**OFFICE OF THE REGISTRAR :: DIBRUGARH UNIVERSITY :: DIBRUGARH**

Ref. No. DU/DR-A/137th AC/L.Sc./Syllabus(Zoology)/FYIPGP/9th & 10th Sem./2026/878 Date: 25.08.2026

## NOTIFICATION

As recommended by the meeting of the ***Board of Studies (BoS) in Life Sciences*** and 161st Meeting of the Post Graduate Board, D.U. held on 23.06.2026, the Academic Council, Dibrugarh University in its 137th meeting held on 29.06.2026 ***vide Resolution No. 15*** has approved the syllabus of 9th and 10th semesters of FYIPGP Life Sciences (Zoology) with effect from 2026-2027 academic session.

The syllabus is attached herewith.

Issued with due approval.

25/8/26

Deputy Registrar (Academic) i/c
Dibrugarh University

Copy forwarded for kind information and necessary action to:

1. The Hon'ble Vice-Chancellor, Dibrugarh University.
2. The Deans, Dibrugarh University.
3. The Registrar, Dibrugarh University.
4. The Controller of Examinations, Dibrugarh University.
5. The Inspector of Colleges, Dibrugarh University.
6. The Head, Department of Life Sciences, Dibrugarh University.
7. The Heads / Chairpersons of the Teaching Departments / Centre of Studies, Dibrugarh University.
8. The Joint / Deputy Controller of Examinations – 'C' / 'A' & 'B', Dibrugarh University.
9. The Senior Programmer, Dibrugarh University with a request to upload the Notification along with attached syllabi on the DU website.
10. File.

25/8/26

Deputy Registrar (Academic) i/c
Dibrugarh University

# Syllabus of FYIPGP Life Sciences (Zoology)

## Department of Life Sciences

**Approved in the BoS held on 16 June 2026**
**DIBRUGARH UNIVERSITY**

## Vision of the Department

*Investigate and analyze biological diversity for designing solutions to mitigate public health issues and climate change through sustainable management of bioresources.*

**Mission of the Department**

*The Department is committed to develop competent human resources in the field of life sciences to address issues associated with sustainable development goals, health and welfare of the society.*

**Thrust Areas of Research**

*Inventorization, Bioprospecting and Database Development of Endemic Flora & Fauna of Northeast India*

**Values of the Department**

**Excellence in Education**: Commitment to provide high-quality education in life sciences.
**Research Integrity:** Upholding the highest standards of honesty and ethical practices in research.
**Innovation:** Encouraging creativity and innovation in both teaching and research.
**Collaboration:** Fostering collaborative efforts within the department and with external partners.
**Diversity and Inclusion:** Embracing diversity and striving for an inclusive environment for all students and staff.

**Programs offered:**

1) M.Sc. in Life Sciences (Botany)
2) M. Sc. in Life Sciences (Zoology)
3) FYIPGP in Life Sciences (Botany)
4) FYIPGP in Life Sciences (Zoology)
5) Ph.D. in Life Sciences

**Program Educational Objectives:**

1) Formulate strategies to achieve the sustainable development in harnessing biological resources.
2) Evaluate environmental problems and design innovative solutions.
3) Demonstrate attitude to employ multidisciplinary approaches for problem solving.

**Program Outcomes:**

1) Develop ideas to assess and inventorize existing biological resources of this region
2) Formulate innovative strategies for conservation of biogenetic resources for human welfare

3) To explore and validate ethnobiological knowledge of Northeast India
4) To provide solutions for existing societal problems using biological knowledge
5) Develop research skills to solve complex biological issues and achieving SDGs
6) Execute good communication skills for disseminating knowledge of biological sciences
7) To promote attitude to work as a team appreciating ethical values

**Program Specific Outcomes:**

1) Evaluate the diversity and evolution of organisms
2) Analyze the fundamentals of life sustaining processes
3) Design strategies for issues concerning public health and human welfare
4) Critically analyze the environmental issues and develop strategies to address them
5) Formulate measures to mitigate climate change effects

| Year | Sem. | Corse code | Title of the course | Credit |
|---|---|---|---|---|
| | I | Core-I | Animal Diversity I | 4 |
| | | Minor-I | Animal Diversity I | 4 |
| | | GEC-I | Natural Resource Management | 3 |

| | | | | |
|---|---|---|---|---|
| I | | AEC-I | Modern Indian Language | 4 |
| | | SEC-I | Seritechnique | 3 |
| | | VAC-I | Understanding India | 2 |
| | | **Total Credit** | | **20** |
| | II | Core-II | Animal Diversity II | 4 |
| | | Minor-II | Animal Diversity II | 4 |
| | | GEC-II | Biodiversity and Human Welfare | 3 |
| | | AEC-II | English Language and Communication Skills | 4 |
| | | SEC-II | Vermicomposting/Introduction to Artificial Intelligence in Biological Sciences | 3 |
| | | VAC-II | Yoga | 2 |
| | | VAC-Compulsory Add-on Course | Environmental Studies | 4 |
| | | **Total Credit** | | **20** |
| | | **UG CERTIFICATE** | | |
| II | III | Core-III | Cell Biology | 4 |
| | | Core-IV | Biochemistry and Molecular Biology | 4 |
| | | Minor-III | Biotechnology, Tissue Culture and Animal Cell Culture | 4 |
| | | GEC-III | Ethnobiology | 3 |
| | | SEC-III | Multi-Disciplinary Course: Analytical Tools and Techniques in Science | 3 |
| | | VAC-III | Digital and Technological Solutions / Digital Fluency | 2 |
| | | | **Total Credit** | **20** |
| | IV | Core-V | Genetics | 4 |
| | | Core-VI | Microbiology and Immunology | 4 |
| | | Core-VII | Bioinformatics and Biostatistics | 4 |
| | | Core-VIII | Evolutionary Biology | 4 |

| | | | | |
|---|---|---|---|---|
| | | Minor-IV | Biodiversity and Conservation Biology | 4 |
| | | **Total Credit** | | **20** |
| | | **UG DIPLOMA** | | |
| III | V | Core IX | Comparative Anatomy and Animal Physiology | 4 |
| | | Core X | Embryology | 4 |
| | | Core XI | Insect Morphology and Basics of Ichthyology | 4 |
| | | Minor-V | Embryology | 4 |
| | | Int./CE | (Internship +Community Engagement)/Community Engagement/Internship | 4 |
| | | **Total Credit** | | **20** |
| | VI | Core XII | Animal Physiology: Controlling and Co-ordinating Systems | 4 |
| | | Core XIII | Animal Behaviour and Chronobiology | 4 |
| | | Core XIV | Animal Ecology and Wildlife Management | 4 |
| | | Core XV | Animal Taxonomy and Systematics | 4 |
| | | Minor-XI | Animal Physiology: Controlling and Co-ordinating Systems | 4 |
| | | **Total Credit** | | **20** |
| | | **UG DEGREE** | | |
| IV | VII | Core XVI | Environmental Biology | **4** |
| | | Core XVII | Advanced Molecular Biology | **4** |
| | | Core XVIII | Advanced Cell Biology | **4** |
| | | RM | Research Methodology and Research Ethics | **4** |
| | | Minor-7 | Advanced Analytical Techniques | **4** |
| | | | **Total Credit** | **20** |
| | VIII | Core XIX | Intermediary Metabolism | **4** |
| | | Core XX | Advanced Genetics & Plant Breeding | **4** |

| | | | | |
|---|---|---|---|---|
| | | Minor-8 | Bioethics and IPR | **4** |
| | | Dissertation/ 2 DSE | Dissertation<br>Or<br>DSE 1: Climate Change and Biological Adaptation<br>DSE 2: Computational Biology<br>(In lieu of the project) | **8/4+4** |
| V | IX | DSC1 | Reproductive Physiology | **4** |
| | | DSC2 | Molecular Endocrinology | **4** |
| | | DSC3 | Developmental Biology | **4** |
| | | DSE1 | Biochemistry-I: Protein Chemistry and Enzymology<br>OR<br>Entomology-I: Insect Physiology and Toxicology<br>OR<br>Fish and Fisheries-I: Integrated Fish Biology | **4** |
| | | Project/ Field Based learning | Field Study | **4** |
| | | | **Total Credit** | **20** |
| | X | DSC4 | Immunology | **4** |
| | | DSC5 | Parasitology | **4** |
| | | DSE2 | Biochemistry-II: Industrial Biochemistry<br>OR<br>Entomology -II:<br>Applied Entomology<br>OR<br>Fish and Fisheries-II : Fisheries Resources, Aquaculture and Management | **4** |
| | | Dissertation/ 2 DSE | Dissertation (Based on DSE2)<br>Or<br>(DSE 3: To be opted from SWAYAM<br>DSE 4: To be opted from SWAYAM) | **8/(4+4)** |
| | | | **Total Credit** | **20** |

## SEMESTER I

**Title of the Course : Animal Diversity I**
**Course Code : CORE I**
**Nature of the Course : CORE**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1) Describe different phyla in animal kingdom
2) Organize the organisms in different categories based on morphological characteristics
3) Analyze the interrelationship among different species and genera within each group of animals

**Learning Outcomes:**

1) Understand the various phyla in Animal Kingdom
2) Compare various organisms based on morphology
3) Classify different groups of animals

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2,CO3 | | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

**Unit 1: Protista, Parazoa and Metazoa 12 lectures**

General characteristics and Classification up to Classes
Structural organization & nutrition of *Amoeba ,Euglena*, and *Paramecium.*
Locomotion and Reproduction in Animal protista (Protozoa)

**Unit 2: Porifera, Cnidaria & Ctenophora 8 lectures**

General characteristics and Classification up to classes with examples
Canal system in sponges and Evolutionary significance

**Unit 3: Platyhelminthes &Nemathelminthes 8 lectures**

General characteristics and Classification up to classes
Life cycle of *Taenia solium, Fasciola hepatica* and *Ascaris lumbricoides*
Parasitic adaptation in Helminths.

