyla. Distinguishing characters and examples of Nemertinea, Rotifera, Acanthocephala, Sipunculida, Echiurida, Bryozoa (Ectoprocta), Brachyopoda, Phoronida etc.

Major – I Practical: MJC45ZOO101(P)25

Practical [Credit 1] **30 hrs/50 marks**

1. Study of the whole mounts of *Euglena, Amoeba, Paramecium (including* Binary fission and Conjugation), *Obelia, Physalia, Aurelia, Tubipora, Gorgonia, Metridium/Adamsia, Pennatula, Fungia, Madrepora, Sycon, Hyalonema, Spongilla, Fasciola hepatica & life cycle stages*, *Taenia solium* , *Ascaris lumbricoides,* Aphrodite, Nereis, Heteronereis, Serpula, Chaetopterus, Hirudinaria, Limulus, Palamnaeus, Palaemon, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Apis, Musca, Peripatus, Chiton, Dentalium, Pila, Unio, Pinctada, Sepia, Octopus, Nautilus, Pentaceros/Asterias, Ophiura, Echinus, Cucumaria.
2. Study of T.S. of *Sycon,* L.S. of *Sycon,* T.S. through pharynx, gizzard, and intestine of earthworm
3. Temporary mounts of Ovary of Earthworm; Parapodia of Nereis; Mouth parts of house fly & mosquito; Radula of Pila; whole mounts of *Daphnia*, Cyclops.
4. Dissection of digestive, reproductive and excretory system of Cockroach; Dissection of digestive and nervous system of Pila.

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: 4 Numbers/ 5 marks each (Identification =1, Classification= 2, Characters = 2) Total = 20 marks
2. Study of Sections (Slides): 1 number/ 2 marks (Identification with reasons = 2)
3. Dissections : 1 number /10 marks (Dissection : 7; Display: 3)
4. Temporary mounts : 1 number/ 3 marks (Slide making : 2 , display : 1)
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of non- chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non- chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/Class in order to test whether the teaching imparted had been followed by the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce:*** *Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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

Minor -I: MNC45**ZOO101(T)25**

(**Fundamentals of Zoology – 1**: Non- Chordates)

Objective:

The course is aimed with the objective of providing knowledge of the diversity of animal life especially among the non Chordates. It shall provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. Morphological and anatomical features of diverse animal groups; their significance and their relationships have been incorporated to create interest among the students to explore the animal diversity in nature.

Outcome:

The outcome expected on completion of Course:

- Having knowledge of habitat and structural organization of non- chordates .
- Appreciate the diversity of non-chordates living in diverse habit and habitats.
- Critically think about the organization, complexity and characteristic features of non-chordates.
- Getting familiarized with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

Course Content:

Theory [Credits: 3] 45 hrs/ 100 marks(70 for end exam, 30 for Internal assessment)

Unit 1: Animalia, Protista, Porifera 9 hrs/ 14 marks

Characteristics of Animalia; Characters up to classes for Protozoans; Life cycle and pathogenicity of *Entamoeba histolytica;* Introduction to Parazoa/ Porifera; General characteristics and Classification up to classes of Porifera; Water Canal systems in sponges, Economic importance of Sponges

Unit 2: Cnidaria, Ctenophora & Platyhelminthes 9 hrs/ 14 marks

Introduction to Metazoa: General characteristics and Classification up to classes of Coelenterata; Regeneration in *Hydra*; Life Cycle of *Aurelia*; Corals and coral reefs, Statocyst of a Ctenophora; General characteristics and Classification up to classes of Platyhelminthes; Difference between Trematoda & Cestoda; Morphology, Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium.*

Unit 3: Nemathelminthes, Coelomates & Annelida 9 hrs/ 14 marks

General characteristics and Classification up to classes of Nemathelminthes; Morphology, Life cycle and pathogenicity of *Ascaris lumbricoides;* Parasitic adaptation in Nematodes; General characteristics and Classification up to classes for Annelida; Difference of *Neanthes* and *Heteroneris*; Morphology, Digestive system, Circulatory system, Excretory system and Reproductory system of Earthworm.

Unit 4: Arthropoda, Onychophora & Mollusca 9 hrs/ 14 marks

Structural organization in different classes of Arthropods; Types, morphology, life history and economic importance of mosquito; Social life in bees, Economic importance of Insects, Metamorphosis in Insects. General characteristics of Onychophora, General characteristics and Classification up to classes of Mollusca; External features, digestive system, Nervous system in *Pila* sp., Pearl formation in bivalves

Unit 5: Echinodermata & Minor Phyla 9 hrs/ 14 marks

General characteristics and Classification up to classes of Echinodermata; Water-vascular system, Larval forms in echinoderms. Introduction to minor phyla. General characters of Acanthocephala, Echiurida, Bryozoa and Rotifera.

Minor -I Practical: MNC45**ZOO101(P)25**

(**Fundamentals of Zoology – 1**: Non- Chordates)

Practical [Credit 1] **30 hrs/50 marks**

1. Study of the whole mounts of *Amoeba, Obelia, Physalia, Aurelia, Pennatula, Sycon, Hyalonema, Spongilla, Fasciola hepatica & life cycle stages*, *Taenia solium , Ascaris lumbricoides,* Aphrodite, Nereis, Heteronereis, Serpula, Chaetopterus, Hirudinaria, Limulus, Palamnaeus, Palaemon, Sacculina, Julus, Apis, Musca, Peripatus, Chiton, Dentalium, Pila, Unio, Pinctada, Sepia, Octopus, Asterias.
2. Study of T.S. of *Sycon,* T.S. through pharynx, gizzard, and intestine of earthworm
3. Temporary mounts of Obelia colony; Mouth parts of mosquito; whole mounts of Daphnia, Cyclops.
4. A Project on the Study of the Life Cycle of an Insect.

