MANIPUR UNIVERSITY

UG COURSE IN ZOOLOGY (NEW)

(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 Enhancement Course	**AEC-1 Pool**	Language and 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	**AEC-2 Pool**	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; M o r p h o l o g y , 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/100 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: 8 Numbers/ 5 marks each (Identification =1, Classification= 2, Characters = 2) Total = 40 marks
2. Study of Sections (Slides): 3 numbers/5 marks (Identification with reasons = 5, with 4 reasons) 15 marks
3. Dissections : 1 number /16 marks (Dissection : 10; Display: 3, Diagram 3)
4. Temporary mounts : 1 number/ (Slide making : 4 , display : 2, Procedure: 6) 12 marks
5. Note Book: 7 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/100 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: 8 Numbers/ 5 marks each (Identification =1, Classification= 2, Characters = 2) Total = 40 marks
2. Study of Sections (Slides): 2 numbers/5marks (Identification=1reasons = 4) 10 marks
3. Dissections : 1 number /16 marks (Dissection : 10; Display: 3, Diagram 3)
4. Temporary mounts : 1 number/ 12 marks (Slide making : 4 , display : 2, Procedure: 6)
5. Project report submission : 7 marks
6. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
7. 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-Science and non-Zoology Students. 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; Differencebetween 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

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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] 45hrs/ 100 marks

Unit 1: Introduction & Status of Aquarium Fish Industry (6 Hours/ 20 Marks)

Aquarium fish industry as a profitable cottage industry; Global and national economic importance of ornamental fisheries; Overview of endemic and exotic species of aquarium fish; General biology, lifespan, feeding habits, and breeding nature of ornamental fish.

Unit 2: Biology and Sexual Dimorphism of Select Species (6 Hours/ 20 Marks)

General principles of sexual dimorphism in ornamental fishes; Freshwater Species: Biology and sexual dimorphism of Guppy, Molly, Swordtail, Goldfish, and Angelfish; Marine Species: Biology and sexual dimorphism of Blue Morph, Anemonefish, and Butterflyfish; Broodstock: Identification and selection criteria for healthy male and female breeders.

Unit 3: Food and Feeding of Aquarium Fish (6 Hours/ 20 Marks)

Live Feeds: Use of live fish feed organisms in aquarium culture; Specific advantages and disadvantages of live food items; Introduction, types, and nutritional value of formulated feeds; Raw materials, formulation matrix, and preparation methods of artificial feeds; Specific advantages and disadvantages of formulated diets.

Unit 4: Fish Capture, Handling & Transportation Systems (6 Hours/ 20 Marks)

Pre-Transport: Conditioning, capture methods, handling techniques, and pre-transport maintenance; Transport Modes: Comparative study of closed and open fish transport systems; Packaging and transport: Materials required, conditioning preparation, and step-by-step procedure for packing; Essential safety precautions, density management, and logistics during transit; Acclimatization techniques, water balancing, and post-transport maintenance protocols.

Unit 5: Aquarium Maintenance & Commercial Budgeting (6 Hours/ 20 Marks)

General aquarium upkeep, siphoning, water exchange, and health monitoring; System Upkeep: Cleaning, maintenance of filters, aerators, heaters, and lighting setups; Farm Design: Spatial layout planning for an ornamental fish rearing unit; Commercial Budgeting: Financial planning and budget sheets for setting up a cottage-scale Aquarium Fish Farm.

Skill Enhancement Course (SEC) -I Practical :SEC45ZOO101a(P)25

(Aquarium Fish Keeping)

Practical [Credit: 1] **30 hrs/ 100 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: 5 numbers/ 5 marks (Identification with reasons = 1+ 4 = 5 each). Total = 25 marks
2. Identification of sexes in aquarium fishes 3 number/5 marks (Identification of species and sex, reasons=4) 15 marks
3. Monitoring of Water quality : procedure, Observation & result – 10 marks
4. Composition and formulation of fish feed. 10 marks
5. Project proposal: (Subject content, Presentation, Diagrams/Photos) 15 marks
6. Presentation on a topic of Aquarium fish culture. 10 marks
7. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
8. 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/ 100 marks**

Unit 1: History, Systematics, and Diversity of Bees (6 Hours/ 20 Marks)

History, development, and economic importance of apiculture; Taxonomic classification and evolutionary history of honeybees; Identification, distribution, and biology of different honeybee species; Distribution, habitat preferences, and occurrence of honeybees in North-East India.

Unit 2: Social Organization and Behavioral Dynamics (6 Hours/ 20 Marks)

Morphological variations and functions of the Queen, Drone, and Worker bees; Structural hierarchy, division of labor, and communication systems in a bee colony; Communication mechanics through bee dances (round and waggle dances) and the phenomenon of swarming; Dispersal strategies and field foraging methods for pollen and nectar collection.

Unit 3: Apiary Management and Equipment (6 Hours/ 20 Marks)

General concepts, site selection criteria, and core principles of apiary setup; Identification of local flora, floral calendar creation, and importance of bee pasturage; Crucial parameters for selecting specific honeybee species for commercial artificial rearing; Detailed study of essential apiary tools, safety gear, and handling equipment.

Unit 4: Hive Construction and Processing Technology (6 Hours/ 20 Marks)

Comparative study of structural designs of Newton and Langstroth beehives; Apiary maintenance protocols during the high-yield Honey Flow Period and the scarce Lean Period; Step-by-step procedures for both indigenous traditional methods and modern mechanical extraction; Purification, quality checking, moisture control, processing, and standard packaging of harvested honey.

Unit 5: Diseases and natural enemies (6 Hours/ 20 Marks)

Identification, etiology, and diagnostic symptoms of major bacterial, viral, and fungal bee diseases; Prevention protocols, biological control, and chemical curative measures against bee diseases and natural enemies.

Skill Enhancement Course (SEC) -I Practical : SEC45ZOO101b(P)25

(Apiculture)

Practical [Credit: 1] 30 hrs/ 100 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/ (Identification – life stages, morphology and species with 4 reasons = 1 + 4 = 5) 30 marks
2. Identification of Queen /Drone/Brood Cells (Real/Photos) 2 specimens/ (Identification with 4 reasons)10 marks
3. Project report: 15 marks (Subject content, Presentation, Diagrams/Photos)
4. Presentation on a topic related to Apiculture. 10marks
5. Temporary mount preparation 1 slide/ 10marks (Procedure, slide submission)
6. Submission of Specimens (Dry hives, Different species and life stages of honey bees, Bee box etc.) 8 marks
7. Note Book: 7 marks (Based on the neatness, inclusiveness, overall presentation)
8. 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/ 100 marks**

Unit 1: Introduction, Status, and Diversified Poultry (6 Hours/ 20 Marks)

Importance, history, and foundational role of poultry farming in agriculture; Present status, global market trends, and future prospects of the poultry industry; Taxonomic classification, structural types, and commercial breeds of chicken; Introduction to alternative poultry types including ducks, geese, quails, guinea fowls, and turkeys; Biology, management, and economic aspects of large flightless birds (Emu farming).

Unit 2: Genetic Improvements & Scientific Brooding (6 Hours/ 20 Marks)

Overview of improved high-yielding varieties and commercial strains of chicken; Principles of selection, modern breeding techniques, and genetic optimization for egg and meat traits; Scientific brooding systems, temperature regulation, and equipment used for young chicks; Rearing Systems: Housing design and essential farm equipment required specifically for broiler rearing.

Unit 3: Commercial Production & Hatchery Management (6 Hours/ 20 Marks)

Operational management of commercial layer farms (egg production) and broiler farms (meat production); Incubator and setter operations, egg selection, sanitization, storage, and hatching workflows; Implementation and economics of the multiple batch rearing system; Key performance indices (Feed Conversion Ratio, mortality rates) and farm record-keeping methods.

Unit 4: Nutrition, Feed Additives, and Milling (6 Hours/ 20 Marks)

Definition of basic poultry feeds, essential nutrients, and baseline quality ingredients; Strategic evaluation of raw materials based on cost, geographic availability, and shelf life; Metabolic roles of nutritional supplements, feed antibiotics, and anti-oxidants in bird performance; Functional mechanisms of feed processing machinery including Hammer mills, mixers, and pellet mills; Pre-mix formulation techniques, ingredient inventory management, and technical feed mill operations.