**Unit 4: Introduction to Coelomates, Annelida and Arthropods 9 lectures**

Evolution of coelom and metamerism
General characteristics and Classification up to classes
Excretion in Annelida. Respiration in Arthropoda

**Unit 5: Onychophora & Mollusca and Echinodermata 8 lectures**

General characteristics
Classification up to classes
Torsion and detorsion in Gastropoda
Water-vascular system in Asteroidea

**Unit 6: Lab Course** **15 lectures**

1) Study of the following specimens:

Protista: Amoeba, Euglena, Plasmodium, Paramecium

Cindaria: Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora and One specimen/slide of anyctenophore

Annelids: Neries, Aphrodite, Chetopterus, Pheretima, Hirudanaria

Arthropods:Limulus, Belastoma, Palamnaeus, Daphnia, Palaemon, Cance, Brachionus Bombyx, Periplaneta, Samia ricini. Antheraea spp.Termite and honey bee.

Helminths: Ascaris, Taenia, Fasciola.

Molluscs:Chiton, Dentalium, Pila, Doris, Helix, Unio, Sepia, Octopus and Nautilus.

Echinoderms: Pentaceros, Asterias, Ophiura, Echinus, Antedon

2) Study of *Sycon* (T.S. and L.S.), *Hyalonema, Euplectella, Spongilla*

3) Study of whole mount of *Euglena*, *Amoeba* and *Paramecium,* Binary fission and Conjugation in *Paramecium.*

4) Study of mouth parts of periplaneta

5) Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/micro-photographs)

6) Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs).

7) Study of septal nephridia in earthworm, digestive system of periplaneta (virtual).

**Suggested Readings**

1. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
2. Kingsley J. Text Book of Vertebrate Zoology Publisher: Nabu Press ISBN: 9781171586524, 1171586523
3. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrate

## SEMESTER I

**Title of the Course : Animal Diversity I -Minor**
**Course Code : Minor I**
**Nature of the Course : Minor**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Describe different phyla in animal kingdom
2. Organize the organisms in different categories based on morphological characteristics
3. Analyze the interrelationship among different species and genera within each group of animals
4. Evaluate Zoogeographical realms.

**Learning Outcomes:**

1. Understand the various phyla in Animal Kingdom
2. Compare various organisms based on morphology
3. Classify different groups of animals

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2,CO3 | CO4 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

**Unit 1: Protista, Parazoa and Metazoa 12 lectures**

General characteristics and Classification up to Classes
Structural organization & nutrition of *Amoeba ,Euglena*, and *Paramecium.*
Locomotion and Reproduction in Animal protista (Protozoa)

**Unit 2: Porifera, Cnidaria& Ctenophora 8 lectures**

General characteristics and Classification up to classes with examples
Canal system in sponges and Evolutionary significance

**Unit 3: Platyhelminthes &Nemathelminthes 8 lectures**

General characteristics and Classification up to classes
Life cycle of *Taenia solium, Fasciola hepatica* and *Ascaris lumbricoides*
Parasitic adaptation in Helminths.

**Unit 4: Introduction to Coelomates, Annelida and Arthropods 9 lectures**

Evolution of coelom and metamerism
General characteristics and Classification up to classes
Excretion in Annelida. Respiration in Arthropoda

**Unit 5: Onychophora& Mollusca and Echinodermata 8 lectures**

General characteristics
Classification up to classes

Torsion and detorsion in Gastropoda
Water-vascular system in Asteroidea

**Unit 6: Lab Course** **15 lectures**

1) Study of the following specimens:
   Protista: Amoeba, Euglena, Plasmodium, Paramecium
   Cindaria: Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora and One specimen/slide of anyctenophore
   Annelids: Neries, Aphrodite, Chetopterus, Pheretima, Hirudanaria
   Arthropods:Limulus,Belastoma, Palamnaeus, Daphnia, Palaemon, Cance, Brachionus, Bombyx, Periplaneta, *Samia ricini, Antheraea* spp.Termite and honey bee.
   Helminths: Ascaris, Taenia, Fasciola.
   Molluscs:Chiton,Dentalium,Pila,Doris,Helix,Unio, Sepia, Octopus and Nautilus.
   Echinoderms: Pentaceros, Asterias, Ophiura, Echinus, Antedon
2) Study of *Sycon*(T.S. and L.S.), *Hyalonema, Euplectella,Spongilla*
3) Study of whole mount of *Euglena*, *Amoeba* and *Paramecium,* Binary fission and Conjugation in *Paramecium.*
4) Study of mouth parts of periplaneta
5) Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/micro-photographs)
6) Study of adult *Ascaris lumbricoides* and its life stages(Slides/micro-photographs).
7) Study of septal nephridia in earthworm, digestive system of periplaneta (virtual).

**Suggested Readings**


- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
- Kingsley J. Text Book of Vertebrate Zoology Publisher: Nabu Press ISBN: 9781171586524, 1171586523
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrate


**SEMESTER I**

**Title of the Course : Natural Resource Management**
**Course Code : GEC I**

**Nature of the Course: Generic Elective Course**
**Total Credits : 03**
**Distribution of Marks: 40 IA+60 END = 100**

**COs:**

1. Distinguish between renewable and non-renewable resources
2. Analyse threats to natural and biological resources of NE India
3. Examine management strategies for sustainable utilization of resources

Learning outcomes:

1. Differentiate natural and biological resources of NE India
2. Identify the threats and issues related to the natural resources
3. Execute conservation and management strategies for natural resources

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1, CO2, CO3 | | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment:**

1. Internal examination
2. Viva-voce/Group discussion/Home assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Viva-voce examination

**Course content**

**UNIT-I: Natural resources: 07 classes**

Definition and types. Natural resources of NE India. Renewable and non-renewable sources of energy.

**UNIT-II: Sustainable utilization of land and water resources**: **15 classes**

Soil degradation and management; water resources (Freshwater, marine, estuarine) wetlands; Threats and management strategies and their management.

**UNIT-III: Biodiversity: 08 classes**

Definition, types, significance, threats, management strategies, CBD, Bioprospecting

**UNIT IV: 15 classes**

**Contemporary practices in resource management**: EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. National and international efforts in resource management and conservation.

**SUGGESTED READINGS:**

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.

**SEMESTER I**

| | | |
|---|---|---|
| **Title of the Course** | **:** | **SERITECHNIQUE** |
| **Course Code** | **:** | **SEC I** |
| **Nature of the Course** | **:** | **Skill Enhancement Course** |
| **Total Credits** | **:** | **03** |

**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Discuss the concept of sericulture.
2. Explain the rearing technique and associated tools.
3. Examine the diseases and learn the control measures.

**LEARNING OUTCOMES:**

After the completion of this course, the learner will be able to:

CO1: Comprehend the aspects of Seri-technology

CO2: Analyze and develop the skill to rear silkworms for entrepreneurship and explore the challenges in entrepreneurship development.

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1, CO2, CO3 | | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment:**

- Internal examination (Theory)

- Internal examination (Practical)
- Viva-voce/Group discussion/Home assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Viva-voce examination
- Report submission of field visit
- Submission of practical record file

Unit 1: **Sericulture**: Introduction: history and present status; Silk route. Sericulture industry in different states, employment, potential in mulberry and non-Mulberry sericulture. Entrepreneurship in sericulture: Identification of wild and domesticated silkworms (5 lectures)

Unit 2: **Rearing of silkworm**: Silkworm rearing -Rearing house and rearing appliances, Early age and Lateage rearing. Types of mountages. Spinning,harvesting and storage of cocoons. Pests and diseases Pests of silkworm: Uzi fly, Apantelesand vertebrates. Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial. Symptoms, Control and prevention of pestsand diseases. (10 lectures)

Unit 3: **Host plants for Eri silkworms:** *Ricinus communis* ,*Heteropanax fragrans* , their phytochemical profile, cultivation and management; primary and alternative host plants for Muga silkworm:*Machilu sgamblei* , *Litsea monopetala* and *Litsea cubeba,*their nutritional profile. (6lectures)

Unit 4: **Lab Course I**

i)Sex separation in larva, pupa and adult of silkworm

ii)Identification of different diseased silkworms based on external symptoms (Grasserie, Flacherie, Muscardine and Pebrine) and Identification of permanent slide of gut bacteria of silkworm, spores of Pebrine, spores of Muscardine

iii) Rearing of eri silkworm on artificial diet (12 lectures)

Unit 5: **Lab Course II** (12 lectures)

i)Identification and study of Sericulture products, types of yarns

ii)morphology and identification of *Ricinus communis*, *Heteropanax fragrans*, *Machilus gamlei*, *Litsea monopetala* and *Litsea cubeba*

iii) Project

iv)Field visit

**SUGGESTED READINGS**


- Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore

- Silkworm Rearing and Disease of Silkworm, 1956, Ptd. By Director of Ptg., Stn. & Pub. Govt. Press,Bangalore
- Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR &TI,Mysore.
- Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub. Co. Ltd., Tokyo, Japan1972.
- Manual of Silkworm Egg Production; M. N. Narasimhanna, CSB, Bangalore1988.
- Silkworm Rearing; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome1988.
- A Guide for Bivoltine Sericulture; K. Sengupta, Director, CSR & TI


## SEMESTER II

**Title of the Course : Animal Diversity II**
**Course Code : CORE II**
**Nature of the Course : CORE**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Describe different phyla in animal kingdom
2. Organize the organisms in different categories based on morphological characteristics

3. Analyze the interrelationship among different species and genera within each group of animals
4. Evaluate Zoogeographical realms.

**Learning Outcomes:**

1) Understand the various phyla in Animal Kingdom
2) Compare various organisms based on morphology
3) Classify different groups of animals

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2,CO3 | CO4 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.3 |
| AVERAGE | 3 | 2 | 2.5 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit 1:**Introduction to Chordates:** General characteristics and outline classification Protochordata: General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates*;* Retrogressive metamorphosis in Urochordata; Origin of Chordata: Theories of origin of chordates, Advanced features of vertebrates over Protochordata **11 lectures**

Unit 2:**Agnatha& Pisces** **9 lectures**

Agnatha: General characteristics and classification of cyclostomes up to class with example

Pisces: General characteristics of Chondrichthyes and Osteichthyes, classification up to order Osmoregulation

Unit 3: **Amphibia & Reptilia** **9 lectures**

Amphibia: Origin of *Tetrapoda* (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Reptilia: General characteristics and classification up to order; Affinities of *Sphenodon*; Poison apparatus and Biting mechanism in snakes

Unit 4: **Aves & Mammals** **9 lectures**

Aves: General characteristics and classification up to order *Archaeopteryx*-- a connecting link; Principles and aerodynamics of flight, Flight adaptations

Mammals: General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages

Unit 5: **Zoogeography** **7 lectures**

Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms

**Unit 6: Lab Course** **15 lectures**

1. To study the following specimen:
   **Protochordata**; Balanoglossus, Herdmania, Branchiostoma, Colonial Urochordata. Sections of Balanoglossus through proboscis and branchiogenital regions,
   **Fishes;***Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas,* Flat fish,*Channa*spp. *Puntius*spp. *Trichogaster, Heteropneusteus*spp., *Clarias* spp., *Mystus*spp.
   **Amphibia;***Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandr*

**Reptilia;***Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus*
**Aves**; Study of six common birds from different orders.
**Mammalia;** Sorex, Bat (Insectivorous and Frugivorous), Funambulus, Loris, Herpestes, Erinaceous.