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: 4 Numbers/ 5 marks each (Identification =1, Classification= 2, Characters = 2) Total = 20 marks
2. Study of Sections (Slides): 1 number/ 2 marks (Identification with reasons = 2) Total = 2
3. Temporary mounts : 2 numbesr/ 3 marks (Slide making : 2 , display : 1) Total=6
4. Project report submission : 7 marks
5. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of non- chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behaviour of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non- chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/Class in order to test whether the teaching imparted had been followed by the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

1. **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
2. **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
3. **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
4. ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
5. **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

1. Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
2. Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
3. Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
4. 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
5. Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Online Tools and Web Resources:

1. 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
2. ePG Pathshala (MHRD) Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35

MULTI-DISCIPLINARY COURSE – 1 : MDC45ZOO101(T)25

(Introduction to Animal Diversity – 1 : non-Chordates)

Objective:

The course is aimed with the objective of providing introductory ideas of the diversity of animal life among the non-Zoology Students offering this MDC. It shall provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life.

Outcome:

The outcome expected on completion of Course:

- Having knowledge of habitat and structural organization of animals .
- Appreciate the diversity of non-chordates living in diverse habit and habitats.
- Critically think about the organization, complexity and characteristic features of non-chordates.
- Getting familiarized with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

Course Content:

Theory [Credits: 3] 45 hrs/ 100 marks(70 for end exam, 30 for Internal assessment)

Unit 1: Origin of Life; Introduction to Animals 9 hrs/ 14 marks

Origin of life on Earth: Arrival of simple form from primordial chemicals Complexity of Life: Origin of metazoans; Concept of Cellularity, Body symmetry, Germ layers & Body cavities Sequence & strategies of life cycle: Concept of classification of life cycles, adaptations & relationship between ontogeny & phylogeny. Characteristics of Animalia; Difference of living animals & non-living things; Animals in Mythology and Indian knowledge systems.

Unit 2: Single Cell organisms to Platyhelminthes 9 hrs/ 14 marks

Physical characteristics, and medical importance of Protozoans; General characteristics and Economic importance of Sponges; Introductory ideas of the Water Canal systems in sponges. Introduction to Metazoa: General characteristics of Coelenterata; Regeneration in *Hydra*; Characters & importance of Jelly fishes; Corals and coral reefs; General characteristics of Platyhelminthes; Difference between Trematoda & Cestoda; Life cycle & medical importance of Liver fluke and common Tape worm.

Unit 3: Nemathelminthes to Annelida 9 hrs/ 14 marks

General characteristics of a Nematode; Life cycle and importance of roundworm*;* Medical importance of Nematodes specially in relation to immunocompromised Persons; General characteristics of Annelida; Life cycle of Earthworm and Leech. Earthworm as a friend of the Farmers & their rearing for sustainable use; Identification using diagrammatic sketches or Photographs with characters & Medicinal uses of Leeches.

Unit 4: Arthropoda to Onychophora 9 hrs/ 14 marks

Structural organization in different classes of Arthropods; Types, morphology, life history and economic importance of mosquito; characters & life history of Spiders, characters of Centipedes & millipedes; Social life in bees, Economic importance of Insects, Metamorphosis in Insects.

Harmful effects of Barnacles in water; General characteristics of Onychophora.

Unit 5: Mollusca to Minor Phyla 9 hrs/ 14 marks

General characteristics of Mollusca; External features & introductory ideas on the digestive system & Nervous system in *Pila* sp., Pearl formation in bivalve. General characteristics of Echinodermata; Water-vascular system, Larval forms in echinoderms. Introduction to minor phyla. General characters of some important groups of minor phyla.

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of non-chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of non- chordate biology would be created to ensure effective learning and understanding of the concepts. Field-based project activities have been included to create interest among the students to study and explore the biology and behavior of non-chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of non- chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/Class in order to test whether the teaching imparted had been followed by the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

Class Tests: Regular class tests will judge the grasp of the topics by the students.

Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.

Regular Presentations: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.

***Viva-voce**: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

Barnes, R.D. (2006). Invertebrate Zoology, 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 PublishersPechenik, 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

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

Skill Enhancement Course (SEC) -I: SEC45ZOO101a(T)25

(Aquarium Fish Keeping)

Objective:

The course will impart basic knowledge of ornamental fish Industry and inculcate its scope as an avenue for career development as an entrepreneur or as an aquari-culturist. It will provide a clear understanding of the basics of biology and habits of aquarium fish, so as to facilitate taking up ornamental fish keeping as an enterprise, even at the household level. The skill capacity building of students will be promoted by teaching the techniques of aquarium constructions, feed formulation and preparation, transportation, maintenance and management of the system. Students will have 'hands-on' experience by exposure to technology, production, functioning or operation of an aquarium in the ornamental fish farms, hatcheries, and fish feed production plant as study tours or field visits.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Acquire knowledge aboutdifferent kinds of fish , their compatibility in aquarium.
- Become aware of Aquarium as commercial, decorative items and of scientific values.
- Develop personal skills on maintenance of aquarium.
- Know about the basic needs to set up an aquarium, i.e., dechlorinated water, reflector, filters,scavenger, aquatic plants etc. and the ways to make it cost-effective.