Unit 5: Biosecurity, Farm Hygiene, and Poultry Pathology (6 Hours/ 20 Marks)

Structural rules for poultry house sanitation, waste disposal, and routine litter management; Safety standards, disinfection protocols, and continuous monitoring of feed and water lines; Major classification, clinical symptoms, etiology, and transmission pathways of viral, bacterial, and fungal diseases; Preventative biosafety measures, outbreak control protocols, and isolation management; Designing standard commercial vaccination schedules, vaccine administration routes, and monitoring protocols.

Skill Enhancement Course (SEC) -I Practical : SEC45ZOO101c(P)25

(Poultry Farming)

Practical [Credit: 1] **30 hrs/ 100 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) : 6 numbers/ 5 marks (Identification with reasons = 1 + 4 = 5 each). Total = 30 marks
2. Monitoring of Nutritive value, Protein content: procedure & result – 10 marks
3. Poultry feed preparation (Procedure and formulation) 8 marks
4. Fecal sample examination: Identification of Parasites with reasons, drawing of diagram and procedure (1 + 2 + 3 + 4= 10)
2. Project Report: 15 marks (Subject content, Presentation, Diagrams/Photos)
3. Presentation on a topic related to Poultry. 10 marks
4. Note Book: 7 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 and hands on experience at a farm 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.

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 ndia.com
https://dahd.nic.in

MANIPUR UNIVERSITY

Courses for UG Zoology

SEMESTER II

MANIPUR
UNIVERSITY UG
COURSE IN 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

Semester	Course Opted	Course code	Name	Credit
II	Ability EnhancementCourse	**AEC-2 Pool**	Academic Writing	4
	Major-I	**MJC45ZOO102(T)25**	Chordates : General 3 organization – Hemichordata to Mammalia	3
	Major -I Practical	**MJC45ZOO102(P)25**		1
	Minor-I	**MNC45ZOO102(T)25**	Fundamentals of Zoology-2 : Non Chordates	3
	Minor-I Practical	**MNC45ZOO102(P)25**	„	1
	Multidisciplinary Course - 1	**MDC45ZOO102(T)25**	Introduction to Animal diversity - 2	3
	Skill Enhancement Course (SEC)- I	**SEC45ZOO102a(T)25** **SEC45ZOO102b(T)25** **SEC45ZOO102c(T)25** **SEC45ZOO102d(T)25**	Sericulture Vermicomposting Organic farming Fish farming	2
	Skill Enhancement Course (SEC)- I Practical	**SEC45ZOO102a(P)25** **SEC45ZOO102b(P)25** **SEC45ZOO102c(P)25** **SEC45ZOO102d(P)25**	Sericulture/ Vermicomposting/ Organic farming/ Fish farming	1
	Value added Course (VAC) - I	**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- 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/ 14 marks

Comparison of Chordates & non-Chordates; General characteristics and outline classification of Chordates; Advancement of Chordate over other Phyla. Dipleurula concept and the Echinoderm theory of origin of chordates. 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 9 hrs/ 14 marks

Phylogeny or evolutionary history of Vertebrates: Salient features of Vertebrates, Diversity of Vertebrates; Comparative account between Protochordates & Vertebrates; Distinctive features of Poikilothermic & Homeothermic Vertebrates. 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/ 14 marks

General characteristics of Chondrichthyes and Osteichthyes, Classification up to order ;Types of Scales, Fins; Hypophysis & its role in induced breeding; Parental care; Migration, Osmoregulation and Swim bladder in Fish. 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/ 14 marks

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/ 14 marks

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 [Credits 2] **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, Vipera, Naja, Hydrophis, Zamenis, Crocodylus ; Aves: Study of six common birds from different orders. Types of beaks and claws; Mammalia: Sorex, Bat (Insectivorous and Frugivorous), Loris, Herpestes, Erinaceous.

2 Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules Study of Weberian ossicles of Mystus, pecten from fowl head and brain of fowl.

3 Visit to a place near the Institute to get familiarized with different vertebrates available in the area & submission of a report.

Examination evaluation Structure:

1 Museum Specimen / Models: 8 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 40 marks
2 Slide identification :3 number (Identification =1, Characters = 4) Total = 15marks
3 Visit to a place near the Institute to get familiarized with different vertebrates available in the area & submission of a report: 15marks
4. Presentation on any topic from General organization of Chordates: Hemichordata to Mammalia 10 marks
5. Note Book: 10 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 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 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/ 14 marks

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/ 14 marks

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/ 14 mark

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/ 14 marks

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;

<u>Unit 5:</u> Mammals (Prototheria, Metatheria & Eutheria) 9 hrs/ 14 marks

General characters and classification ofMammals up to Class; Distinctivecharacters 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, Vipera, Naja, Hydrophis, Zamenis, Crocodylus ; Aves: Study of six common birds from different orders. Types of beaks and claws; Mammalia: Sorex, Bat (Insectivorous and Frugivorous), Loris, Herpestes, Erinaceous.

2. Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slide of *Herdmania* spicules Study of Weberian ossicles of Mystus, pecten from fowl head and brain of fowl.

3. Visit to a place near the Institute to get familiarized with different vertebrates available in the area & submission of a report.

Examination evaluation Structure:

1 Museum Specimen / Models: 8 Numbers/ 5marks each (Identification =1, Classification= 2, Characters = 2) Total = 40 marks

2 Slide identification :3 number (Identification =1, Characters = 4) Total = 15marks

3 Visit to a place near the Institute to get familiarized with different vertebrates available in the area & submission of a report: 15marks

4. Presentation on any topic from General organization of Chordates: Hemichordata to Mammalia 10 marks

5. Note Book: 10 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 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

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 able 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/ 14 marks

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 9 hrs/ 14 marks

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/ 14 marks

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/ 14 marks

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) 9 hrs/ 14 marks

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
(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/ 100 marks

Unit 1: Introduction, Diversity, and Economics of Sericulture (6 Hours/ 20 Marks)

Definition, history, historical Silk Route, and the present global and national status of sericulture; Silk varieties, properties, commercial usage, export values, and rural employment generation opportunities; Taxonomy, distribution, and classification of different types of silkworms; Characteristics of univoltine, bivoltine, and multivoltine races; comparative study of exotic and indigenous strains.

Unit 2: Biology and Life Cycles of Silkworms (6 Hours/ 20 Marks)

Biology, life cycle, and developmental stages of the mulberry silkworm (*Bombyx mori*); Introduction to non-mulberry sericulture systems, host plants, and geographic distribution; Detailed life history and developmental cycles of Eri (*Samia ricini*) and Muga (*Antheraea assamensis*); Biology, life cycle stages, and morphological variations of Tasar (*Antheraea mylitta* / *Antheraea proylei*).

Unit 3: Moriculture and Rearing Infrastructure (6 Hours/ 20 Marks)

Selection of high-yielding mulberry varieties, soil preparation, plantation methods, and establishment of a mulberry garden; Design, environmental requirements, and architectural planning for an ideal silkworm rearing house; Study of essential farm appliances including rearing trays, stands, leaf chopping knives, and hygrometers; Importance of hygiene; preparation and application of disinfectants such as Formalin, Bleaching Powder, and RKO (Resham Keet Oushadh).

Unit 4: Rearing Technology, Harvesting, and Mountages (6 Hours/ 20 Marks)

Special environmental controls, feeding regimes, and handling techniques for young instars (Chawki rearing); Management, space optimization, and feeding schedules for late-stage mature larvae; Signs of larval maturity, population density on mountages, and comparative study of

different types of mountages (Chandrika, plastic nets); Time of harvesting, deflossing, sorting defective cocoons, and safe storage protocols for commercial cocoons.

Unit 5: Post-Harvest Processing, Pathology, and Pest Management (6 Hours/ 20 Marks)

Cocoon drying/stifling methods, silk reeling mechanics, re-reeling, yarn bundling, and final packing. Basics of silk degumming, dyeing technologies, and introductory concepts of silk weaving; Etiology, major clinical symptoms, and transmission pathways of viral (Grasserie), bacterial (Flacherie), fungal (Muscardine), and protozoan (Pebrine) diseases; Biology, damage symptoms, and integrated control measures against the Uzi fly, dermestid beetles, and vertebrate pests.