2. Dissection of weberian ossicles of *Mystus.*
3. To study and prepare a chart of keys of identification of poisonous and non- poisonous snakes.
4. Study of animal organ system: Urinogenital System of fish (locally available fish).
5. Sections of Amphioxus through pharyngeal, intestinal and caudal regions. Permanent slide of Herdmania spicules, Placoid and Cycloid Scales in Fishes, Types of beaks and claws, pecten from Fowlhead .
6. To submit a Project Report on any related topic to larval forms.

**Suggested Readings**


- Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford universitypress.
- Pough H. *Vertebrate life,* VIII Edition, PearsonInternational.
- Darlington P.J. *The Geographical Distribution of Animals*, R.E. Krieger PubCo.
- Hall B.K. and Hallgrimsson B. (2008).*Strickberger's*
- *Evolution*. IV Edition. Jones and Bartlett PublishersInc.


## SEMESTER II

| | |
|---|---|
| **Title of the Course** | **: Animal Diversity II** |
| **Course Code** | **: Minor II** |
| **Nature of the Course** | **: Minor** |
| **Total Credits** | **: 04** |
| **Distribution of Marks** | **: (30+10 =40) (IA) + (45+15= 60) (END) = 100** |

**COs:**

1) Describe different phyla in animal kingdom
2) Organize the organisms in different categories based on morphological characteristics
3) Analyze the interrelationship among different species and genera within each group of animals
4) Evaluate the theories of Zoogeography

**Learning Outcomes:**

1. Understand the various phyla in Animal Kingdom
2. Compare various organisms based on morphology
3. Classify different groups of animals

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2,CO3 | CO4 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.4 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.4 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.3 |
| AVERAGE | 3 | 2 | 2.5 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens

- Submission of collected specimens
- Viva-voce examination

**Unit 1:Introduction to Chordates: 11 lectures**

General characteristics and outline classification. Protochordata: General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata;
Origin of Chordata: Theories of origin of chordates, Advanced features of vertebrates over Protochordata

**Unit 2:Agnatha & Pisces 9 lectures**

Agnatha: General characteristics and classification of cyclostomes up to class with example

Pisces: General characteristics of Chondrichthyes and Osteichthyes, classification up to order Osmoregulation

**Unit 3: Amphibia & Reptilia 9 lectures**

Amphibia: Origin of *Tetrapoda* (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Reptilia: General characteristics and classification up to order; Affinities of *Sphenodon*; Poison apparatus and Biting mechanism in snakes

**Unit 4: Aves & Mammals 9 lectures**

Aves: General characteristics and classification up to order *Archaeopteryx*-- a connecting link; Principles and aerodynamics of flight, Flight adaptations. Mammals: General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages

**Unit 5: Zoogeography 7 lectures**

Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms

**Unit 6: Lab Course 15 lectures**

1. To study the following specimen:
   **Protochordata**; Balanoglossus, Herdmania, Branchiostoma, Colonial Urochordata. Sections of Balanoglossus through proboscis and branchiogenital regions,
   **Fishes;***Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas,* Flat fish,*Channa*spp. *Puntius*spp. *Trichogaster, Heteropneusteus*spp., *Clarias* spp., *Mystus*spp.
   **Amphibia;***Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandr*
   **Reptilia;***Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus*
   **Aves**; Study of six common birds from different orders.
   **Mammalia;** Sorex, Bat (Insectivorous and Frugivorous), Funambulus, Loris, Herpestes, Erinaceous.

2. Dissection of weberian ossicles of *Mystus.*
3. To study and prepare a chart of keys of identification of poisonous and non- poisonous snakes.
4. Study of animal organ system: Urinogenital System of fish (locally available fish).
5. Sections of Amphioxus through pharyngeal, intestinal and caudal regions. Permanent slide of Herdmania spicules, Placoid and Cycloid Scales in Fishes, Types of beaks and claws, pecten from Fowlhead .
6. To submit a Project Report on any related topic to larval forms.

**SUGGESTED READINGS**


- Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford universitypress.
- Pough H. *Vertebrate life,* VIII Edition, PearsonInternational.
- Darlington P.J. *The Geographical Distribution of Animals*, R.E. Krieger PubCo.
- Hall B.K. and Hallgrimsson B. (2008). *Strickberger's Evolution*. IV Edition. Jones and Bartlett PublishersInc.


## SEMESTER II

| | | |
|---|---|---|
| **Title of the Course** | **:** | **Biodiversity and Human Welfare** |
| **Course Code** | **:** | **GEC II** |
| **Nature of the Course** | **:** | **Generic Elective Course** |
| **Total Credits** | **:** | **03** |
| **Distribution of Marks** | **:** | **40 IA + 60 END= 100** |

**COs:**

1. Differentiate the levels of biological diversity
2. Examine the causes of loss of biodiversity
3. Analyze the biodiversity conservation strategies
4. Evaluate the role of different organisms in human welfare

**Learning Outcomes:**

1. Distinguish the biodiversity levels
2. Analyze threats to biodiversity
3. Understand the conservation measures for biodiversity
4. Examine the role of plants, animals and microbes in human welfare

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | CO1 | CO2, CO3 | CO4 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| CO4 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 2.0 |
| AVERAGE | 3.0 | 2.2 | 2.2 | 1.7 | 1.7 | 1.7 | 1.7 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of assignment on relevant topic
- Viva-voce examination

**UNIT-1: Biodiversity and its scope (Lectures 9)**

Genetic diversity, Species diversity, Plant and animal diversity at the ecosystem level, Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle.

**UNIT-2: Loss of Biodiversity (Lectures 12)**

Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Management of Biodiversity: Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.

**UNIT-3: Conservation of Biodiversity (Lectures 12)**

Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.

**UNIT-4: Role of plants and animals in relation to Human Welfare (Lectures 12)**

Importance of forestry and wildlife to human welfare: their utilization and commercial aspects; Ornamental plants and animals (fishes) of NE India; uses of microorganisms in human welfare (food, agriculture, medicine)

**Suggested readings:**

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi

## SEMESTER II

**Title of the Course : Vermicomposting**
**Nature of the Course : SEC**
**Code : SEC II**
**Total Credits : 03**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**Course outcomes:**

1) Describe the biology of some important species of earthworms used in vermiculture
2) Demonstrate skills on production of vermicompost.
3) Analyse benefits and problems with vermiculture and vermicompost

**Learning Outcome:**

1) identify the earthworm species used in vermiculture
2) understand the benefit of vermiculture
3) display the skill of vermicompost production
4) interpret the problems associated with the vermicomposting technique

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | | CO2 | CO3 | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1.8 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 1.8 |
| AVERAGE | 3 | 2 | 2.0 | 1.7 | 1.7 | 1.7 | 1.7 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment:**

1. One internal examination
2. Viva-voce
3. Group discussion
4. Home assignments

**Attainment strategies of COs:**

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Hands-on training on preparation of vermicompost
3. Demonstration of large-scale production of vermicompost
4. Field collection of locally available earthworms for vermicomposting
5. Seminar/group discussion

**Unit -1: Introduction to vermiculture (Lecture 7)**

Vermiculture - definition, meaning, history, economic importance, value in the maintenance of soil structure, role as four r's of recycling (reduce, reuse, recycle and restore), Role in biotransformation of the residues generated by human activity and production of organic fertilizers, Useful species of earthworms, local and exotic species of earthworms

**Unit -2: Biology of certain important earthworms native to NE India (Lecture 8)**

Taxonomy and reproduction of Lumbricidae. Vital cycle: alimentation, fecundity, annual reproducer potential; limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors).

**Unit-3: Process of Vermicomposting (Lecture 8)**

Small scale earthworm farming for home gardens - earthworm compost for home gardens Conventional commercial composting - earthworm composting larger scale (pit, brick and, heap systems)
Earthworm farming, extraction (harvest), vermicomposting harvest and processing. Vermiwash collection, composition and use.
Enemies of earthworms, sickness and worm's enemies; frequent problems – prevention and fixation.

**Unit-4: Applications of vermiculture (Lecture 7)**

Benefits of vermicompost, Use of vermicompost in agriculture, Basic characteristics of earthworm suitable for vermicomposting, Problems in vermicomposting, vermicomposting of dairy waste.

**Unit-5: Lab Course (Lecture 15)**

1. Key to identify different types of earthworms.
2. Study of Life stages & development of earthworms.
3. Study of Vermiculture, Vermiwash& Vermicompost equipments, devices.
4. Preparation vermibeds, maintenance of vermicompost & climatic conditions.
5. Study of verm diseases & enemies
6. Field trip- collection of native earthworms & their identification

**Suggested Readings:**

Bhatt J.V. & S.R. Khambata (1959) "Role of Earthworms in Agriculture" Indian Council of Agricultural Research, New Delhi

Edwards, C.A. and J.R. Lofty (1977) "Biology of Earthworms" Chapman and Hall Ltd., London.

Lee, K.E. (1985) "Earthworms: Their ecology and Relationship with Soils and Land Use" Academic Press, Sydney.

Wallwork, J.A. (1983) "Earthworm Biology" Edward Arnold (Publishers) Ltd. London. Kevin, A and K.E.Lee (1989) "Earthworm for Gardeners and Fisherman" (CSIRO, Australia, Division of Soils).