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) -I Practical : SEC45ZOO101a(P)25

(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)

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, presentation to show the significance of the course- its commercial, scientific and aesthetic prospects. Learning must include a visit toany farm or lab by students. Practical exercise with the setup of an aquarium and its maintenance; hands-on training for the formation of feeds will develop skill among students.

Assessment Methods:

Measures to be adopted for assessment are as follows-

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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:

SEC45ZOO101b(T)25

(Apiculture)

Objective:

The course will make the student aware about the significance of beekeeping as an economically viable industry. It will help the students to understand the biology and behaviour of bees. It will also help the students to develop entrepreneurial skills required for self-employment in beekeeping sector specially on the techniques of honey bee rearing, optimization of techniques based on climate and the geographical regions, and various measures to be taken to maximize the benefits.

Outcome:

Upon completion of the course, students shall be able to:

- Learn about the various species of honey bees, their social organization and importance.
- Share knowledge about the opportunities and employment in apiculture- in public, private and government sector.
- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.

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, behavioral 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) -I Practical : SEC45ZOO101b(P)25

(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)

Teaching and Learning Process:

Information and concepts about benefits of honey bees in human life and how these benefits can be reaped will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of bees in nature and study of rearing technology will be assisted through visits to various apiculture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make learning by students more dynamic. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of bee biology will be promoted to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of bees andtheir rearing methods. Collection of plants and bee products will also help students to know the benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Measures to be adopted for assessment are as follows-

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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: SEC45ZOO101c(T)25
(Poultry Farming)

Objective:

The course is aimed with the objective of providing knowledge of the Poultry farming; their significance, types & breeds. Modern system of rearing and breeding of Broilers have been incorporated in order to create interest among the Students to explore this system of practice.

Outcome:

The outcome expected on completion of Course:

- Having knowledge of different Poultry birds & rearing practices.
- Understand the economic importance of these birds, Feed preparation, Scientific rearing practices and control of diseases.

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) -I Practical : SEC45ZOO101c(P)25

(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)

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, presentation to show the significance of the course- its commercial, scientific and aesthetic prospects. Learning must include a visit toany farm or lab by students. Practical exercise and hands on experience at a farm will develop skill among students.

Assessment Methods: Measures to beadopted for assessment are as follows -

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester.A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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

MANIPUR UNIVERSITY

Courses for UG Zoology

SEMESTER II

Course Structure (NEW)

(As per Manipur University Ordinance for Four Year Undergraduate Program 2025 based on NEP – 2020)

1.1 Credit distribution for the course

II	Ability Enhancement Course	**AEC45Z00102(T)25**	Academic Writing	4
	Major-2	**MJC45ZOO102(T)25**	Chordates : General organization – Hemichordata to Mammalia	3
	Major-2 Practical	**MJC45ZOO102(P)25**	,,	1
	Minor-2	**MNC45ZOO102(T)25**	Fundamentals of Zoology-2 : Chordates	3
	Minor-2 Practical	**MNC45ZOO102(P)25**	,,	1
	Multidisciplinary Course - 2	**MDC45ZOO102(T)25**	Introduction to Animal diversity - 2	3
	Skill Enhancement Course (SEC)- II	**SEC45ZOO102a(T)25** **SEC45ZOO102b(T)25** **SEC45ZOO102c(T)25**	A-Sericulture **or** B-Vermicomposting **or** C-Fish Farming	2
	Skill Enhancement Course (SEC)- II Practical	**SEC45ZOO102a(P)25** **SEC45ZOO102b(P)25** **SEC45ZOO102c(P)25**	A-Sericulture **or** B-Vermicomposting **or** C-Fish Farming	1
	Value added Course (VAC) - 2	----------	From the Pool	2
				20
Summer Internship in a Research laboratory or a Government Institute outside the College in an area of Zoology. This must be taken up during summer vacation in the first year (i.e. during Semester I and II)				**4**
Exit option with Bachelor's Certificate in Zoology on completion of Courses equal to a minimum of 44 Credits including the Credits for the work-based summer internship.				

***N.B.**: Students can earn upto 40 % of the total Credits of a given Semester through online learning Courses offered via SWAYAM or any other platform recognized by the UGC, provided they need to declare their chosen Courses before the semester begins. Only equivalent Credits or those exceeding the Credit allocation in Multidisciplinary Courses (MDC), Ability Enhancement Courses (AEC), Skill Enhancement Courses (SEC) and Value-added Courses (VAC) may be selected. For Zoology Students, Multi-disciplinary Course can be selected from other Subjects. Multi-disciplinary Course "*Introduction *to Animal diversity" must be offered by Students of subjects other than Zoology*

Major- 2: MJC45ZOO102 (T)25

(Chordates: General organization of Chordates: Hemichordata to Mammalia)

Objective:

The course is designed with an aim to provide scope and historical background of chordates. It will impart knowledge regarding basic concepts of origin of chordates and make the students understand the characteristics and classification of animals with notochord. The adequate explanation to the students regarding various mechanisms involved in thriving survival of the animals within their geographic realms will create interest among students.

Outcome: Upon completion of the course, the students will be able to:

- Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.
- Study about diversity in animals making students understand about their distinguishing features.
- Appreciate similarities and differences in life functions among various groups of animals in Phylum Chordata.
- Comprehend the circulatory, nervous and skeletal system of chordates.
- Know about the habit and habitat of chordates in marine, fresh water and terrestrial ecosystems.