Skill Enhancement Course (SEC) – II Practical : SEC45ZOO102a(P)25 (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/cocoon) : 4 numbers/ 5 marks (Identification with reasons = 1 + 4 = 5 each). Total = 20 marks
2. Identification of diseases and enemies: 4 numbers/5 marks (Identification=1, reason=4) 20 marks.
3. Identification of appliances used for Silkworm rearing & silk threads– 4 numbers/5marks (Identification = 1, Reason = 4) 20 marks
4. Dissection, display and labeled diagram of Silk gland. (Dissection = 4, Display = 3, drawing=3) 10 marks
5. Report submission: 15 marks (Subject content, Presentation, Diagrams/Photos)
6. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
7. Viva-Voce: 10 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.htm

Skill Enhancement Course (SEC) - II: SEC45ZOO102b(T)25 (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/ 100 marks

Credits: 2 | **Total Duration:** 30 Hours | **Total Marks:** 100

Unit 1: Foundations of Vermiculture and Earthworm Diversity (6 Hours / 20 Marks)

Terminology: Introduction to vermiculture, historical background, definitions, and core principles; **Soil Ecology:** Economic importance of earthworms and their ecological value in maintaining soil structure and aeration; **Species Classification:** Ecological classification of earthworms (Epigeic, Anecic, and Endogeic categories; **Diversity:** Comparative study of useful species, contrasting local/endemic strains with popular exotic species (e.g., *Eisenia fetida*).

Unit 2: Biology and Physiology of Earthworms (6 Hours / 20 Marks)

Taxonomic positioning, nomenclature, and external morphological identification features of *Pheretima posthuma*; Basic structural anatomy, digestive layout, circulatory architecture, and excretory systems; Reproductive physiology, cocoon formation, hatching mechanics, fecundity, and annual reproductive potential.

Unit 3: Biotransformation and Production Methods (6 Hours / 20 Marks)

Operational role of earthworms in the breakdown, decomposition, and biotransformation of organic agro-residues; Site selection, baseline materials, and procedural steps for home-scale container and pit vermicomposting methods; Technical setup, row configuration, and structural design for commercial-scale bed farming and windrow methods; Identifying critical threshold parameters and limiting factors that cause failure in vermicomposting systems.

Unit 4: Environmental Parameters and Processing Technology (6 Hours / 20 Marks)

Continuous monitoring of critical temperature, moisture content, aeration levels, and optimal pH ranges; Nutrient composition profiles of final vermicompost, tracking primary elements (NPK ratios) and micronutrients; Separation methods, mechanical worm extraction, screening, sieving, and bulk harvesting of vermicompost; Quality stabilization, moisture curing, standard packaging materials, commercial storage conditions, and transport rules.

Unit 5: Vermiculture Pathology, Protection, and Economics (6 Hours / 20 Marks)

Identification of major microbial, fungal, or environmental stress diseases affecting earthworm populations; Common predatory threats and pests including ants, termites, mites, centipedes, birds, and rodents; Implementation of protective boundary mesh, chemical-free traps, and preventative crop management practices; Overview of value-added products (like Vermiwash extraction), market demands, and commercial small-scale business budgeting.

Skill Enhancement Course (SEC) – II Practical : SEC45ZOO102b(P)25 (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 vermicomposing units using locally available resources
6. Vercompost production, harvesting and packaging
7. Study of cocoon and vermicast
8. Study of pests and diseases of earthworms
9. Visit to a local Vermicomposting Unit & submission of report.

Examination evaluation Structure:

1. Identification & Characters of different Earthworms (live/ Preserved specimen /Photo): 4 numbers/ 5 marks (Identification with reasons = 1 + 4 = 5 each). Total = 20 marks
2. Identification of appliances used for Vermicomposting – 4 numbers/ (Identification = 1, Reason = 4) 20 marks
3. Identification of pests and diseases of earthworm. 2 number/5 marks (Identification = 1, reason =4). 10marks
4. Dissection, display and labeled diagram of internal organs of Earthworm. (Dissection = 4, Display = 3, Drawing =3) 10 marks
5. Report submission: 15 marks (Subject content, Presentation, Diagrams/Photos)
6. Presentation on a topic related to vermicomposting. 10 marks
7. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
8. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

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 amongthe 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 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:

- 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

Online Tools and Web Resources:

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

Skill Enhancement Course (SEC) - II: SEC45ZOO102c(T)25
(Organic Farming)

Objective:

The course will make the students aware about the significance of Organic farming. It will help the students to understand benefits of organic nutrients and the need for conservation of age old indigenous practices.

Outcome:

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

- Learn about the history of Organic farming.
- Recognize various pre requisites of this method.
- Be aware about the opportunities and management strategies involved.
- Gain thorough knowledge about the techniques involved in Organic farming.
- Develop knowledge about quality maintenance, accreditation & marketing opportunities.

Course Content:

Theory [Credits: 2] 30 hrs/ 100 marks

Unit 1: Foundations and Principles of Organic Farming (6 Hours / 20 Marks)

Definition, scope, core concepts, and fundamental principles of organic farming; Historical development of organic agriculture and an overview of the global market scenario; Baseline requirements, farm conversion periods, and essential entry criteria for setting up an organic farm; Detailed assessment of current prospects, adoption bottlenecks, and operational problems in organic farming.

Unit 2: Biodiversity and Soil Carbon Management (6 Hours / 20 Marks)

Importance of ecological biodiversity on a farm and specific strategic measures to preserve it; Current status of soil organic carbon (SOC) and its critical role in maintaining long-term soil health; Practical field-level management practices to build, enrich, and maintain soil organic carbon percentages.

Unit 3: Organic Nutrient Sources and Waste Recycling (6 Hours / 20 Marks)

Sourcing organic nutrients from internal on-farm networks and external off-farm inputs; Preparation, usage, and nutritional values of bulky organic manures and concentrated organic inputs; Standard scientific methods for the decomposition, processing, and recycling of organic agricultural wastes; Classification, application modes, and efficiency of nitrogen-fixing and phosphorus-solubilizing bio-fertilizers.

Unit 4: Ecological Crop and Non-Chemical Weed Management (6 Hours / 20 Marks)

Implementation models for strategic intercropping, crop rotation, cover crops, and mulching; Selection of green manure crops, growth stages, and techniques for in-situ soil incorporation;

Practical execution of preventative, physical, cultural, mechanical, and biological weed control measures.

Unit 5: Bio-Intensive Plant Protection, ITK, and Certification (6 Hours / 20 Marks)

Formulation and application of bio-intensive pest and pathogen management systems; Validation and scientific rationale of traditional Indigenous Technical Knowledge (ITK) in organic agriculture; Regulatory standards of the National Programme for Organic Production (NPOP) and crop production standards; Indian certification agencies, accreditation protocols, labeling laws, marketing setups, and export market opportunities.

Skill Enhancement Course (SEC) – II Practical : SEC45ZOO102c(P)25

(Organic Farming)

Practical [Credit: 1] 30 hrs/ 100 marks

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

Examination evaluation Structure:

1. Identification different Soil types. 3 numbers / 5 marks (Identification = 1, Reason = 4) 15 marks
2. Identification of common pests/physiological disorders, 4 numbers/5 marks(Identification=1, reasons=2, remedy=2) 20 marks
3. Identification of appliances / farm equipments/ implements & drawing (2 number / 5 marks) (identification = 1, drawing = 4) 10 marks
4. Testing of Soil.(15 marks) (Testing = 7, Procedure = 5 , Result = 3)
5. Calculation of different Fertilizers required for Crops. 5 marks
6. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
7. Presentation on a topic related to Organic farming. 10 marks
8. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
9. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about benefits of Organic farming will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of farms and study of different technologies will be assisted through visits to various farms; 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 Organic farming 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 farm implements and their workings. Visit to various Organic Villages will clarify their concepts about Organic farming and the marketability of Organic products.

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. Panda S.C. 2018. Soil Management and organic farming. Agrobios
2. Dahama, A.K.2009. Organic farming for sustainable agriculture, Agrobros publishers.
3. SP. Palaniappan and K Annadurai. 2008. Organic Farming: Theory and Practice. Scientific Publishers.
4. Panda, S.C. 2012. Principles and Practices of Organic Farming. Agribios (India), Jodhpur.
5. Gehlot, D. 2010. Organic Farming- Components and Management. Agribios (India), Jodhpur.
6. Dushyant Gehlot . 2010. Organic farming: Components and management. Agrobios (India), Jodhpur.
7. Ranjan Kumar Biswas.2014. Organic farming in India. N.D. Publishers. New Delhi.