Dash, M.C., B.K.Senapati, P.C. Mishra (1980) " Verms and Vermicomposting" Proceedings of the National Seminar on Organic Waste Utilization and Vermicomposting Dec. 5-8, 1984, (Part B), School of Life Sciences, Sambalpur University, Jyoti Vihar, Orissa.

Kumar, A. (2005) Verms and Vermitechnology, APH Publishing.

Lekshmy, M. S., Santhi R. (2012) Vermitechnology, Sara Publications, New Delhi, India Chauhan, A. (2012) Vermitechnology, Vermiculture, Vermicompost and Earthworms: Vermiculture, Vermicomposting, Vermitechnology and Mirobes,Lambert Academic Publishing, Germany

| | | |
|---|---|---|
| **Title of the Course** | **:** | **INTRODUCTION TO ARTIFICIAL INTELLIGENCE (AI) IN BIOLOGICAL SCIENCES** |
| **Course Code** | **:** | **SEC II** |
| **Nature of the Course** | **:** | **Skill Enhancement Course** |
| **Total Credits** | **:** | **3** |
| **Distribution of Marks** | **:** | **(30+10 =40) (IA) + (45+15= 60) (END) = 100** |

**COs:**

1. Comprehend the fundamentals of AI
2. Analyze the concept of Data in terms of Biological Sciences
3. Explore the diverse applications of AI in biological research, including healthcare, precision medicine, and bioinformatics.
4. To develop an awareness of the ethical and societal implications of AI driven biology research, including issues related to bias, fairness, privacy, and data security.

Learning Outcomes:

- Understand the fundamental concept of AI
- Discuss the concept of Data in Biology
- Examine applications of AI and have awareness about ethical and societal implications

**Modes of internal assessment:**

1. One internal examination
2. Viva-voce/Group discussion/Home assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination
- Viva-voce examination

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | CO4 | CO2 CO3 | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1.8 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1.8 |
| CO4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1.0 |
| AVERAGE | 2.0 | 1.7 | 1.7 | 1.5 | 1.5 | 1.5 | 1.5 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

| **UNITS** | **CONTENTS** | **L** | **T** | **P** | **Total Hours** |
|---|---|---|---|---|---|
| **1** | **Overview of Artificial Intelligence in Biological Sciences:**<br>Introduction to Artificial Intelligence(AI).Understanding the basics of machine learning and deep learning in the context of biological data analysis. | 04 | 01 | 00 | 05 |
| **2** | **Biological Data and Data Collection Techniques:** Introduction to biological data: types, sources, and characteristics, Methods for collecting and preprocessing biological data. Ethical considerations in data collection and handling.<br>**Practical/Case studies on above topics** | 04 | 01 | 02 | 05 |

| | | | | | |
|---|---|---|---|---|---|
| **3** | **Overview of AI applications in Pharmaceutical sciences, Biotechnology, and Life sciences:**<br>Case studies highlighting the use of AI in drug discovery, areas of Life Sciences, biotechnology. Challenges and opportunities in integrating AI into biological research workflows.<br>**Practical/case studies on above topics** | 04 | 01 | 02 | 05 |
| **4** | **Role of AI in biological data analysis:**<br>Predictive modeling, biomarker discovery, and personalized treatment, Application of AI in precision medicine: patient stratification, disease diagnosis, and treatment optimization, AI-driven approaches in environmental biotechnology: biodiversity conservation, pollution monitoring and ecological modeling.<br>**Practical/case studies on above topics** | 10 | 01 | 03 | 15 |
| **5** | **Ethical Considerations in AI-driven Biology Research:** Understanding bias and fairness issues in biological data and AI algorithms. Addressing privacy concerns associated with the use of biomedical data in AI driven studies, Promoting transparency, accountability, and responsible conducting AI-based biological research. Ethical guidelines<br>**Practical/case studies on above topics** | 10 | 01 | 03 | 15 |
| | **Total (in Hrs)** | **32** | **05** | **10** | **45** |

***Where, L:Lectures T:Tutorials P:Practicals***

## SEMESTER III

**Title of the Course : Cell Biology**
**Course Code : CORE-III**
**Code : CORE**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1) Differentiate the structure and functions of cellular components
2) Evaluate the cell division mechanism and cell cycle.
3) Analyze cell signalling mechanism.

**Learning Outcomes:**

1) Understand the cell structure and functions of cell organelles.
2) Analyze cell division and cell cycle mechanisms.
3) Interpret the cell signalling mechanisms**.**

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1, CO3 | CO2 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 2.3 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2.4 |
| AVERAGE | 3.0 | 2.0 | 2.3 | 2.3 | 2.7 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce/Group discussion/Home assignments

**Attainment strategy:**

1. Continuous evaluation through in and end semester theory and practical examinations
2. Laboratory practices on cells, cellular organelles and cellular processes
3. Practical record book/field book

**Unit-I:Overview of cell: Prokaryotic and Eukaryotic cells 10 classes**

Plasma Membrane and Cytoskeleton: Various models of plasma membrane structure, Transport across membranes: Active and Passive transport, Cell junctions: Tight junctions, Desmosomes, Gap junctions, Structure and Functions: Microtubules, Microfilaments and Intermediate filaments

**Unit-II: Endomembrane System: Structure and Functions: 08 classes**

Endoplasmic Reticulum, Golgi Apparatus, Lysosomes

**Unit-III: Mitochondria and Peroxisomes: 09 classes**

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis, Peroxisomes

**Unit-IV: Nucleus: 09 classes**

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus Chromatin: Euchromatin and Hetrochromatin and packaging (nucleosome).

**Unit-V: Cell Division and Cell Signalling 09 classes**

Mitosis, Meiosis, Cell cycle and its regulation, GPCR and Role of second messenger (cAMP).

**Unit-VI: Lab course 15 lectures**

1. Preparation of temporary squash of any suitable material to study various stages of mitosis.
2. Study of various stages of meiosis.
3. Preparation of permanent slide to demonstrate: Mucopolysaccharides by PAS reaction
4. Preparation of Proteins by Mercurobromophenol blue/FastGreen
5. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
6. Measurement of cell size by micrometric method.
7. Study the phenomenon of plasmolysis and deplasmolysis.
8. Study of cell and cell organelles with the help of electron micrographs (demonstration).

**Suggested Readings**

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 7th Edition (John Wiley & Sons, Inc., 2013).

2. Alberts, B. et al., Molecular Biology of the Cell, 5th Edition (Garland Publishing, 2008).
3. Becker, W. M. et al., The World of Cell, 8th Edition (Benjamin Cummings, 2011).
4. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D.Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
5. Cooper, G. M. and Hausman, R. E., The Cell: A Molecular Approach, 5th Edition (ASM Press and Sinauer Associates, Inc., 2009).

## SEMESTER-III

**Title of the Course : Biochemistry and Molecular Biology**
**Course Code : CORE-IV**
**Code : CORE**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1) differentiate the biomolecules of living organisms, their interactions for perpetuation of life
2) analyze structure-function relationships of nucleic acids and protein
3) distinguish between replication, transcription and translation in prokaryotes and eukaryotes
4) interpret the gene expression mechanisms

Learning Outcome:

1) identify the various biomolecules and understand their function
2) differentiate the cellular processes such as replication, transcription and translation
3) understand gene expression mechanism

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | CO4 | CO1, CO2, CO3 | | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| CO4 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 2.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AVERAGE | 3.0 | 2.2 | 2.2 | 1.7 | 1.7 | 1.7 | 1.7 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce/Group discussion/Home assignments

**Attainment strategy:**

1. Continuous evaluation through in and end semester theory and practical examinations
2. Laboratory practices on biochemical and molecular biology processes
3. Practical record book/field book

**Unit I** **7 classes**

Introduction to Biochemistry, scopes; chemical basis of life, functional groups; water as solvent, ionization of water, weak acids; pH, buffer solution; types of chemical bonds in biological systems and types of biomolecules (Macro and small molecules) and functions. Laws of thermodynamics, concept of free energy, energy coupling reactions, ATP as energy currency molecule, redox reactions and concept of electron transport chain in mitochondria.

**Unit-II** **8 classes**

Proteins: Classification and functions of proteins. Amino acids, properties, and functions. Peptide bonds and peptide groups; structural organization of protein- primary, secondary, tertiary, and quaternary. Ramachandran Plot. The structural and functional relationship of protein- Ribonuclease-A, myoglobin, hemoglobin; protein denaturation and renaturation. Catabolic route and reactions of amino acids (Transamination, oxidative deamination and decaroxylation, urea cycle). Structure and classification of enzyme. Introduction to mechanism of enzyme action, and enzyme inhibition.

**Unit-III** **8 classes**

Carbohydrates: Overview on the sources, and biological functions; Classification (monosaccharide, disaccharide, and polysaccharide). Classes and structure of mono and disaccharides; glycosidic bond: Stereoisomerism, mutarotation, anomer, epimer etc.; glycoproteins and glycolipids. Catabolic pathways of carbohydrates (Glycolysis, Krebs cycle, Pentose phosphate pathway, gluconeogenesis, glycogen metabolism).

**Unit-IV** **7 classes**

Lipids: Structure, classification, and biological functions of lipids; storage and membrane lipids, lipoprotein. Fatty acids: classification; saturated, unsaturated, polyunsaturated; essential and non-essential fatty acids. Concept of beta-oxidation.

**Unit-V Molecular biology** **15 classes**

Nucleic acids: Types and functions of DNA, RNA; constituent monomers (nucleotides and nucleoside), DNA as genetic material, Structure of DNA and tRNA. DNA replication: Chemistry of replication, DNA polymerases, synthesis of leading and lagging strands

Prokaryotic transcription: RNA polymerase, promoters, sigma factors, initiation, elongation, and termination (Rho-dependent and independent), Eukaryotic transcription: types of eukaryotic RNA polymerases. Overview on the regulation of gene expression in prokaryotes; Transcriptional regulation in bacteria.

**Unit VI: Lab course** **15 lectures**

1. Preparation of different biochemical solutions, dilutions, preparation of buffer solutions, etc.
2. Identification of unknown carbohydrates (starch, sucrose, glucose, galactose, and fructose)
3. Quantitative/qualitative estimation of ascorbic acid
4. Quantitative estimation of glucose
5. Quantitative estimation of protein
6. Quantitative estimation of free phosphate
7. Separation of amino acids by TLC and determination of Rf value.
8. Bead and stick model of nucleic acid
9. Study of chromatin organization
10. DNA isolation and agarose gel electrophoresis

**SUGGESTED READINGS:**

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons.Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins,Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates,MA.
4. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London.