Course Content: Theory [Credits: 3] 45 hrs/ 100 marks (25 for Internal assessment, 5 for attendance & 70 for end Semester exam)

Unit 1: Introduction to Chordates, Protochordata **9 hrs**

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. 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 2: Origin of Vertebrates, Agnatha **9hrs**

Phylogeny or evolutionary history of Vertebrates: Salient features of Vertebrates, Diversity of Vertebrates; Comparative account between Protochordates & Vertebrates; Distinctive features of Poikilothermic & Homeothermic Vertebrates. General characteristics and classification of cyclostomes up to Class; Structure & Life cycle of*Petromyzon* & *Myxine*; Features & significance of the Extinct first Jawed Vertebrates.

Unit 3: Pisces , Amphibia **9 hrs**

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. 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 4: Reptilia, Aves **9 hrs**

General characteristics and classification up to order; Affinities of *Sphenodon*; External features of *Calotes versicolor* & *Uromastix hardwickii*; Poisonapparatus and biting mechanism in snakes; Difference between Venomous and non – venomous Snakes. 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 5: Mammals (Prototheria, Metatheria & Eutheria) **9 hrs**

General characters and classification ofMammals 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. General characters and classification up to order; Adaptations in Toothless, Aquatic, Flying &Fossorialmammals; TypesofFeet; Adaptiveconvergence in Mammals; Dentition in Mammals.

Major- 2 Practical: MJC45ZOO102 (P) 25

(Chordates: General organization of Chordates: Hemichordata to Mammalia)

Practical [Credit 1] **30hrs**

Study of Museum Specimen/ Models :

Protochordata: *Balanoglossus, Herdmania, Branchiostoma*; **Agnatha:** Petromyzon, Myxine; **Fish:** Scoliodon, Pristis, Torpedo, Mystus, Heteropneustes, Labeo, Echeneis, Anguilla, Hippocampus, Tetrodon, Anabas, Flat fish; **Amphibia:** Ichthyophis, Necturus, Bufo, Hyla, Alytes, Salamandra ; **Reptilia:** Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Draco, Bungarus, Viper, Naja, Hydrophis, Zamenis, Crocodile ; **Aves:** Study of six common birds from different orders. Types of beaks and claws; **Mammalia:** Sorex, Bat (Insectivorous and Frugivorous), Loris, Herpestes, Erinaceous.

1. **Identification of Slides:** Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, anterior region, intestinal and caudal regions. Permanent slide of *Herdmania* spicules. T.S of skin of mammal.

2. **Temporary Slide Preparation:** Study of Fish Scale (Placoid, Cycloid and Ctenoid)

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

4. **Dissection:** Extraction of Pituitary gland, Weberian Ossicles and Accessary respiratory organ of Fishes

Examination evaluation Structure:

1. **Museum Specimen / Models**: 5 Numbers/ 5 marks each (Identification = 1, Classification = 2, Characters = 2) **Total = 25 marks**
2. **Slide identification :** 4 Numbers/4marks each (Identification =1, Characters = 3) **Total = 16 marks**
3. **Temporary Slide Preparation**: 1 Number (Mounting of Slide =5, Diagram =2, Characters =3) **Total = 10 marks**
4. **Study of Bone**: 4 Number/ 3marks each (Identification=1, Characters=2) **Total = 12 marks**
5. **Dissection:** 1 Number (Dissection =8, Display =4, Diagram =3) **Total = 15 marks**
6. **Note Book: 10 marks** (Based on the neatness, inclusiveness, overall presentation)
7. **Viva-Voce: 12 marks** (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology and anatomy of chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk- n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of chordate biology would be created to ensure effective learning and understanding of the concepts. Field- based project activities can be included to create interest among the students to study and explore the biology and behavior of chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data

collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.

- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester.A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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

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

Minor-2: MNC45ZOO102 (T) 25
(Fundamentals of Zoology – 2: Chordates)

Objective:

The course is designed with an aim to provide scope and historical background of chordates. It will impart knowledge regarding basic concepts of origin of chordates and make the students understand the characteristics and classification of animals with notochord. The adequate explanation to the students regarding various mechanisms involved in thriving survival of the animals within their geographic realms will create interest among students.

Outcome:

Upon completion of the course, the students will be able to:

- Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.
- Study about diversity in animals making students understand about their distinguishing features.
- Appreciate similarities and differences in life functions among various groups of animals in Phylum Chordata.
- Comprehend the circulatory, nervous and skeletal system of chordates.

- Know about the habit and habitat of chordates in marine, fresh water and terrestrial ecosystems.

Course Content:

Theory [Credits: 3] 45 hrs/ 100 marks (25 for Internal assessment, 5 for attendance & 70 for end Semester exam)

Unit 1: Introduction to Chordates, Protochordata 9 hrs

Comparison of Chordates & non-Chordates; General characteristics and outline classification of Chordates; General characteristics of Hemichordata, Urochordata and Cephalochordata; Structure & Life Cycle of *Balanoglossus;* Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata.

Unit 2: Origin of Vertebrates, Agnatha 9 hrs

Salient features of Vertebrates, Diversity of Vertebrates; Comparative account between Protochordates & Vertebrates; Distinctive features of Poikilothermic & Homeothermic Vertebrates. General characteristics and classification of cyclostomes up to Class; Structure & Life cycle of *Petromyzon*.