Online Tools and Web Resources:

http://ecoursesonline.iasri.res.in/

www.ifoam.org

www.apeda.org

Skill Enhancement Course (SEC) - II: SEC45ZOO102d(T)25
(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 effectivesiteselection, 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 analysing real-life case studies and success stories.

Theory [Credits: 2] **30 hrs/ 100 Marks**

Unit 1: Foundations of Aquaculture and Pond Construction (6 Hours / 20 Marks)

Core definition, operational scope, and socio-economic importance of fish farming; Criteria for engineering site selection and structural pond construction; Classification of rearing methods including composite fish farming and integrated fish farming; Comparative study of semi-intensive and intensive fish farming practices.

Unit 2: Pond Preparation and Water Quality Management (6 Hours / 20 Marks)

Physical pond preparation stages involving liming, fertilization, and basal weed control; Eradication protocols for invasive aquatic weeds, predatory insects, and natural fish enemies; Water quality management; Monitoring and balancing pH, Biochemical Oxygen Demand (BOD), dissolved oxygen, and Ammonia (NH_3) values.

Unit 3: Fish Seed, Biology, and Population Management (6 Hours / 20 Marks)

Identification features of Indian Major Carps (IMC) and common exotic fishes; Feeding behaviors and food habits of different culturable fish species; Structural timeline of pre-stocking, stocking, and post-stocking fish pond management; Calculating optimal stocking rates and multi-species stocking ratios; Diagnostics of common fish diseases and their specific control measures.

Unit 4: Induced Breeding, Hatcheries, and Processing (6 Hours / 20 Marks)

Induced breeding techniques of Indian Major Carps (IMC) and exotic fishes; Selection, conditioning, and brooder management; Technical process of hypophysation; use of synthetic hormones (Ovaprim, Ovatide), detailing dosing and administration pathways; Structural design and operation of Hapa type hatcheries and Chinese hatchery systems; Commercial fish harvesting methods and traditional preservation techniques including drying, smoking, and fermentation.

Unit 5: Modern Aquaculture Technologies and Entrepreneurship (6 Hours / 20 Marks)

Application of sustainable, climate-resilient, and resource-efficient technologies in aquaculture; Microbial and engineering principles behind Biofloc technology (BFT) and Recirculatory Aquaculture Systems (RAS); **Ecological Engineering:** Integrated designs using Aquaponics and Integrated Multi-Trophic Aquaculture (IMTA) systems; Scope, economic significance, and professional development of entrepreneurship in fisheries; Real-world evaluation through industry success stories and case studies.

Skill Enhancement Course (SEC) – II practical : SEC45ZOO102d(P)25

(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 oxygen, BOD.
3. Identification of common Zoo 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 of pituitary gland.
6. Identification of common fish diseases (bacterial, fungal and viral)
7. Visit to a fish farm/ fish hatchery with Demonstration of RAS/Aquaponics/ Biofloc and Report Submission

Examination evaluation structure:

1. Identification of fish seed/ adult fish & characters of specimen: 5 numbers/ 5 marks (Identification with comments: 1+4 = 5). Total: 5x5 = 25
2. Water quality analysis: Procedure, Observation & Result – 15 marks
3. Identification of aquatic weeds/ insects/planktons: 4 numbers (Identification with characters: 1+4 =5). Total: 4x5 = 20
4. Dissection & display of pituitary gland with diagram. 8+3+4=15 marks
5. Field report: 10 marks (Content, presentation)
6. Note book submission: 5 marks (Based on Inclusiveness, neatness and presentation)
7. Viva: 10 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 enhancestudents'learning and confidence. Thepresentations will beassessed 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. Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan publication Corp., India.
2. Pandey, K and J.P. Shukla (2013) Fish and Fisheries. Rastogi Publication.
3. Pillay, T.V.R. (1990) Aquaculture, Principles and Techniques. Fishing News Book Ltd.
4. Chonder, S.L. (1994) Induced Carp Breeding. CBS Publishers and Distributors, New Delhi
5. John, S. L. and C. S. Paul (2012) Aquaculture: Farming Aquatic Animals and Plants. 2nd Edition, Wiley-Blackwell
6. Avnimelech, Y. (2015) Biofloc technology, a practical guidebook. 3rd Edition, World Aquaculture Society.
7. Timmons, M.B., T, Guerdat and B.J. Vinci (2018) Recirculatory Aquaculture. 4th Edition, Ithaca Publishing Company, New York.
8. Burnell G, Allan G. 2009. New Technologies in Aquaculture. 1st Edition. Woodhead Publishing House.
9. Tidwell JH. (Ed.). 2012. Aquaculture Production Systems. Wiley-Blackwell.
10. Goddek, S., Joyce, A., Kotzen, B., and Burnell, G. M. (Eds.). (2019). Aquaponics food production systems. Springer.

MANIPUR UNIVERSITY
UG COURSE IN ZOOLOGY
COURSE STRUCTURE (NEW)
IIIrd SEMESTER

SEMESTER	COURSE OPTED	COURSE CODE	NAME	CREDIT
III	Major 3	MJC50ZOO203(T)25	Principles of Animal Systematics (Theory)	3
	Major 3 Practical	MJC50ZOO203(P)25	Principles of Animal Systematics (Practical)	1
	Major 4	MJC50ZOO204(T)25	Cell and Molecular Biology (Theory)	3
	Major 4 Practical	MJC50ZOO204(P)25	Cell and Molecular Biology (Practical)	1
	Minor- 3	MNC50ZOO203(T)25	Cell Biology and Principles of Taxonomy (Theory)	3
	Minor 3 Practical	MNC50ZOO203(P)25	Cell Biology and Principles of Taxonomy (Practical)	1
	Multidisciplinary Course-3 (MDC-3)	MDC50ZOO203(T)25	Animals, Humans, and the Environment (Theory)	3
	Skill Enhancement Course (SEC)-III	SEC50ZOO203a-c (T)25	Poultry Farming/Fish Farming/ Organic Farming*	2
	Skill Enhancement Course (SEC)-III Practical	SEC50ZOO203a-c(P)25	Poultry Farming/Fish Farming/ Organic Farming*	1
	Value Added Course		To be opted from University VAC pool	2
	Total Credit			**20**

Major 3: MJC50ZOO203(T)25

Principles of Animal Systematics (Theory)

Course Objectives

- Introduce core concepts, history, and the foundational importance of animal taxonomy and systematics.
- Explain the mechanisms of speciation, species concepts, and evolutionary relationships among animal groups.
- Familiarize students with the rules, principles, and typification protocols of the International Code of Zoological Nomenclature (ICZN).
- Train students in practical field collection, preservation, curation, and the use of dichotomous keys.
- Expose students to modern taxonomic tools including chemotaxonomy, cytotaxonomy, and molecular DNA barcoding.

Course Outcomes

- Differentiate between alpha, beta, and gamma taxonomy and apply phenetic and cladistic systems.
- Analyze evolutionary trees, recognize monophyletic or polyphyletic groups, and explain speciation pathways.
- Apply ICZN rules correctly to assign, evaluate, or revise scientific zoological names.
- Execute ethical scientific collection, safely curate specimens, and build or navigate taxonomic keys.
- Utilize modern biochemical, chromosomal, and DNA-based barcoding methods to resolve complex taxonomic issues

Course Content:

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

Course Unit

Unit 1: Introduction to Systematics and Taxonomy 9hrs/20 marks

Definition, history, and importance of taxonomy and systematic; Alpha, Beta, and Gamma taxonomy levels; Taxonomic hierarchy; Role of systematics in biology, conservation, and agriculture; Phenetic vs. cladistic classification systems.

Unit 2: Concept of Classification & Evolutionary Principles 9hrs/20 marks

Biological, evolutionary, and phylogenetic species concepts; Mechanisms of allopatric, sympatric, and parapatric speciation; Morphological, embryological, behavioral, and ecological characters; Monophyly, polyphyly, paraphyly, and evolutionary trees.

Unit 3: International Code of Zoological Nomenclature 9hrs/20 marks

History, Operative Principles, And Important Rules Of ICZN; Binomial and Trinomial Nomenclature Systems; Concepts of Holotype, Allotype, Paratype, Syntype, Neotype, Lectotype, Paralectotype, Type locality; Law of Priority, Homonyms, and Synonyms.

Unit 4: Taxonomic Procedures & Methodology 9hrs/20 marks

Methods of collecting, preserving, and curating animal specimens: morphology and meristic; Structure and use of dichotomous taxonomic keys; Structure of a taxonomic description and revision; Ethics in animal collection and taxonomic publication.