5. Lehninger by D. Nelson, and M. Cox, (2017) “The principles of Biochemistry”, 7 thedition, M.W.H. Freeman and Company, New York.
6. Berg, J. M., Tymoczko, J. L., Gatto, G. J., Jr., & Stryer, L. (2019). Biochemistry (9th ed.). W. H. Freeman.
7. Kennelly, Peter J., et al., editors. Harper's Illustrated Biochemistry. 33rd ed., McGraw Hill, 2026.

## SEMESTER III

**Title of the Course : Biotechnology, Tissue Culture and Animal Cell Culture**
**Course Code : Minor III**
**Nature of the Course: Minor**
**Total Credits : 04**
**Distribution of Marks: (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1) Interpret the principle, practices and application of biotechnology.
2) Examine the process of genetic engineering.
3) Demonstrate plant tissue culture and animal cell culture.

**Learning Outcomes:**

1) Apply the concept of biotechnology
2) Discuss the tools and techniques involves in genetic engineering.
3) Understand the process of plant tissue culture and animal cell culture.

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | | | |
| Procedural | | | CO1, CO3 | CO2 | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2.6 |
| AVERAGE | 3.0 | 2.0 | 2.3 | 2.3 | 2.3 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce/Group discussion/Home assignments

**Attainment strategy:**

1. Continuous evaluation through in and end semester theory and practical examinations
2. Laboratory practices on biotechnology, cell and tissue culture
3. Practical record book/field book

**Unit 1: Recombinant DNA technology (Lecture: 5)**

Introduction to biotechnology; Restriction Endonucleases (History, Types I-IV, biological role and application); Cloning Vectors; types

**Unit-2:Gene Cloning (Lecture: 8)**

Recombinant DNA technology, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning, DNA libraries, cDNA libraries, colony hybridization; Somatic cell nuclear transfer.

**Unit-3: Applications of Biotechnology (Lecture: 12)**

Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

**Unit-4: Animal cell culture (Lecture: 8)**

Historical perspective; Composition of media; Nutrient and hormone requirements, maintenance of aseptic condition, types of cell lines, Application of cell culture, MTT assay

**Unit-5: Plant Tissue Culture (Lecture: 12)**

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, Cryopreservation; Germplasm Conservation).

**Unit 6: Lab course 15 lectures**

1. Preparation of MS medium and callus.
2. Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, Datura, Brassica etc.

3. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
4. Construction of restriction map of circular and linear DNA from the data provided
5. Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA.
9. Demonstration of animal cell culture technique through photographs/animation

**Suggested Readings**

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.

2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.

4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.

5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A

## SEMESTER III

**Title of the Course : Ethnobiology**
**Course Code : GEC III**
**Nature of the Course : GEC**

**Total Credits : 03**
**Distribution of Marks : 40 IA + 60END = 100**

**COs**:

1) Discuss the indigenous practices of ethnic groups of Northeast India
2) Use of traditional knowledge system of the region for sustainable development
3) Compare medicinal and agronomic values of biological resources of the region
4) Protection of traditional knowledge through IPR

**Learning outcome:**

1) Understand the traditional practices of ethnic communities of the region
2) Implementation of IKS for sustainable development goals
3) Apply the indigenous knowledge in daily life
4) Analyze the IPR for protection of traditional knowledge

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | CO4 | |
| Procedural | | | CO2 | CO3 | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2.3 |
| CO2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2.3 |
| CO3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2.3 |
| CO4 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 3.0 | 3.0 | 2.0 | 1.8 | 1.8 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam

- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Viva-voce examination

**Unit 1: Ethnobiology (Lectures 15)**

**C**oncept, history, theory; hypotheses, evolution and scope;
Indigenous knowledge and traditional practices, ethnobiology of north east India or some Himalayan communities. Major ethnic group in North East India; their social institutions, livelihood, cultural and religious practices, other belief systems, sacred groove. Methods of biological resource conservation; ecorestoration. Scope for development of plant resources.

**Unit 2:Traditional Knowledge (Lectures 10)**

Traditional knowledge system of different indigenous
community of North Eastern India. Application and practices of traditional knowledge system in agriculture, healthcare, livelihood and alternative food; fooder. Sustainable utilization of biological resources and biodiversity conservation. Current status of Ethnobiology, biodiversity and traditional knowledge.

**Unit 3:Ethnobiology and Its Relevance in Contemporary Research (Lectures 8)**

Ethnobiology; drug discovery. Ayurvedic drug preparation and drug adulteration. Chemical composition of few medicinal and aromatic plants, extraction and uses pertaining to typical Indian formulation ofdrugs. Ethnopharmacological validation of traditional medicine; approaches to drugdiscovery from ethnobotanical leads.

**Unit 4: Traditional Agronomic Practices (Lectures 5)**

Shifting cultivation, weed and flood management, beekeeping,Aquaculture

**Unit 5 : Protection of traditional knowledge (Lectures 7)**

Ethnobiology; IPR, biopiracy, National Biodiversity protection initiatives; Convention on Biological Diversity, Nagoya protocol.

**Suggested Readings**

1) S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
2) S.K. Jain (ed.) Glimpses of Indian. Ethnobotany, Oxford and I B H, New Delhi – 1981
3) S.K. Jain (ed.) 1989. Methods and approaches in ethnobotany. Society of ethnobotanists,Lucknow, India.
4) S.K. Jain, 1990. Contributions of Indian ethnobotny.Scientific publishers, Jodhpur.

5) Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons – _Chichester
6) Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India.Botanical Survey of India. Howrah._8) Rajiv K. Sinha – Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996_9) Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd

## SEMESTER III

**Course: Multi-disciplinary Course on Analytical Tools and Techniques in Science**
**Course Code: SEC III**
**Course Nature: Skill Enhancement Course**
**Marks: (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**Course Outcome:**

1) Analyze different separation techniques
2) Compare various microscopic techniques
3) Examine the structure of DNA and its amplification
4) Contrast among blotting techniques
5) Investigate biological and chemical samples through the application of different tools and techniques

**Learning Outcome:**

1) Demonstrate various separation techniques
2) Operate different microscopes
3) Describe DNA structure and amplification
4) Distinguish between blotting techniques
5) Evaluate biological and chemical samples with the use of various tools and techniques

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | | | |
| Procedural | | | | CO1,CO2, CO3,CO4 | CO5 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2.1 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CO4 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1.7 |
| CO5 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1.7 |
| AVERAGE | 2.0 | 2.0 | 2.2 | 2.2 | 2.0 | 1.6 | 1.6 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Practical demonstration of the major analytical equipments
- Submission of practical record book
- Hands on activities in operating equipment

**15 lectures**

**Unit 1:** Chromatographic methods: Adsorption and partition principle. Thin layer chromatography (TLC), Paper (radial, ascending, descending), and column chromatography. Fundamentals of spectroscopic techniques: (a) UV-vis spectroscopy: Overview of spectroscopy techniques, Basic principles of electromagnetic radiation, Interaction of light with matter, Components of a UV-Vis spectrophotometer, Sample handling techniques, Beer-Lambert Law and its application in UV-Vis spectroscopy, Factors affecting absorbance spectra (solvent, pH, temperature, etc.), Applications of UV-Vis Spectroscopy in qualitative and quantitative analysis, in kinetic studies (monitoring reaction rates). (b) IR Spectroscopy: Introduction to IR Spectroscopy, Components of an IR spectrometer, Sample handling techniques, Vibrational modes of molecules, Theory behind IR spectra interpretation.

**15 lectures**

**Unit 2:** Microscopy- Concept of Resolution and Magnification, Optical Microscopy- Bright Field Microscopy, Dark Field Microscopy, Phase Contrast Microscopy, Fluorescence Microscopy and Electron Microscopy. Centrifugation technique- Principle of centrifugation, Differential and Density gradient centrifugation (Rate Zonal Centrifugation, Isopycnic Centrifugation). Concept of DNA structure, PCR-based DNA amplification: PCR chemicals and principle of PCR. Electrophoretic separation of biomolecules- principle; Blotting techniques—Southern, Northern, and Western.

**Unit 3:** **15 lectures**

**Lab Course:**

• Separation of biological/ chemical samples using paper Chromatography and TLC

- Spectrophotometer estimation of biological/ chemical samples
- Structural elucidation of unknown compounds using IR spectroscopy
- Handling of Microscope and visualization of different samples
- Separation of samples using centrifuge
- Amplification of DNA using PCR
- Agarose gel electrophoresis of PCR amplified DNA

**Suggested Readings:**

1) Biophysical Chemistry: Principles and Techniques. Upadhyay, Upadhyay and Nath. Himalaya Publishing House. ISBN: 978-93-5142-227-3
2) Wilson And Walker's Principles And Techniques Of Biochemistry And Molecular Biology. Andreas Hofmann (Editor), Samuel Clokie (Editor). ISBN: 978-1316614761
3) Biological Instrumentation & Methodology. Bajpai P.K. ISBN: 978-8121926331

**SEMESTER-IV**

| | | |
|---|---|---|
| **Title of the Course** | **:** | **Genetics** |
| **Code** | **:** | **CORE-V** |
| **Nature of Course** | **:** | **Core** |
| **Total Credits** | **:** | **04** |

**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1) Interpret the basic patterns of inheritance
2) Evaluate genetic disorders and mutations

**Learning Outcome:**

1) Understand the concept of inheritance
2) Analyze mutations and genetic disorders

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | | |
| Procedural | | | | | CO2 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2.1 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.5 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination
- Submission of practical file

- Viva-voce examination

**Unit-I: Mendelian genetics and its extension** **15 classes**

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; autosomesand sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits; Polygenic inheritance.

**Unit-II: Extrachromosomal Inheritance** **9 classes**

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium*.

**Unit-III: Linkage, crossing over, and chromosome mapping** **9 classes**

Linkage and crossing over-Cytological basis of crossing over; Genetic mapping, Sex linked, Sex influenced, Sex limited inheritances, quantitative traits/loci.