Unit 3: Pisces, Amphibia 9 hrs

General characteristics of Chondrichthyes and Osteichthyes, Classification up to Classes ; Types of Scales, Fins; Parental care; Migration, Osmoregulation and Swim bladder in Fish. General characteristics and classification up to Class; Distinctive characters of Apoda, Urodela & Anura; Neoteny & Paedogenesis; Parental care in Amphibians; Defensive mechanisms in Amphibians

Unit 4: Reptilia, Aves 9 hrs

General characteristics and classification up to Class for reptiles; External features of *Calotes versicolor*; Poison apparatus and biting mechanism in snakes; Difference between Venomous and non – venomous Snakes. General characteristics and classification up to Class for Birds; 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 5: Mammals (Prototheria, Metatheria & Eutheria) 9 hrs

General characters and classification of Mammals up to Class; Distinctive characters of Prototheria and Metatheria; Significance of marsupium or abdominal pouch; Adaptive radiation with reference to locomotory appendages. Adaptations in Toothless, Aquatic, Flying & Fossorial mammals; Types of Feet; Adaptive convergence in Mammals; Dentition in Mammals.

Minor-2 Practical: MNC45ZOO102(P)25

(Fundamentals of Zoology – 2: Chordates)

Practical [Credit 1] **30 hrs/ 100 marks**

1. **Study of Museum Specimen/ Models** :

   Protochordata: *Balanoglossus, Herdmania, Branchiostoma*; **Agnatha:** Petromyzon, Myxine; **Fish:** Scoliodon, Pristis, Torpedo, Mystus, Heteropneustes, Labeo, Echeneis, Anguilla, Hippocampus, Tetrodon, Anabas, Flat fish; **Amphibia:** Ichthyophis, Necturus, Bufo, Hyla, Alytes, Salamandra ; **Reptilia:** Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Draco, Bungarus, Viper, Naja, Hydrophis, Zamenis, Crocodile ; **Aves:** Study of six common birds from different orders. Types of beaks and claws; **Mammalia:** Sorex, Bat (Insectivorous and Frugivorous), Loris, Herpestes, Erinaceous.

2. **Identification of Slides:** Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, anterior region, intestinal and caudal regions. Permanent slide of *Herdmania* spicules. T.S of skin of mammal.

3. **Temporary Slide Preparation:** Study of Fish Scale (Placoid, Cycloid and Ctenoid)

4. **Study of Bone:** Disarticulated skeleton of Frog, *Varanus*, Fowl and Rabbit (Skull, Vertebral Column, Sternum, Girdles and Ribs)

5. **Dissection:** Pituitary gland, Weberian Ossicles and Accessary respiratory organ of Fishes

Examination evaluation Structure:

1. **Museum Specimen / Models**: 5 Numbers/ 5marks each (Identification = 1, Classification = 2, Characters = 2) **Total = 25 marks**
2. **Slide identification :** 5 Numbers/3marks each (Identification =1, Characters = 2) **Total = 15 marks**
3. **Temporary Slide Preparation**: 1 Number (Mounting of Slide =5, Diagram =2, Characters =3) **Total = 10 marks**
4. **Study of Bone**: 5 Number/ 3marks each (Identification=1, Characters=2) **Total= 15 marks**
5. **Dissection:** 1 Number (Dissection =8, Display =4, Diagram =3) **Total = 15 marks**
6. **Note Book: 8 marks** (Based on the neatness, inclusiveness, overall presentation)
7. **Viva-Voce: 12 marks** (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about morphology and anatomy of chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk- n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be

used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of chordate biology would be created to ensure effective learning and understanding of the concepts. Field- based project activities can be included to create interest among the students to study and explore the biology and behavior of chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester.A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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

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

Multidisciplinary Course- 2: MDC45ZOO102(T)25

(Introduction to Animal diversity-2)

Objective:

The course is designed with an aim to provide scope and historical background of the animals specially the Chordates. The adequate explanation to the students regarding various mechanisms involved in thriving survival of the animals within their geographic realms and adaptations will create interest among students.

Outcome:

Upon completion of the course, the students will be unable to:

1. Understand different chordates
2. Study about diversity in animals making students understand about their distinguishing features.
3. Appreciate similarities and differences in life functions among various groups of animals.
4. Know about the habit and habitat of chordates in marine, fresh water and terrestrial ecosystems.

Course Content:

Theory [Credits: 3] 45 hrs/ 100 marks (25 **for Internal assessment, 5 for attendance & 70 for end Semester exam)**

Unit 1: Introduction to Chordates, Protochordata **9 hrs**

General characteristics and classification of Chordates upto Classes; General characteristics of Hemichordata, Urochordata and Cephalochordata; Structure & Life Cycle of *Balanoglossus.*

Unit 2: Origin of Vertebrates, Agnatha **9hrs**

Characters of Vertebrates, examples; Comparative account between Protochordates & Vertebrates; Distinctive features of Poikilothermic & Homeothermic Vertebrates. Structure & Life cycle of Agnatha / *Petromyzon*.

Unit 3: Pisces , Amphibia **9 hrs**

General characteristics of Pisces, Classes with examples; Types of Scales, Fins; Parental care; Osmoregulation and Swim bladder in Fish. Amphibians: Class with examples; Distinctive characters of Apoda, Urodela & Anura; Parental care in Amphibians; Defensive mechanisms in Amphibians.

Unit 4: Reptilia, Aves **9 hrs**

General characteristics , Classes with examples; External features of a *lizard*; Poison

apparatus and biting mechanism in snakes; Difference between Venomous and non – venomous Snakes. General characteristics of Birds; Classes with examples, Types of feathers , types of Beaks; Flight mechanism & adaptations; Perching mechanism and migration in birds.