Unit 5: Modern Trends in Systematics 9hrs/20 marks

Chemotaxonomy: Use of biochemical compounds and proteins; Cytotaxonomy: Chromosomal numbers, structure, and karyotypes; Molecular Systematics (DNA barcoding).

Major 3: MJC50ZOO203(P)25

Principles of Animal Systematics (Practical)

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

1. Study of taxonomic hierarchy using representative animals.
2. Preparation and use of dichotomous keys.
3. Resolving name conflicts via the Principle of priority
4. Type specimen analysis and categorization
5. Nomenclature of new species by providing collection data
6. Study of zoological nomenclature through practical examples.
7. Observation of preserved museum specimens and taxonomic labels.
8. Identification of homologous and analogous organs.
9. Field visit to a museum, Zoological park, or biodiversity park (wherever feasible) and submission of visit report.

Examination evaluation Structure:

1. Museum Specimen: 7 Numbers/ 5 marks each (Identification =1, Classification= 2, Characters = 2) Total = **35 marks**
2. Identification of permanent Slides): 2 numbers/4 marks (Identification=1 reasons = 3). **8 marks**
3. Resolving name conflicts via the Principle of priority. **3 marks**
4. Type specimen analysis and categorization. **5 marks**
5. Nomenclature of new species by providing collection data. **4 marks**
6. Construction and use of dichotomous keys for identification of selected animals. Principle & objective – 1, Selection of diagnostic characters –2 Construction of dichotomous key –4, Identification using the key – 3. **Total=10**
7. Construction and Interpretation of Simple Cladograms. Identification of taxa and derived characters- 2, Construction of simple cladogram (root, branching, labels)-4, Interpretation of relationships (sister groups, common ancestry, sequence of divergence)- 3, Scientific terminology and conclusion-1. **Total-10**
8. Project report submission: **10 marks**
9. Note Book: **5 marks** (Based on the neatness, inclusiveness, overall presentation)
10. 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 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

- Mayr, E., & Ashlock, P. D. (1991). *Principles of systematic zoology* (2nd ed.). McGraw-Hill.
- Kapoor, V. C. (1998). *Theory and practice of animal taxonomy* (6th ed.). Oxford & IBH Publishing Co.
- Narendran, T. C. (2008). *An introduction to taxonomic theory and practice*. Zoological Survey of India.

Major 4: MJC50ZOO204(T)25

Cell and Molecular Biology (Theory)

Course Objectives

- **Provide** a foundational overview of the structural and functional organization of prokaryotic and eukaryotic cells.
- **Detail** the mechanisms governing biomembrane dynamics, transport, and the roles of cellular organelles.
- **Elucidate** the mechanisms of DNA replication, transcription, and translation inside living systems.
- **Explain** gene regulation networks and the pathways that trigger programmed cell death (apoptosis).

Course Outcomes

After successful completion of the course, students will be able to:

- Explain the structural organization and functional properties of biological membranes and distinguish between prokaryotic and eukaryotic cell systems, including different mechanisms of passive, facilitated, and active transport, endocytosis, phagocytosis, pinocytosis, and exocytosis.
- Describe the structure and functions of major cell organelles and the cytoskeleton, with emphasis on the endomembrane system, mitochondria, lysosomes, peroxisomes, ribosomes, microfilaments, intermediate filaments, and microtubules, and relate their organization to cellular functions.
- Understand the organization of the nucleus and genetic material and explain chromatin organization, nuclear pore complexes, nucleoli, DNA replication in prokaryotes and eukaryotes, and the basic mechanisms involved in DNA repair.
- Explain the processes of transcription and translation and distinguish between gene expression mechanisms in prokaryotic and eukaryotic cells, including RNA polymerases, RNA processing, splicing, 5′ capping, polyadenylation, and the major stages of protein synthesis.
- Describe mechanisms of gene regulation and cell-cycle control, including the lac and trp operons, eukaryotic transcription factors, mitosis, meiosis, and cell-cycle checkpoints.
- Explain basic cellular signaling and programmed cell death, including extracellular receptors, secondary messengers, signal transduction pathways, and the major mechanisms of apoptosis.
- Apply knowledge of cell and molecular biology to interpret basic experimental observations and biological processes, thereby developing scientific reasoning and an understanding of the relationship between cellular structure, molecular mechanisms, and cellular function.

Course Content

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

Course Units

Unit 1: Membrane Structure and functions **9hrs/ 20 marks**

Structural comparison between Prokaryotic and Eukaryotic cell systems; Membrane Structure: Fluid Mosaic Model; chemical composition of biological membranes; Membrane Transport: Mechanics of passive, active, and facilitated transport systems; Pathways of endocytosis, phagocytosis, exocytosis, and pinocytosis.

Unit 2: Cell Organelles & Cytoskeleton **9hrs/ 20 marks**

Endomembrane System**:** Structures and functional pathways of the Endoplasmic Reticulum (rough and smooth) and Golgi complex; Ultrastructure and genetic autonomy of Mitochondria; Structures, functions, and roles of Lysosomes, Peroxisomes, and Ribosomes; Cytoskeleton: Microfilaments, intermediate filaments, and microtubules contributing to cell motility and shape.

Unit 3: Nucleus and DNA Replication **9hrs/ 20 marks**

Nuclear Envelope: Structure of the nuclear envelope, nuclear pore complex, and nucleolus organization; Genetic Material: Organization of chromatin from nucleosomes into higher-order chromosome structures; DNA Replication: Enzymes and steps of replication in prokaryotes vs. eukaryotes; basic mechanisms of DNA repair.

Unit 4: Central Dogma: Transcription and Translation **9hrs/ 20 marks**

Transcription: Mechanics of RNA synthesis in prokaryotes and eukaryotes; roles of distinct RNA Polymerases; RNA Processing: Post-transcriptional modifications including splicing, 5' capping, and 3' polyadenylation; Translation: Mechanisms of protein synthesis: initiation, elongation, and termination phases in cells.

Unit 5: Gene Regulation, Cell Cycle and Signaling **9hrs/ 20 marks**

Gene Regulation: Prokaryotic operon systems (Lac and Tryp Operon); eukaryotic transcription factors; **Cell cycle:** Phases of mitosis and meiosis; checkpoints and regulation; **Signaling and Death:** Overview of extracellular receptors, secondary messengers, and Programmed Cell Death (Apoptosis) pathways.

Major 4: MJC50ZOO204(P)25

Cell and Molecular Biology (Practical)

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

1. Preparation and observation of animal cells (cheek epithelial cells).
2. Study of mitosis using onion root tip or prepare slides.
3. Study of meiosis using grasshopper testis.
4. Identification of cell organelles from photomicrographs and electron micrographs.
5. Study of prokaryotic (bacterial) and eukaryotic (plant and animal) cell structures using differential staining techniques.
6. Demonstration of osmotic dynamics (plasmolysis and deplasmolysis) and cell membrane permeability using red blood cells or plant tissues.
7. Preparation of polytene chromosome spreads from *Chironomus* or *Drosophila* salivary glands to study gene puffing activity
8. Isolation and subcellular fractionation of cellular organelles (e.g. Nucleus, Chloroplast, mitochondria) via differential centrifugation
9. Demonstration on separation, visualization, and size determination of isolated DNA fragments using Agarose Gel Electrophoresis (AGE)
10. A visit to a well-equipped research facility laboratory/centre within the state and submission of visit report.