**Unit IV: Chromosomal & gene mutation** **12 classes**

Chromosomal mutation: Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy. Gene mutations: Types of gene mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method; Transposons

**Unit V: Lab course** **15 classes**

1. Study of Mendel's laws and gene interactions. Verify result using chi-square test.
2. Study of Human Karotypes by pictorial demonstration.
3. Chromosome mapping using point test cross data.
4. Preparation of polytene chromosome from *Chironomous/Drosophilla* larvae.
5. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
6. Study of aneuploidy: Down's, Klinefelter's, and Turner's syndromes.

**Suggested readings**

1. Genetics: Analysis & Principles Author: Robert J. Brooker Publisher: McGraw-Hill Science Engineering; 4 edition (21 January 2011)

2. Concepts of Genetics Authors: William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, Darrell KilliannPublisher: Benjamin-Cummings Pub Co; Student edition (19 November 2014)

3. Introduction to Genetic Analysis (Introduction to Genetic Analysis (Griffiths)) Hardcover – Import, 16 Feb 2007 Authors: Anthony J. F. Griffiths, Susan R. Wessler , Richard C. Lewontin, Sean B. CarrollPublisher: WH Freeman; 11th ed. 2016 edition (12 January 2015)

## SEMESTER-IV

**Title of the Course : Microbiology and Immunology**
**Code : CORE-VI**
**Nature of Course : Core**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1) Classify microorganisms based on different parameters
2) Demonstrate different processes involved in microbiology
3) Differentiate between microbial groups
4) Apply microbes for human welfare
5) Evaluate different antibiotics, immunological processes and vaccines

**Learning Outcome:**

1) Distinguish microbes based on different parameters
2) Understand different microbial processes for application in human welfare
3) Describe immunological concepts
4) Understand antibiotic classes and vaccines

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | | CO2, CO4 | CO3 | CO5 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2.1 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1.7 |
| CO5 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1.7 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AVERAGE | 2.0 | 2.0 | 2.2 | 2.2 | 2.0 | 1.6 | 1.6 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book

**Unit I: Brief history and development of microbiology**: **10 classes**

Introduction to study of Microbiology, conflict over spontaneous generation, role of microorganisms in disease, scope of microbiology, development of Koch's postulate.

Classification of microorganisms; morphological, biochemical and molecular characteristics; nutritional types in microorganisms; Culture media, microbial growth curve, uncultured microbes.

**Unit II: Prokaryotic cell structure and viruses:** **15 classes**

Bacterial cell wall, cytoplasmic structure and inclusions bodies, sporulation and spore, diversity in bacterial structure; actinomycetes, rickettsias, mycoplasma; archaea. Basic structures, classification, double-stranded and single-stranded DNA and RNA viruses, replication strategies of DNA and RNA viruses; viroids and prions; bacteriphages with suitable examples.

**Unit-III: Application of microbes:** **10 classes**

Role of microbes in bio-geo-chemical cycling, biological nitrogen fixation; industrial application of microbes: alcohol, organic acids, vaccine, antibiotics; microbial biofilm; wastewater treatment; biofertilizer and biopesticides; Microbial diseases and their control: Host-pathogen relationship, mechanisms of virulence, quorum sensing, pathogenesis in plants and animals

**Unit-IV: Immunology** **10 classes**

Immunity and types (innate immunity and adaptive immunity); Natural immunity and artificial immunity; Active and passive immunity; discrimination between self and non-self,; Immune responses; Antibody-mediated immune response (AMIS) and Cell-mediated immune response (CMIS); Cells of the immune system; lymphoid organs; Antigens – basic concepts, Immunoglobulins.

**Unit V: Lab Course:** **15 classes**

1. Bacterial growth on solid and broth media, pure culture technique, slant preparation
2. Bacterial colony morphology and diversity
3. Gram staining of bacteria
4. Biochemical characterization of bacteria
5. Demonstration of lymphoid organs (by video)
6. Histological study of spleen, thymus and lymph nodes through slides/ photographs
7. Model and/or Chart preparation/submission

**Suggested Readings**

1. Willey, J., Sherwood, L. and WoolvertonC., Microbiology, 10th edition (McGraw-Hill Science, 2017).
2. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R., Microbiology, Publisher McGraw Hill Education (India) Private Limited, ISBN-10 0074623206, 5th Edition, 2001.
3. Tortora, G.J., Fernke, B.R. and Case, C.L., Microbiology – An Introduction, 9th Edition,
4. Basic Immunology: Functions and Disorders of the Immune System, Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai ( Elseviers Saunders 4 th Edition).
5. Kuby Immunology, Thomas J. Kindt, Barbara A. Osborne, Richard A . Goldsby (W.H. Freeman Publishers, Sixth Edition).
6. M. T. Madigan, J. M. Martinko, K. S. Bender, D. H. Buckley, D. A. Stahl, T. Brock, Brock Biology of Microorganisms, 14th Edition , Pearson Hall International, 2017.
7. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education
8. Delves, P., Martin, S., Burton, D., Roitt, I. Roitt's Essential Immunology (WileyBlackwell, 11th Edition).

## SEMESTER-IV

**Title of the Course : Bioinformatics and Biostatistics**
**Code : CORE-VII**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Understanding the basic concepts of bioinformatics and biostatistics
2. Use of biological databases for data retrieval
3. Analysis of biological data for solving biological problems
4. Evaluation of the significance of biological experiments

**Learning Outcome:**

1. Describe the various biological databases
2. Summarize the data retrieve from biological databases
3. Compare and contrast the biological data for better interpretation
4. Application of statistical tools for testing the significance of tests

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | | CO2 | CO3 | CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit I: Introduction to Bioinformatics** **10 lectures**

Introduction, Biological Databases, Classification of Biological Databases, Biological Database Retrieval System. National Centre for Biotechnology Information (NCBI), Protein Database, Gene Expression Database, EMBL Nucleotide Sequence Database (EMBL-Bank). DNA Data Bank of Japan (DDBJ), Data Submission to NCBI, Protein Information Resource (PIR), Swiss-Prot.

**Unit-II: Sequence Alignments & Molecular Phylogeny** **15 lectures**

Sequence analysis tools. BLAST, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino AcidSubstitution Matrix (BLOSUM). Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

**Unit-III: Biostatistics (Descriptive)** **10 lectures**

Sampling: Sample size and sampling types. Frequency Distributions and Measures of central tendency: mean, mode, median. Measures of dispersion: range, variance, standard deviation, coefficient of variation, measures of skewness and kurtosis.

**Unit-IV: Biostatistics (Inferential)** **10 lectures**

Basic concept of Probability, Bayesian Rules, Random variable, Distributions of random variables, Binomial, Poisson. Correlation and regression. Test of Significance: Hypothesis testing; null and alternative hypotheses; Type I and Type II errors; level of significance and p-value. Parametric tests: Student's t-test, Z-test, Analysis of Variance (One-way ANOVA and Two-way ANOVA), and multiple comparison procedures (Post-hoc tests/Critical Difference analysis). Non-parametric tests: Chi-square test and Mann–Whitney U test.

**Unit V: Lab Course** **15 lectures**

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.

3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.
6. Statistical Measures: mean, mode, median, variance, standard deviation
7. Tests of significance

**Suggested Readings**

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, “Database System Concepts”, McGraw-Hill, 6th Edition, 2011.
2. Date C.J, “An Introduction to Database”, Addison-Wesley Pub Co, 7th Edition, 2001
3. Elmashri& Navathe, “Fundamentals of Database System”, Addison-Wesley Publishing, 3rd Edition, 2000
4. Jhonson RA et al. (2015) Miller &Freund’s probability and statistics for engineers.
5. Ross S (2018) Introduction to probability and statistics for engineers and scientists.
6. Fundamentals of Biostatistics by Bernard Rosner Publisher: Cengage Learning;

   7 edition

## SEMESTER-IV

**Title of the Course : Evolutionary Biology**
**Code : CORE-VIII**
**Total Credits : 04**
**Distribution of Marks: (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Describe the concept and theories of Evolution
2. Analyze the evolutionary evidences and theories of origin of life
3. Evaluate population genetics and evolution of man

**Learning Outcomes:**

1. Understand the theory of origin of life on Earth
2. Discuss the theories on the basis of evidences
3. Analyze population genetics

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2, CO3 | | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**15 lectures**

**Unit 1: Life's Beginnings:** Chemogeny, RNA world, Fe-S complex theory of the origin of metabolism, Biogeny, Origin of photosynthesis, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo- Darwinism, Germplasm theory, Synthetic theory and its significance. Causes of variation at individual level-recombination, mutation, hybridization and lateral gene transfer; factors affecting variation at individual level.

**10 lectures**

**Unit 2: Evidences of Evolution:** Fossil record : types of fossils, transitional forms, geological time scale, evolution of horse, neutral theory of molecular evolution, example of globin gene family. Role of neutral mutation in evolution or adaptation and adaptability.

**10 lectures**

**Unit 3: Population genetics in evolution**: Application of Hardy-Weinberg Law in population genetics, gene pool and genetic equilibrium; Evolutionary forces upsetting H-W equilibrium; Concept of natural selection- types of selection, role of natural selection on population genotypes. Genetic Drift: mechanism, founder's effect, bottleneck phenomenon, Role of Migration and Mutation in changing allele frequencies in evolution.

**10 lectures**

**Unit 4: Product of evolution**: Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches. Mass extinctions (causes and effects), example of K-T extinction. Evolution of Man.

**Unit 5: Lab Course** **15 lectures**

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies

5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.

**Suggested Readings**

1. Concept of Species. Slobodehikoff
2. Introduction to Evolution .Harper and Row. New York.
3. Roberts, A. (2018) Evolution: the human story, Dorling, Kindersley Ltd.
4. Hall, B.K. and Hallgrimson, B. (2013). Evolution. V Edition, Jones and Barlett Publishers.
5. Barton N.H., Briggs D.E.G., Eisen J.A., Goldstein D.B. and Patel N.H., (2007) 1st Ed. Evolution, Cold Spring Harbor Laboratory Press.