Unit 5: Mammals (Prototheria, Metatheria & Eutheria) 9hrs

General characters , Class with examples ; Distinctive characters of Prototheria, Metatheria and Eutheria; Adaptations in Toothless, Aquatic, Flying & Fossorial mammals; Types of Feet; Dentition in Mammals.

Teaching and Learning Process:

Information and concepts about morphology and anatomy of chordates will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations in nature through real animals/preserved specimens/models. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal modelsystems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of chordate biology would be created to ensure effective learning and understanding ofthe concepts. Field-based project activities can be included to create interest among the students to study and explore the biology and behavior of chordates inculcating research aptitude. In addition, study of animals in their natural habitat will improve the observation skills, data collection skills, critical thinking and analytical skills of students. Furthermore, museology will give them a comprehensive idea of structural features of chordates and the basis of classification. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to beadopted for assessment are as follows.

Class Tests: Regular class tests will judge the grasp of the topics by the students.

Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.

Regular Presentations: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.

Viva-voce*: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.

Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester.A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

1. Young, J. Z. (2004). The Life of Vertebrates. III Edition, Oxford university press.

2. Parker T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates.VII Edition, Volume II

3. 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.

Skill Enhancement Course (SEC) - II: SEC45ZOO102a(T)25
(A-**Sericulture**)

Objective:

The course will make the students aware about the significance of sericulture as a profit-making enterprise. It will help the students to understand the biology of silkworms, its nutritional requirement to secrete quality silk, the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits.

Outcome:

Upon completion of the course, students shall be able to:

- Learn about the history of sericulture and silk routes.
- Recognize various species of silk moths in India, both exotic and indigenous races.
- Be aware about the opportunities and employment in sericulture industry- in public, private and government sector.
- Gain thorough knowledge about the techniques involved in silkworm rearing and silk reeling.
- Develop entrepreneurial skills necessary for self-employment in mulberry and seed production.

Course Content:

Theory [Credits: 2] **30 hrs**

Unit 1: Introduction to Sericulture; Systematics and Biology of Silkworm 8 hrs

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 **7 hrs**

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,

Unit 3: Pests and Diseases **7 hrs**

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Diseases of silkworm, Causal factors: Bacteria, Viruses, Fungus, Protozoan, Parasitoides, Common conditions observed in field rearing in Manipur, Symptoms and field diagnostics, Hygiene, record-keeping and for sustainable rearing, Control and preventive measures of pests and diseases.

Unit 4: Silk Production, Processing and Economics **8 hrs**

Structure and composition of silk, Post- harvest technology- Harvesting and storage of cocoons, Cocoon drying, Silk reeling: (Traditional and modern reeling methods, Reeling appliances), Dyeing ,weaving, bundling and packing, Silk testing and grading, Sericulture industry in India:(Role of Central Silk Board, Employment generation and rural development), By-products of sericulture, Skill development and Entrepreneurship opportunities in sericulture, Local markets, cooperatives, SHGs/NGOs, State-level initiatives in Manipur.

Skill Enhancement Course (SEC) – II Practical: SEC45ZOO102a(P)25
(A-**Sericulture**)

Practical [Credit: 1] **30 hrs/ 100 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/ 5 marks (Identification with reasons = 2 + 3 = 5 each). **Total = 15 marks**
2. Identification of appliances used for Silkworm rearing & silk threads– 4 numbers/ 3 marks each (Identification = 1, Reason = 2) **Total= 12 marks**.
3. Dissection and display of Silk gland. **Total=15 marks** (Dissection = 8, Display = 4, Diagram=3)
4. Demonstration of harvesting method of Silkworms (Site Selection = 2, Stepwise procedure =10 and precautionary measures = 3). **Total= 15 marks**
5. Detection of common diseases and pests in field samples (Procedure) **Total =10 marks**
6. Report submission: **15 marks** (Subject content, Presentation, Diagrams/Photos)
7. Note Book**: 6 marks** (Based on the neatness, inclusiveness, overall presentation)
8. Viva-Voce: **12 marks** (Testing of Knowledge in the said Course

Teaching and Learning Process:

Information and concepts about benefits of silkworms in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of silkworms in nature and study of rearing technology will be assisted through visits to various sericulture institutes, which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make students' learning more dynamic. Enquiry-based collaborative learning through presentations, debates, group discussions, and roundtables on the various aspects of silkworm biology will be promoted, to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of worms and their rearing methods. Visit to various sericulture institutes will clarify their concepts about the silkworms and their rearing technology.

Assessment Methods:

Measures to be adopted for assessment are as follows -

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students

based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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 silk- worms.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
- HouseYup-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.html

Skill Enhancement Course (SEC) - II: SEC45ZOO102b(T) 25

(B-Vermicomposting)

Objective:

The course will make the students aware about the significance of Vermicomposting as a profit- making enterprise. It will help the students to understand the biology of Earthworm, nutritive values of Vermicompost & Vermicast.

Outcome:

Upon completion of the course, students shall be able to:

- Learn about the history of Vermiculture.
- Recognize various species of Earthworms in India, both exotic and indigenous races.
- Be aware about the opportunities and employment in rural cottage industry.
- Gain thorough knowledge about the techniques involved in Earthworm rearing and Vermicompost preparation.
- Develop entrepreneurial skills necessary for self-employment in Vericomposting.