Examination evaluation Structure:

11. Identification of cell organelles (photo/picture): 5 Numbers/ 3 marks each (Identification =1, Characters = 2) **Total = 15 marks**
12. Study of Mitosis/Meiosis **Total= 15 marks**. Principle & objective – 3 marks, procedure- 6 marks, Observation & Identification of stages – 3 marks, Interpretation/comparison – 2 marks, Result/conclusion – 1 mark
13. Preparation of polytene chromosome spreads from *Chironomus* or *Drosophila* salivary glands. **Total= 15 marks.** Principle & objective – 3 marks, preparation procedure – 6 marks, Observation & identification – 3 marks, Interpretation of bands/gene puffing – 2 marks, Result/conclusion – 1 mark
14. Study of prokaryotic (bacterial) and eukaryotic (plant and animal) cell structures using differential staining techniques. **Total= 15 marks.** Principle & objective – 3 marks, Staining technique and slide preparation procedure – 6 marks, microscopic observation/identification – 3 marks, Comparative interpretation – 2 marks, Result/conclusion – 1 mark.
15. Demonstration on separation, visualization, and size determination of isolated DNA fragments using Agarose Gel Electrophoresis (AGE). **Total= 15 marks** Principle & objective – 2, Procedure/technique – 6, Observation & visualization – 2, DNA size determination – 3, Result & interpretation – 1, Precautions – 1
16. Project report submission: **10 marks**
17. Note Book: **5 marks** (Based on the neatness, inclusiveness, overall presentation)
18. Viva-Voce: **10 marks** (Testing of Knowledge in the said Course)

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

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular biology of the cell* (6th ed.). Garland Science.
2. Cooper, G. M., & Hausman, R. E. (2019). *The cell: A molecular approach* (8th ed.). Oxford University Press.
3. Karp, G. (2019). *Cell and molecular biology: Concepts and experiments* (9th ed.). Wiley.
4. Verma, P. S., & Agarwal, V. K. (2016). *Cell biology, genetics, molecular biology, evolution and ecology*. S. Chand Publishing.
5. Power, C. B. (1990). *Cell biology*. Himalaya Publishing House.
6. De Robertis, E. D. P., & De Robertis, E. M. F. (2017). *Cell and molecular biology* (8th ed.). Lippincott Williams & Wilkins.

MINOR- 3: MNC50ZOO203(T)25

Cell Biology and Principles of Taxonomy (Theory)

Course Objectives

- **Understand** the fundamental structural and functional organization of prokaryotic and eukaryotic cell systems.
- **Elucidate** the structure and dynamics of biomembranes, cellular organelles, and the cell division cycle.
- **Introduce** the foundational theories, terminology, and historical milestones of animal taxonomy and systematics.
- **Familiarize** students with the formal operational rules of the International Code of Zoological Nomenclature (ICZN).
- **Expose** students to modern taxonomic tools, linking cellular characteristics (cytotaxonomy) to evolutionary relationships.

Course Outcomes

- **Differentiate** between cell types and map how nutrients move across biological boundaries.
- **Identify** cellular organelles and recognize individual structural phases during cell division.
- **Classify** animals systematically by navigating species concepts and geographic speciation models.
- **Apply** ICZN guidelines flawlessly to evaluate scientific nomenclature, synonymy, and type specimens.
- **Interpret** basic evolutionary lineage trees and utilize chromosomal structures to resolve taxonomic groupings.

Course content

[Credit:3] 45 hours/100 marks 100 marks (70 for end exam, 30 for Internal assessment)

Unit 1: Membrane Structure and functions 9 Hrs/20 marks

Structural comparison between Prokaryotic and Eukaryotic cell systems; Membrane Structure: Fluid Mosaic Model; chemical composition of biological membranes; Membrane Transport: Mechanics of passive, active, and facilitated transport systems; Pathways of endocytosis, phagocytosis, exocytosis, and pinocytosis.

Unit 2: Cell Organelles & Cytoskeleton 9 Hrs/20 marks

Endomembrane System**:** Structures and functional pathways of the Endoplasmic Reticulum (rough and smooth) and Golgi complex; Ultrastructure and genetic autonomy of Mitochondria; Structures, functions, and roles of Lysosomes, Peroxisomes, and Ribosomes; Cytoskeleton: Microfilaments, intermediate filaments, and microtubules contributing to cell motility and shape.

Unit 3: Introduction to Systematics and Taxonomy **9 Hrs/20 marks**

Definition, history, and importance of taxonomy and systematic; Alpha, Beta, and Gamma taxonomy levels; Role of systematics in biology, conservation, and agriculture; Phenetic vs. cladistic classification systems.

Unit 4: Concept of Classification & Evolutionary Principles **9 Hrs/20 marks**

Biological, evolutionary, and phylogenetic species concepts; Mechanisms of allopatric, sympatric, and parapatric speciation; Morphological, embryological, behavioral, and ecological characters; Monophyly, polyphyly, paraphyly, and evolutionary trees.

Unit 5: International Code of Zoological Nomenclature **9 Hrs/20 marks**

History, Operative Principles, And Important Rules Of ICZN; Binomial and Trinomial Nomenclature Systems; Concepts of Holotype, Allotype, Paratype, Syntype, Neotype, Lectotype, Paralectotype, Type locality; Law of Priority, Homonyms, and Synonyms.

Minor 3: MNC50ZOO203(P)25

Cell Biology and Principles of Taxonomy (Practical)

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

10. Study of taxonomic hierarchy using representative animals.
11. Identification of common invertebrates and vertebrates up to phylum/class using diagnostic characters.
12. Preparation and use of dichotomous keys.
13. Study of zoological nomenclature through practical examples.
14. Preparation and observation of animal cells (cheek epithelial cells).
15. Identification of cell organelles from photomicrographs and electron micrographs.
16. Study of prokaryotic (bacterial) and eukaryotic (plant and animal) cell structures using differential staining techniques.

Examination evaluation Structure:

19. Museum Specimen: 8 Numbers/ 5 marks each (Identification =1, Classification= 2, Characters = 2) **Total = 40 marks**
20. Construction and use of dichotomous keys for identification of selected animals. Principle & objective – 2, Selection of diagnostic characters – 4, Construction of dichotomous key – 4, Identification using the key – 5 **Total=15 marks**
21. Study of prokaryotic (bacterial) and eukaryotic (plant and animal) cell structures using differential staining techniques. **Total= 15 marks.** Principle & objective – 3 marks, Staining technique and slide preparation procedure – 6 marks, microscopic observation/identification – 3 marks, Comparative interpretation – 2 marks, Result/conclusion – 1 mark.
22. Identification of cell organelles: 5 Numbers/ 3 marks each (Identification =1, Characters = 2) **Total = 15 marks**
23. Note Book: **5 marks** (Based on the neatness, inclusiveness, overall presentation)
24. Viva-Voce: **10 marks** (Testing of Knowledge in the said Course)

Teaching-Learning Process

The course will be delivered through interactive lectures, PowerPoint presentations, diagrams, animations, demonstrations, and specimen-based learning. Discussions, case studies, group activities, student presentations, and problem-based exercises will be used to develop conceptual understanding and critical thinking. Practical examples and visual materials will be used to explain membrane structure and transport, cell organelles, cytoskeleton, systematics, taxonomy, classification, evolutionary relationships, and the principles of zoological nomenclature. Students will be encouraged to participate in quizzes, assignments, projects, specimen identification, and classification exercises to reinforce learning and apply theoretical concepts. Continuous assessment through class tests, assignments, presentations, and other formative activities will provide regular feedback on student progress.

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

- *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology* by P.S. Verma and V.K. Agarwal *(S. Chand Publications).*
- *Principles of Systematic Zoology* by Ernst Mayr and Peter D. Ashlock *(McGraw-Hill).*
- *Karp's Cell and Molecular Biology: Concepts and Experiments* by Gerald Karp *(Wiley).*
- *Theory and practice of Animal Taxonomy:* V.C Kapoor. Oxford and IBH Publishing Co. Pvt. Ltd.
- *An Introduction to Taxonomy*: T.C. Narendran. ZSI, Kolkata.
- *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology* by P.S. Verma and V.K. Agarwal *(S. Chand Publications)*
- Cell Biology by C.B. Power
- De Robertis, E.D.P., & De Robertis, E.M.F. (2018). *Cell and Molecular Biology*, 9th Edition. Lippincott Williams & Wilkins.

Multidisciplinary Course-3 (MDC-3): MDC50ZOO203(T)25

Title: Animals, Humans, and the Environment (Theory)

Course Objective

The course aims to provide students with a basic understanding of animal life, animal diversity, behavior, ecology, and the relationship between animals, humans, and the environment. It seeks to develop awareness of the effects of human activities on wildlife and ecosystems, while introducing students to wildlife conservation, sustainable coexistence, and the importance of animal health in human well-being.