## SEMESTER-IV

**Title of the Course : Biodiversity and Conservation Biology**
**Code : Minor IV**
**Nature of Course : Minor**
**Total Credits : 04**
**Distribution of Marks: (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Describe the concept of biodiversity, its conservation and legislation
2. Analyze the monitoring strategies and threats to biodiversity
3. Evaluate biodiversity of a region for formulation of conservation strategies

**Learning Outcomes:**

1. Understand the concept of biodiversity and biodiversity indices
2. Discuss the threats to biodiversity and possible conservation methods
3. Describe environmental legislation
4. Monitor biodiversity and take steps for conservation

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | | | CO2 | CO3 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit 1: Biodiversity** **15 lectures**

Biodiversity concept, Definition and type of biodiversity: species, genetic and molecular diversity. Biodiversity hotspots in India.Biogeographical realms of the world, geographic origins and distribution of species. Reduction in biological diversity, present scenario.

**Unit 2: Monitoring and documentation of biodiversity** **10 lectures**

Measuring biodiversity, biodiversity indices- Shannon-Wiener, Margaleff and Simpson). Biodiversity Utility.

**Unit 3: Conservation** **10 lectures**

Conservation of biodiversity in protected habitats, seed banks, gene banks, germ plasma repositories, conventions of biological diversity.

**Unit 4:Habitat restoration and Environmental legislation** **10 lectures**

Habitat restoration strategies. Protective legislation for specific animals, protective legislation for wildlife.

**Unit 5: Lab activities** **15 lectures**

1. To determine the frequency, density and abundance of the primary producers of a grassland community by quadrate method.
2. To determine the abundance and density of soil fauna.
3. To study aquatic ecosystem.
4. Field survey

**SEMESTER V**

**Title of the Course : Comparative Anatomy and Animal Physiology**

**Course Code : CORE IX**
**Nature of the Course : Core**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

COs:

1. Describe the different systems of vertebrates
2. Distinguish between the mechanisms of various physiological systems
3. Examine the body parameters based on the knowledge
4. Analyze the structural modifications in anatomy of different groups

Learning outcomes:

1. Compare the various physiological systems
2. Analyze the mechanisms involved in the systems
3. Apply the knowledge to correlate various parameters of the body
4. Describe the anatomy of different systems in Vertebrates

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | CO2 | | | |
| Procedural | | | | CO4 | CO3 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam

- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**UNIT 1: Structural Components of an organism (Lectures 12)**

Integument Structure. Outline of axial and appendicular skeleton, Structure of a typical vertebra and its classification based on centrum. Jaw suspensorium. Tissues: epithelial tissue, connective tissue, muscular tissue and nervous tissue. Bone and cartilage types.

**UNIT2: Digestive System and Excretory System (Lectures 13)**

Alimentary canal and associated glands, dentition. Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water. Succession of the kidney, Structure of kidney and its functional unit; Mechanism of urine formation and its regulation. Concept of homeostasis and maintenance of volume and composition of body fluid. Concept of osmoregulation, Osmotic and salinity stress; Desiccation and dehydration stress.

**Unit 3: Respiratory System (Lectures 10)**

Brief account of gills, lungs, air sacs and swim bladder. Mechanism of breathing and regulation, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Oxygen-haemoglobin dissociation curve and factors affecting O2 and CO2 transport (Bohr's effect, Haldane effect, chloride shift, etc.). Respiratory acidosis and alkalosis. Adaptation to high altitude. Mountain sickness and acclimatization.

**Unit 4: Circulatory System and Reproductive System (Lectures 10)**

Evolution of heart and aortic arches; Coronary circulation and heart diseases. Origin and conduction of cardiac impulses, Cardiac cycle; Cardiac output, nervous and chemical regulation of heart rate. Electrocardiogram. Histology of testis and ovary. Physiology of male and female reproductive systems in human, Puberty, menstrual cycle and associated hormones.

**Unit 5: Lab Course (Lectures 15)**

1. Study of the disarticulated skeleton of Frog, Varanus, Fowl, Rabbit (Vertebral Column, Sternum, Girdles, Ribs, Limb bones).

2. Study on permanent slides of skin, Testis, Ovary, lungs, Liver, Kidney, stomach and intestine in vertebrates.
3. Study on effect of temperature and pH on salivary amylase activity.
4. Study on rate of oxygen consumption by fish.
5. Microtomy: Preparation of permanent slide of any organ of vertebrates.

## SUGGESTED READINGS


1. Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company
2. Saladin, K. S., McFarland, R., & Gan, C. A. (2021). Essentials of anatomy & physiology (3rd ed.). McGraw-Hill Education. [1, 2]
3. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
4. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
5. Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons.
6. Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House.
7. Tortora, G.J. - and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley & Sons, Inc.
8. Widmaier, E.P., Raff, H. and Strang, K.T. (2008) Vander 's Human Physiology, XI Edition., McGraw Hill
9. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H. Freeman and Co.


**SEMESTER V**

**Title of the Course : Embryology**

**Course Code : CORE X**

**Nature of the Course : Core**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs**:

1. Conceptualize the basic principles and concepts in the developmental processes from a single cell system to a multi-cellular system
2. Analyze the embryonic and post embryonic developmental processes
3. Evaluate the developmental process of a single fertilized egg to mature into a fully developed complex organism

**Learning Outcome:**

1. Understand the historical perspective and concepts of developmental biology
2. Discuss the embryonic developmental processes
3. Analyze the changes during the process of development

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | | | CO2 | CO3 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book

**UNIT- 1: Introduction (Lectures 10)**

Historical perspectives and basic concepts: Phases of development, Pattern formation, Differentiation and growth, Cytoplasmic determinants and asymmetric cell division

**UNIT- 2: Early Embryonic Development (Lectures 12)**

Gametogenesis: oogenesis, spermatogenesis; Types of eggs, Egg membranes. Cell surface molecules in sperm-egg recognition in animals. Fertilization (External and Internal), monospermy, polyspermy, Changes in gametes, Blocks to polyspermy.

**Unit-3: Cleavage, blastulation and gastrulation (Lectures 12)**

Planes and patterns of cleavage; Types of Blastula; Fate maps. Gastrulation in frog and chick, Embryonic induction and organizers.

**UNIT- 4: Late Embryonic Development (Lectures 11)**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, structure, types, and functions of placenta.

**UNIT- 5: Lab Course: (Lectures 15)**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7- 24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19- 72 hours and Stage 24-96 hours of incubation
3. Model/chart preparation on embryonic development in insect/fish/amphibia/chick.

**Suggestive readings**

1. Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.

2. Gilbert, S. F. (2010) Developmental Biology. IX Edition, Sinauer Associates, Inc.

Publishers, Sunderland, Massachusetts, USA

3. Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.

4. Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition,

International Thompson Computer Press.

## SEMESTER V

**Title of the Course : Introduction to Insect Diversity and Ichthyology**
**Course Code : CORE XI**
**Nature of the Course : Core**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Explain the morphological characters of insects and analyse the modified morphological character used in adaptation
2. Analyse the beneficial and harmful insects and explain their roles
3. Understand the general morphological characters of Fishes
4. Analyze the basic features of Fish Biology

**Learning Outcome:**

1. Apply morphological features of insects and their modifications for study with insects
2. Identify the beneficial and harmful insects
3. Identify the basic features of ornamental and food fishes
4. Apply the concept of fish biology

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO4 | | |
| Procedural | | | | | CO2, CO3 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0.71 |
| CO2 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1.86 |
| CO3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0.57 |
| CO4 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AVERAGE | 2.5 | 2.0 | 0.75 | 0.75 | 0.5 | 0.25 | 0.5 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through the in- and end-semester theory examination
- Submission of assignment on a relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit 1: Overview of insect morphology (10 lectures)**

Features of insect morphology: Head, Body segmentation, mouthparts, wings, legs, Antenna, external genitalia, abdominal appendages and their modifications, Morphological basis of Insect classification up to infraclass.

**Unit 2: Beneficial, harmful, and social insects (12 lectures)**

Dimensions of insect diversity, concepts and significance of beneficial insects: silk, honey and lac-producing insects and production process, insects of forensic importance and their use. Insect pests, parasites and disease vectors: Identification and life cycle of *Bombyx mori, Samia ricini, Antheraea assamensis, Apis* spp., Blow flies, Flesh flies, Cockroach, lemon butterfly, House flies, Mosquitoes, sand flies. Insect societies, honey bee and termite as social insects

**Unit 3: Classification and diversity of fishes (12 lectures)**

Principles of fish taxonomy and systematics, Major groups of fishes: Chondrichthyes (Cartilaginous fishes) Osteichthyes (Bony fishes); Morphological characters used in fish identification; Skin and scales; Fins and fin modifications, Fish diversity of India and Northeast India including hill stream fishes

**Unit 4: Basics of fish biology and fish ecology (11 lectures)**

Growth patterns in fishes, Reproductive systems of fishes, Sexual dimorphism, Fish habitats and ecological niches, Feeding ecology and trophic interactions, Adaptations to aquatic environments

**Unit 5: Lab Course (15 lectures)**

1. Identification of modification of insect appendages

2. Identification of beneficial and harmful insects using examples from theory through permanent slides, museum collections, slide preparation
3. Identification of locally available fishes based on morphometric and meristic features.
4. Identification of fish scales.
5. Study of fish anatomy through dissection
6. Estimation of dissolved oxygen through Winkler's method.
7. Experiment on relative gut length and gastro somatic index.