Course Content:

Theory [Credits: 2] **30 hrs**

Unit 1: Introduction to Vermiculture, role & types of Earthworms. 7 hrs
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, key to identify the species of earthworm.

Unit 2: Biology of Earthworm, Pests & Diseases 8 hrs
Biology of *Pheretima posthuma*: taxonomy, anatomy, physiology and reproduction including fecundity and annual reproduction potential. Pests and diseases of earthworms & preventive measures (Bacterial and fungal infections, Protein Poisoning).

Unit 3: Vermicompost Preparation & Physico-chemical parameters 8 Hrs
Different methods of vermicomposting – small, large- scale bed farming, pit methods, limiting methods in vermicomposting. Extraction, harvesting, processing, packaging, transport and storage of vermicompost. Physico-chemical parameters of vermicompost ; Moisture Content, Temperature, Aeration and pH.

Unit 4: Applications and Economic Importance: 7 hrs Vermi-compost Quality**:** Chemical composition and nutritional value of vermicompost compared to other fertilizers. Vermiwash: Collection, composition, and uses. Entrepreneurship: Business planning, cost estimation, and marketing of vermicompost.

Skill Enhancement Course (SEC) – II Practical: SEC45ZOO102b(P) 25
(B-Vermicomposting)

Practical [Credit: 1] **30 hrs/ 100 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 vermicomposting units using locally available resources
6. Vermicompost 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, Classification and Characters of local and exotic earthworm species (live/ Preserved specimen /Photo): 3 numbers/ 5 marks each (Identification,

Classification and reasons = 1 + 2+2 = 5 each).

Total = 15 marks

2. Identification of appliances used for Vermicomposting : 4 numbers/ 3marks each (Identification= 1, Reason = 2)

Total = 12 marks

3. Dissection, display and diagram of internal organs of Earthworm. (Dissection = 8, Display = 4, Diagram = 3). **Total = 15 marks**
4. Demonstration of pit/bed method of vermicomposting (Site Selection = 2, Stepwise procedure =10 and precautionary measures = 3). **Total= 15 marks**
5. Harvesting and packaging of vermicompost (Procedure =10)

Total =10 marks

6. Report submission: (Subject content, Presentation, Diagrams/Photos)

Total =15 marks

7. Note Book: (Based on the neatness, inclusiveness, overall presentation)

Total = 6 marks

8. Viva-Voce: (Testing of Knowledge in the said Course)

Total =12 marks

Teaching and Learning Process:

Information and concepts about benefits of Earthworms in human life and how the benefits of Vermicomposting can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of Earthworms in nature and study of rearing technology will be assisted through visits to various Vermicomposting units, which will create interest, enhance their understanding and inculcate entrepreneurial skills among students. Blended learning including chalk-n-talk method and e-learning will be encouraged to make students' learning more dynamic. Enquiry-based collaborative learning through presentations, debates, group discussions, and roundtables on the various aspects of Earthworm biology will be promoted, to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of worms and their rearing methods. Visit to various Vermicomposting Units will clarify their concepts about the worms and their rearing technology.

Assessment Methods:

Measures to be adopted for assessment are as follows -

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed

based on the content, novelty, explanation and response to queries raised by peers.

- ***Viva-voce:*** *Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester.A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

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

Skill Enhancement Course (SEC) – II: SEC45ZOO101c(T)25
(C-Fish Farming)

Objective:

The objective of this course is to equip students with fundamental knowledge and practical skills in fish farming, covering its definition, scope, and importance in sustainable food production. It aims to develop student competence in pond preparation techniques, such as liming, fertilization, and weed control, as well as water quality management involving key physical, chemical, and biological parameters. The course introduces various fish farming systems, including composite, integrated, semi-intensive, and intensive practices. Emphasis is placed on effective site selection, pond construction, and comprehensive management practices before, during, and after stocking, including disease control and identification of common fish seed species like Indian Major Carps (IMC) and exotic fishes. Additionally, the course aims to build a strong foundation in induced breeding techniques using hypophysation and synthetic hormones, along with brooder management and hatchery systems like hapa and Chinese hatcheries. It covers traditional fish harvesting methods and preservation techniques such as drying, smoking, and fermentation to promote value addition. The course also introduces modern, climate-resilient, and resource-efficient aquaculture technologies like Biofloc, RAS, Aquaponics, and IMTA. It encourages entrepreneurship in fisheries by highlighting the scope, opportunities, and success stories, thereby fostering innovation and self-reliance among students in the fisheries sector.

Outcome:

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

1. Understand the principles, scope, and importance of fish farming and apply knowledge of pond preparation, water quality management, and fish health care.
2. Identify Indian Major Carps (IMC) and commonly cultured exotic species, along with their food habits, stocking ratios, and seed management practices.
3. Demonstrate knowledge of induced breeding techniques, including the use of synthetic hormones and hatchery operations, for efficient fish seed production.
4. Apply traditional and scientific methods of fish harvesting, preservation, and value addition to enhance post-harvest handling and reduce losses.
5. Gain proficiency in modern aquaculture technologies such as Biofloc, RAS, Aquaponics, and IMTA, and understand their role in sustainable and climate-resilient fish farming.
6. Develop entrepreneurial skills and awareness of business opportunities in the fisheries sector by analyzing real-life case studies and success stories.