Course Outcomes

After successful completion of the course, students will be able to:

- Understand the basic foundations of animal life and describe the general organization of animal cells, energy generation, animal diversity, and the importance of classification.
- Explain animal behavior and communication by recognizing different forms of communication, social organization, division of labour, and migration in animals such as bees, ants, birds, and fish.
- Understand fundamental ecological concepts, including biotic and abiotic components of ecosystems, food chains, food webs, and ecological pyramids.
- Assess the impact of human activities on wildlife and explain how deforestation, urbanization, industrial farming, pollution, poaching, illegal wildlife trade, and overfishing affect animals and their habitats.
- Develop awareness of wildlife conservation and sustainable coexistence through knowledge of the Red Data Book, protected areas, wildlife sanctuaries, national parks, zoological reserves, and conservation strategies.
- Recognize the relationship between animal health and human health and gain basic awareness of important animal/vector-borne diseases such as malaria, dengue, typhus, and rabies.

Course content:

Theory [Credit:3] 45 hours/100 marks (70 for end exams, 30 marks for internal)

Unit 1: Foundations of Animal Life and the Human Connection (9 Hours)

A simple, non-technical look at how animal cells are structured, boundary themselves, and generate energy; Introduction to the massive diversity of animal life and need for classification; Human-animal interactions; domestication of livestock, pets, and beasts of burden.

Unit 2: Animal Behavior and Social Systems (9 Hours)/20 marks

Animal Communication**:** using sounds, visual displays, scents, and dances (Bee, Ants, Birds); The division of labour in Bee; Understanding animal migration in Fish and Birds.

Unit 3: Basics of Ecology (9 Hours) 20 marks

Basic components of an ecosystem, Living and non-living; food chains and food web and ecological pyramids.

Unit 4: The Impact of Human Activities on Wildlife (9 Hours) 20 marks

Consequences of deforestation, urbanization, and industrial farming on animal habitats; Impact of pollution to wild life; The ecological threats posed by illegal wildlife trade, poaching, and commercial overfishing.

Unit 5: Conservation and Sustainable Coexistence (9 Hours) 20 marks

Strategies for wildlife conservation, Red Data Book; understanding protected parks, sanctuaries, and zoological reserves; animal diseases and human health (e.g. Malaria, Dengue, Typhus, Rabies).

Teaching-Learning Process

The teaching-learning process will be student-centered, interactive, and activity-oriented, combining classroom lectures with PowerPoint presentations, audiovisual materials, discussions, question–answer sessions, case studies, and examples from everyday life. Simple diagrams, photographs, videos, and demonstrations will be used to explain animal diversity, behavior, ecology, human–animal interactions, and conservation. Students will be encouraged to participate in group discussions, presentations, projects, assignments, quizzes, and field-based or nature-observation activities to develop critical thinking and environmental awareness. Relevant case studies on wildlife conservation, pollution, human–wildlife conflict, animal diseases, and sustainable coexistence will be incorporated to connect theoretical concepts with real-world situations. Continuous assessment through class tests, assignments, presentations, participation, and project work, along with the semester-end examination, will be used to monitor and evaluate student learning.

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.
- **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

- Hickman, C. P., Jr., Keen, S. L., Eisenhour, D. J., Larson, A., & I'Anson, H. (2019). *Integrated principles of zoology* (18th ed.). McGraw-Hill Education. G
- Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From individuals to ecosystems* (4th ed.). Blackwell Publishing.
- Dugatkin, L. A. (2020). *Principles of animal behavior* (4th ed.). University of Chicago Press.
- Molles, M. C., Jr., & Sher, A. A. (2019). *Ecology: Concepts and applications* (9th ed.). McGraw-Hill Education.
- Primack, R. B. (2014). *Essentials of conservation biology* (6th ed.). Sinauer Associates.
- Miller, G. T., Spoolman, S., & Andrews-Brown, D. M. (2025). *Environmental science* (17th ed.). Cengage
- Alcock, J. (2013). *Animal behavior: An evolutionary approach* (10th ed.). Sinauer Associates.

Note: Out of the three papers offered under SEC-III, students shall choose one paper that they have not opted for in the 1st or 2nd semester.

Skill Enhancement Course (SEC) -III: SEC50ZOO203a(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.

Course Outcomes

After successful completion of the course, students will be able to:

- Understand the importance, status, diversity, and economic significance of poultry farming and identify major commercial and alternative poultry species and breeds.
- Explain the principles of genetic improvement, scientific brooding, housing, and rearing systems used in commercial poultry production.
- Describe the management of layer and broiler farms and hatchery operations, including egg handling, incubation, hatching, performance evaluation, and farm record keeping.
- Understand the principles of poultry nutrition, feed formulation, feed additives, and feed processing and their role in improving poultry productivity.
- Apply basic principles of poultry farm hygiene, biosecurity, sanitation, waste management, and disease prevention.
- Identify major viral, bacterial, and fungal poultry diseases and explain their transmission, symptoms, prevention, control, and isolation measures.
- Understand the principles of poultry vaccination, vaccine administration, and health monitoring for maintaining healthy and productive flocks.
- Develop an integrated understanding of scientific, sustainable, and economically efficient poultry production practices.

Course Content:

Theory [Credits: 2] ***30 hrs/ 100 marks***

Course Unit:

Unit 1: Introduction, Status, and Diversified Poultry (6 Hours/20 Marks)

Importance, history, and foundational role of poultry farming in agriculture; Present status, global market trends, and future prospects of the poultry industry; Taxonomic classification, structural types, and commercial breeds of chicken; Introduction to alternative poultry types including ducks, geese, quails, guinea fowls, and turkeys; Biology, management, and economic aspects of large flightless birds (Emu farming).

Unit 2: Genetic Improvements & Scientific Brooding (6 Hours/20 Marks)

Overview of improved high-yielding varieties and commercial strains of chicken; Principles of selection, modern breeding techniques, and genetic optimization for egg and meat traits; Scientific brooding systems, temperature regulation, and equipment used for young chicks; Rearing Systems: Housing design and essential farm equipment required specifically for broiler rearing.

Unit 3: Commercial Production & Hatchery Management (6 Hours/20 Marks)

Operational management of commercial layer farms (egg production) and broiler farms (meat production); Incubator and setter operations, egg selection, sanitization, storage, and hatching workflows; Implementation and economics of the multiple batch rearing system; Key performance indices (Feed Conversion Ratio, mortality rates) and farm record-keeping methods.

Unit 4: Nutrition, Feed Additives, and Milling (6 Hours/20 Marks)

Definition of basic poultry feeds, essential nutrients, and baseline quality ingredients; Strategic evaluation of raw materials based on cost, geographic availability, and shelf life; Metabolic roles of nutritional supplements, feed antibiotics, and anti-oxidants in bird performance; Functional mechanisms of feed processing machinery including Hammer mills, mixers, and pellet mills; pre-mix formulation techniques, ingredient inventory management, and technical feed mill operations.

Unit 5: Biosecurity, Farm Hygiene, and Poultry Pathology (6 Hours/20 Marks)

Structural rules for poultry house sanitation, waste disposal, and routine litter management; Safety standards, disinfection protocols, and continuous monitoring of feed and water lines; Major classification, clinical symptoms, etiology, and transmission pathways of viral, bacterial, and fungal diseases; Preventative biosafety measures, outbreak control protocols, and isolation management; Designing standard commercial vaccination schedules, vaccine administration routes, and monitoring protocols.

Skill Enhancement Course (SEC) -III Practical SEC50ZOO203a(P)25

(Poultry Farming)

Practical [Credit: 1] **30 hrs/ 100 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): 6 numbers/ 5 marks (Identification with reasons = 1 + 4 = 5 each). Total = 30 marks
2. Monitoring of Nutritive value, Protein content: procedure & result – 10 marks
3. Poultry feed preparation (Procedure and formulation) 8 marks
4. Fecal sample examination: Identification of Parasites with reasons, drawing of diagram and procedure (1 + 2 + 3 + 4= 10)
2. Project Report: 15 marks (Subject content, Presentation, Diagrams/Photos)
3. Presentation on a topic related to Poultry. 10 marks
4. Note Book: 7 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 to any farm or lab by students. Practical exercise and hands on experience at a farm 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.

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 ndia.com

https://dahd.nic.in

Skill Enhancement Course (SEC) -III: SEC50ZOO203b(T)25
(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 analysing real-life case studies and success stories.

Course content:

Theory [Credits: 2] **30 hrs/ 100 Marks**

Unit 1: Foundations of Aquaculture and Pond Construction (6 Hours/20 Marks)

Core definition, operational scope, and socio-economic importance of fish farming; Criteria for engineering site selection and structural pond construction; Classification of rearing methods including composite fish farming and integrated fish farming; Comparative study of semi-intensive and intensive fish farming practices.

Unit 2: Pond Preparation and Water Quality Management (6 Hours/20 Marks)

Physical pond preparation stages involving liming, fertilization, and basal weed control; Eradication protocols for invasive aquatic weeds, predatory insects, and natural fish enemies; Water quality management; Monitoring and balancing pH, Biochemical Oxygen Demand (BOD), dissolved oxygen, and Ammonia (NH_3) values.

Unit 3: Fish Seed, Biology, and Population Management (6 Hours/20 Marks)

Identification features of Indian Major Carps (IMC) and common exotic fishes; Feeding behaviors and food habits of different culturable fish species; Structural timeline of pre-stocking, stocking, and post-stocking fish pond management; Calculating optimal stocking rates and multi-species stocking ratios; Diagnostics of common fish diseases and their specific control measures.

Unit 4: Induced Breeding, Hatcheries, and Processing (6 Hours/20 Marks)

Induced breeding techniques of Indian Major Carps (IMC) and exotic fishes; Selection, conditioning, and brooder management; Technical process of hypophysation; use of synthetic hormones (Ovaprim, Ovatide), detailing dosing and administration pathways; Structural design and operation of Hapa type hatcheries and Chinese hatchery systems; Commercial fish harvesting methods and traditional preservation techniques including drying, smoking, and fermentation.

Unit 5: Modern Aquaculture Technologies and Entrepreneurship (6 Hours/20 Marks)

Application of sustainable, climate-resilient, and resource-efficient technologies in aquaculture; Microbial and engineering principles behind Biofloc technology (BFT) and Recirculatory Aquaculture Systems (RAS); Ecological Engineering: Integrated designs using Aquaponics and Integrated Multi-Trophic Aquaculture (IMTA) systems; Scope, economic significance, and professional development of entrepreneurship in fisheries; Real-world evaluation through industry success stories and case studies.

Skill Enhancement Course (SEC) III Practical: SEC50ZOO203b(P)25

(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 oxygen, BOD.
3. Identification of common Zoo 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 of pituitary gland.
6. Identification of common fish diseases (bacterial, fungal and viral)
7. Visit to a fish farm/ fish hatchery with Demonstration of RAS/Aquaponics/ Biofloc and Report Submission

Examination evaluation structure:

1. Identification of fish seed/ adult fish & characters of specimen: 5 numbers/ 5 marks (Identification with comments: 1+4 = 5). Total: 5x5 = 26

2. Water quality analysis: Procedure, Observation & Result – 15 marks

3. Identification of aquatic weeds/ insects/planktons: 4 numbers (Identification with characters: 1+4 =5). Total: 4x5 = 20

4. Dissection & display of pituitary gland with diagram. 8+3+4=15 marks

5. Field report: 10 marks (Content, presentation)

6. Note book submission: 5 marks (Based on Inclusiveness, neatness and presentation) 7. Viva: 10 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:

- 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.
- Pillay, T.V.R. (1990) Aquaculture, Principles and Techniques. Fishing News Book Ltd. 4. Chonder, S.L. (1994) Induced Carp Breeding. CBS Publishers and Distributors, New Delhi
- John, S. L. and C. S. Paul (2012) Aquaculture: Farming Aquatic Animals and Plants. 2nd Edition, Wiley-Blackwell
- Avnimelech, Y. (2015) Biofloc technology, a practical guidebook. 3rd Edition, World Aquaculture Society.
- Timmons, M.B., T, Guerdat and B.J. Vinci (2018) Recirculatory Aquaculture. 4th Edition, Ithaca Publishing Company, New York.
- Burnell G, Allan G. 2009. New Technologies in Aquaculture. 1st Edition. Woodhead Publishing House.
- Tidwell JH. (Ed.). 2012. Aquaculture Production Systems. Wiley-Blackwell.
- Goddek, S., Joyce, A., Kotzen, B., and Burnell, G. M. (Eds.). (2019). Aquaponics food production systems. Springer.

Skill Enhancement Course (SEC) -III: SEC50ZOO203c(T)25

(Organic Farming)

Objective:

The course will make the students aware about the significance of Organic farming. It will help the students to understand benefits of organic nutrients and the need for conservation of age-old indigenous practices.

Outcome:

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

- Learn about the history of Organic farming.
- Recognize various pre requisites of this method.
- Be aware about the opportunities and management strategies involved.
- Gain thorough knowledge about the techniques involved in Organic farming.
- Develop knowledge about quality maintenance, accreditation & marketing opportunities.

Course Content:

Theory [Credits: 2] 30 hrs/ 100 marks

Unit 1: Foundations and Principles of Organic Farming (6 Hours / 20 Marks)

Definition, scope, core concepts, and fundamental principles of organic farming; Historical development of organic agriculture and an overview of the global market scenario; Baseline requirements, farm conversion periods, and essential entry criteria for setting up an organic farm; Detailed assessment of current prospects, adoption bottlenecks, and operational problems in organic farming.

Unit 2: Biodiversity and Soil Carbon Management (6 Hours / 20 Marks)

Importance of ecological biodiversity on a farm and specific strategic measures to preserve it; Current status of soil organic carbon (SOC) and its critical role in maintaining long-term soil health; Practical field-level management practices to build, enrich, and maintain soil organic carbon percentages.

Unit 3: Organic Nutrient Sources and Waste Recycling (6 Hours / 20 Marks)

Sourcing organic nutrients from internal on-farm networks and external off-farm inputs; Preparation, usage, and nutritional values of bulky organic manures and concentrated organic inputs; Standard scientific methods for the decomposition, processing, and recycling of organic agricultural wastes; Classification, application modes, and efficiency of nitrogen-fixing and phosphorus-solubilizing bio-fertilizers.

Unit 4: Ecological Crop and Non-Chemical Weed Management (6 Hours / 20 Marks)

Implementation models for strategic intercropping, crop rotation, cover crops, and mulching; Selection of green manure crops, growth stages, and techniques for in-situ soil incorporation;

Practical execution of preventative, physical, cultural, mechanical, and biological weed control measures.

Unit 5: Bio-Intensive Plant Protection, ITK, and Certification (6 Hours / 20 Marks)

Formulation and application of bio-intensive pest and pathogen management systems; Validation and scientific rationale of traditional Indigenous Technical Knowledge (ITK) in organic agriculture; Regulatory standards of the National Programme for Organic Production (NPOP) and crop production standards; Indian certification agencies, accreditation protocols, labelling laws, marketing setups, and export market opportunities.

Skill Enhancement Course (SEC) -III: SEC50ZOO203c(P)25

(Organic Farming)

Practical [Credit: 1] 30 hrs/ 100 marks

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

Examination evaluation Structure:

1. Identification different Soil types. 3 numbers / 5 marks (Identification = 1, Reason = 4) 15 marks
2. Identification of common pests/physiological disorders, 4 numbers/5 marks (Identification=1, reasons=2, remedy=2) 20 marks
3. Identification of appliances / farm equipment/ implements & drawing (2 number / 5 marks) (identification = 1, drawing = 4) 10 marks
4. Testing of Soil. (15 marks) (Testing = 7, Procedure = 5, Result = 3)
5. Calculation of different Fertilizers required for Crops. 5 marks
6. Report submission: 10 marks (Subject content, Presentation, Diagrams/Photos)
7. Presentation on a topic related to Organic farming. 10 marks
8. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
9. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about benefits of Organic farming will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of farms and study of different technologies will be assisted through visits to various farms; 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 Organic farming 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 farm implements and their workings. Visit to various Organic Villages will clarify their concepts about Organic farming and the marketability of Organic products.

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:

1. Panda S.C. 2018. Soil Management and organic farming. Agrobios

2. Dahama, A.K.2009. Organic farming for sustainable agriculture, Agrobros publishers.

3. SP. Palaniappan and K Annadurai. 2008. Organic Farming: Theory and Practice. Scientific Publishers.

4. Panda, S.C. 2012. Principles and Practices of Organic Farming. Agribios (India), Jodhpur.

5. Gehlot, D. 2010. Organic Farming- Components and Management. Agribios (India), Jodhpur.

6. Dushyant Gehlot. 2010. Organic farming: Components and management. Agrobios (India), Jodhpur.

7. Ranjan Kumar Biswas.2014. Organic farming in India. N.D. Publishers. New Delhi.

Online Tools and Web Resources:

http://ecoursesonline.iasri.res.in/

www.ifoam.org

www.apeda.org