Theory [Credits: 2] **30 hrs**

Unit 1:Introduction to Fish Farming: **8 hrs**

Definition, scope, and importance of fish farming; Pond preparation – liming, fertilization, weed control; Water quality management- physical, chemical and biological parameters (pH, BOD, dissolved O_2, dissolved CO_2, NH_3); composite farming, integrated, semi-intensive, and intensive fish farming; Site selection, pond construction; Pre-stocking, stocking and post-stocking fish pond management; eradication of weeds, insects and fish enemies.

Unit 2:Induced Breeding: **7 hrs**

Natural breeding of carps, Induce breeding techniques of Indian Major Carps (IMC) and Exotic Carps, Brooder management; Hypophysation, Synthetic hormones (Ovaprim, Ovatide, and WOVA-FH): dosing and administration; Hatchery: Hapa type, Chinese hatchery; Hatchery management, Collection and transportation of fish seed, Stocking density and acclimatization.

Unit 3: Feeding, Health and Farm Management: **8 hrs**

Food habits of different fish species; Natural food organisms in ponds; Supplementary feeding and feed formulation (basic concept); Growth monitoring; Common fish diseases (bacterial, fungal, parasitic); Prevention and control measures of fish diseases; Fish Seed: Identification of Indian major carps (IMC) and common exotic fishes; stocking rate and ratio; Record keeping and farm management, Government schemes and entrepreneurship opportunities

Unit 4: Modern Techniques of fish farming and entrepreneurship: 7 hrs

Fish harvesting methods; Traditional preservation methods: drying, smoking and fermentation; Sustainable, climate resilient and resource efficient technologies - Biofloc technology (BFT), Recirculatory Aquaculture System (RAS), Aquaponics, Integrated Multi-Trophic Aquaculture (IMTA), Cage and pen culture, Scope and significance of entrepreneurship in fisheries, Success Stories and Case Studies.

Skill Enhancement Course (SEC) – II Practical: SEC45ZOO102c(P)25
(C-Fish Farming)

Practical [Credit: 1] **30 hrs/100 marks**

1. Identification of Indian major carps (IMC) and common exotic fishes
2. Physicochemical analysis of water: turbidity, pH, temperature, alkalinity, dissolved O_2, dissolved CO_2, BOD.
3. Identification of common Zoo and Phyto Planktons: *Cyclops, Daphnia, Diatomus, Moina, Keratella, Spirogyra, Chlamydomonas, Ulothrix, Oedogonium, Nostoc, etc.*
4. Identification of aquatic weeds and insects: *Ipomoea, Trapa, Marsilea, Cyperus, Pistia, Azolla, Salvinia, Eichornia, Lemna, Potamegeton Belostoma, Nepa, Corixa, Dysticus,* Dragon fly nymph, May fly, *Notonecta.*
5. Dissection for extraction of pituitary gland.
6. Identification of common fish diseases (bacterial, fungal and viral)
7. Visit to a fish farm/ fish hatchery or to a RAS/ Aquaponics/ Biofloc Unit and Report Submission

Examination evaluation structure:

1. Identification of fish seed/ adult fish & characters of specimen: 5 numbers/ 4 marks (Identification with comments: 1+3 = 4). **Total: 4x5 = 20 marks**
2. Water quality analysis: Procedure & Result **Total: 13 marks**
3. Identification of aquatic weeds/ insects/planktons: 5 numbers (Identification with characters: 1+3 =4). **Total: 4x5 = 20 marks**
4. Dissection & display of pituitary gland/ Weberial ossicles/ accessory respiratory organs with diagram. **Total: 8+4 =12 marks**
5. Field report: **10 marks** (Content, presentation)
6. Note book submission: **10 marks** (Based on Inclusiveness, neatness and presentation)
7. Viva voce: **Total: 15 marks**

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, and presentations to show the significance of the course – its commercial, scientific, and aesthetic prospects. Learning must include a visit to any fish farm or hatchery. Practical exercise with the setup of fish ponds for their management is required.

Assessment Methods:

Measures to be adopted for assessment are as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students.

- Projects and Assignments: Individual/ group projects will inculcate independent thinking as well as teamwork skills among the students.
- Regular Presentation: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation, and response to queries raised by peers.
- Viva voce: Viva voce is another critical component of the assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the examinations is an indicator of students' learning throughout the semester. A comparative assessment of students through final examinations analyses the comprehensive knowledge gained by each student.

Recommended Books:

1. Avnimelech, Y. (2015) Biofloc technology, a practical guidebook. 3rd Edition, World Aquaculture Society.
2. Burnell G, Allan G. 2009. New Technologies in Aquaculture. 1st Edition. Woodhead
3. Chonder, S.L. (1994) Induced Carp Breeding. CBS Publishers and Distributors, New Delhi
4. Goddek, S., Joyce, A., Kotzen, B., and Burnell, G. M. (Eds.). (2019). Aquaponics food production systems. Springer.
5. Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan publication Corp., India.
6. John, S. L. and C. S. Paul (2012) Aquaculture: Farming Aquatic Animals and Plants. 2nd Edition, Wiley-Blackwell
7. Pandey, K and J.P. Shukla (2013) Fish and Fisheries. Rastogi Publication.
8. Pillay, T.V.R. (1990) Aquaculture, Principles and Techniques. Fishing News Book Ltd. Publishing House.
9. Tidwell JH. (Ed.). 2012. Aquaculture Production Systems. Wiley-Blackwell.
10. Timmons, M.B., T, Guerdat and B.J. Vinci (2018) Recirculatory Aquaculture. 4th Edition, Ithaca Publishing Company, New York.
11. Vishwanath, W. 2021. *Freshwater fishes of the Eastern Himalayas*. Academic Press, 411