**Suggested reading**

1. A general text book of entomology, Imms , A. D., Chapman & Hall, UK
2. Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F.,M Saunders College Publication, USA
3. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
4. The Insect Societies, Wilson, E. O., Harvard Univ. Press, UK .
5. Daly and Doyen's Introduction to Insect Biology and Diversity. 3rd Edition. Oxford University Press, Oxford, UK. Whitfield, J. B. and A. H. Purcell III. 2014.
1. G. Helfman, Bruce B. Collette, D.E. Facey, B. W. Bowen: The Diversity of Fishes: Biology, Evolution, and Ecology, John Wiley & Sons
2. R. J. Wootton: Fish Ecology, Springer
3. W. Vishwanath, W.S. Lakra and U.K. Sarkar: Fishes of North East India, NBFGR Publication, Lucknow.
4. D. Kapoor, R. Dayal and A.G. Ponniah: Fish Biodiversity of India, NBFGR Publication, Lucknow.
5. R.H. McConnell: Ecological Studies in Tropical Fish Communities, Cambridge University Press.
6. Matty: Fish Endocrinology.
7. T.K. Govindan: Fish Processing Technology, Oxford & IBH, New Delhi
8. Peter B. Moyle Joseph J. Cech Jr.: Fishes–An Introduction to Ichthyology, Prentice Hall, N.Y .
9. R.K. Rath: Freshwater Aquiculture, Scientific publishers.
10. Hoar and Randall: Fish Physiology, Academic Press, London.
11. Hwett: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News books Ltd. Surrey England.
12. Bardach, Miller and Passino: Ichthyology, John Wiley &Sons, N.Y.
13. H.L. Choudhury & S.B. Singh: Induced Breeding of Carps, ICAR New Delhi
14. W.F. Royce: Introduction to the Practice of Fishery Science, Academic Press, N.Y.
15. V.G. Jhingran:Fish and Fisheries of India, Oxford & IBH, New Delhi.
16. Kyle: The Biology of Fishes.
17. R.G.Wetzel: Limnology,W.G.Saunders, N.Y.
18. M. J. Mannig. and M. F.Tatner: Fish Immunology Academic Press. N.Y.
19. J. S. D. Munshi and G.M.Hughes: Air-breathing fishes of India. Their structure, function

and life history. Oxford & IBH. Publishing Co.
20. R.R.Stickney: Principles of Warm Water Aquiculture, John Wiley & Sons, N.Y.
21. CBL Srivastava: A Text Book of Fishery Science and Indian Fisheries, Kitab Mahal , Allahabad.
22. B.A. Whitton: River ecology, University of California Press.
23. G.V. Nikolsky: The Ecology of Fishes, Academic Press, N.Y.
24. S.P.Biswas: Manual of Methods in Fish Biology, South Asian Publishers, New Delhi.
25. S.P.Biswas : Fundamentals of Ichthyology, Narendra Publication House. New Delhi.

**SEMESTER V**

**Title of the Course : Embryology**
**Course Code : Minor V**
**Nature of the Course : Minor**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**
**COs**:

1. Explain the basic principles and concepts the embryological processes from a single cell system to a multi-cellular system
2. Analyze the embryonic and post embryonic developmental processes
3. Evaluate the development of a single fertilized egg to mature into a fully developed complex organism

**Learning Outcome:**

1. Understand the historical perspective and concepts of embryology
2. Discuss the embryonic developmental processes
3. Analyze the changes during the process of embyological development

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2 | | |
| Procedural | | | | | CO3 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 0 | 1 | 1 | 0 | 1 | 1.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1.57 |
| CO3 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 1.86 |
| AVERAGE | 2.33 | 2.33 | 0.67 | 1.67 | 1.67 | 1.67 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**UNIT- 1: Introduction (Lectures 10)**

Historical perspectives and basic concepts: Phases of development, Pattern formation, Differentiation and growth, Cytoplasmic determinants and asymmetric cell division

**UNIT- 2: Early Embryonic Development (Lectures 12)**

Gametogenesis: oogenesis, spermatogenesis; Types of eggs, Egg membranes. Cell surface molecules in sperm-egg recognition in animals. Fertilization (External and Internal), monospermy, polyspermy, Changes in gametes, Blocks to polyspermy.

**Unit-3: Cleavage, blastulation and gastrulation (Lectures 12)**

Planes and patterns of cleavage; Types of Blastula; Fate maps. Gastrulation in frog and chick, Embryonic induction and organizers.

**UNIT- 4: Late Embryonic Development (Lectures 11)**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, structure, types, and functions of placenta.

**UNIT- 5: Lab Course: (Lectures 15)**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7- 24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19- 72 hours and Stage 24-96 hours of incubation
3. Model/chart preparation on embryonic development in insect/fish/amphibia/chick.

**Suggestive readings**

1. Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.

2. Gilbert, S. F. (2010) Developmental Biology. IX Edition, Sinauer Associates, Inc.

Publishers, Sunderland, Massachusetts, USA

3. Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.

4. Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition,

International Thompson Computer Press.

**SEMESTER V**

| | | |
|---|---|---|
| **Title of the Course** | **:** | **Internship/Community Engagement** |
| **Course Code** | **:** | **Int./CE.** |
| **Nature of the Course** | **:** | |
| **Total Credits** | **:** | **04** |
| **Duration** | **:** | **120 hours** |

## Course Structure

**Internship + Community Engagement: (2+2)= 4 credits**

**OR**

**Intership/Community Engagement: 4 credits**

**Note:**

**Internship + Community Engagement or Internship/Community Engagement** should be carried out during the semester break or convenient period of a total **120 hours**.

## SEMESTER VI

**Title of the Course : Animal Physiology: Controlling and Co-ordinating System**
**Course Code :Core XII**
**Nature of the Course : Core**
**Total Credits :04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Analyze the internal working of organs and organ systems.
2. Evaluate the functioning of various organ systems such as muscular, nervous, and blood in vertebrates.
3. Evaluate the endocrine system and its role in integration.

Learning Outcome:

1. Describe the organ systems and their functions.
2. Discuss about the role of endocrine system.

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | CO1 | | CO2, CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit 1: Muscle and Blood (Lectures 12)**

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus. Components of blood and their functions; Structure and functions of haemoglobin, Haemostasis: Blood clotting system, Blood groups:ABO, Rh factor

**Unit 2: Nervous System (Lectures 12)**

Types of nerves and nervous system, Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission and, Neuromuscular junction; Reflex action and its types - reflex arc

**Unit 3:Structure and Physiology of hearing and vision (Lectures 5)**

Structure of eye and ear. Physiology of hearing and vision.

**Unit 4: Endocrine System (Lectures 16)**

Comparative account of endocrine glands in vertebrates, Histology of pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them and their mechanism of action; Classification of hormones;; Mode of hormone action, Hypothalamus and principal nuclei involved in neuroendocrine control of endocrine system, feedback mechanism.

**Unit 5: Lab Course (Lectures 15)**

1. Preparation of haemin and haemochromogen crystals
2. Recording of simple muscle twitch with electrical stimulation (or Virtual)
3. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
4. Examination of sections of mammalian nerves, different types of muscles.

5. Study of permanent slides of Bone, Cartilage, Tissues, Neurons, Pituitary, Pancreas, Adrenal,Thyroid, Hypothalamus and Parathyroid

## SUGGESTED READINGS

• Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.

• Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.

• Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons.

• Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House.

• Tortora, G.J. - and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley & Sons, Inc.

• Widmaier, E.P., Raff, H. and Strang, K.T. (2008) Vander 's Human Physiology, XI Edition., McGraw Hill

• Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition,Harcourt Asia Pvt. Ltd/ W.B. Saunders Company

• Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.

## SEMESTER VI

**Title of the Course : Animal Behaviour and Chronobiology**
**Course Code : CORE XIII**
**Nature of the Course : Core**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Describe the types of behaviour
2. Interpret the behavioural changes in an animal
3. Analyze the biological clock
4. Evaluate the behaviour of an organism

**Learning Outcomes**

1. Describe types of behaviour and biological rhythms
2. Analyze behaviour of any animal

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | CO2 | CO3 | | |
| Procedural | | | | | CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit 1: Introduction to Animal Behaviour (Lecture 10)**

Introduction to ethology and ethological concepts. TNature vs. Nurture controversy-Role of genes and environment. Types of behaviour. Imprinting. Innate vs acquired behaviour. Fixed Action Pattern. Learning: habituation, Associative Learning.

**Unit 2: Orientation and Communication (Lecture 11)**

Orientation behaviour: Types, mechanism and multiplicity of cues: Visual, magnetic, chemical, sound and electrolocation. Importance of communication; Definition and function, Channels for communication: Chemical, Tactile, Auditory, Visual.

**Unit 3: Social, Sexual and antipredatory Behaviour (Lecture 12)**

Concept of Society, pros and cons of social behaviour. Cooperation and Altruism, Hamilton Rule, Sexual Behaviour: Sexual dimorphism, Mating systems, Courtship behaviour, Parental care. Antipredatory behaviour: Crypsis, camouflage, mimicry, and group defence.

**Unit 4: Introduction to Chronobiology (Lecture 12)**

Historical developments in chronobiology. Biological clocks. Types and characteristics of biological rhythms: Short- and Long- term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Circannual rhythms; ultradian, infradian. Relevance of biological clocks; to insects, birds and mammals. Chronomedicine, Chronotherapy**.**

**Unit 5: Lab Course**: **(Lecture 15)**

1. Study of habituation in mosquito larvae/ snails.
2. Study of taxis in earthworms.
3. Grooming behaviour in cockroaches.
4. Study of social behaviour in ants/ termites.

5. Study of colouration pattern in fish for concealment and courtship.
6. Effect of humidity gradient on distribution of invertebrates (woodlouse/snail/earthworm)
7. Study of foraging behaviour in fish.
8. Behaviour project.

**Suggestive Readings:**


- Alcock, J. (2013) Animal Behaviour, Xth Edition, Sinauer Associates Inc., USA.
- Manning, A. and Dawkins, M. S, (2012) An Introduction to Animal Behaviour, VIth Edition, Cambridge University Press, UK
- McFarland, D. (1985) Animal Behaviour, Pitman Publishing Limited, London, UK
- Binkley, S. (2020). Biological clocks: Your owner's manual. CRC Press.
- Vinod Kumar (2017): Biological Timekeeping: Clocks, Rhythms and Behaviour.
- Wirz-Justice, A., Benedetti, F., & Terman, M. (2013). Chronotherapeutics for Affective Disorders: A Clinician's Manual for Light and Wake Therapy. Karger Medical andScientific Publisher

**SEMESTER VI**

**Title of the Course : Animal Ecology and Wildlife Management**
**Course Code : CORE XIV**
**Nature of the Course : Core**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs**

1. Discuss the concept of ecology and wildlife
2. Interpret population ecology
3. Analyze ecological dynamics
4. Evaluate threats to wildlife

**Learning Outcome**

1. Describe ecological concepts and wildlife ideas
2. Analyze threats to wildlife

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | | CO2 | CO3 | CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit 1: Introduction to ecology (Lectures 10)**

Definitions; ecology, habitat, Ecozone, biosphere, ecosystems, resistance and resilience, autecology, synecology, biome, Liebig's law of minimum, Shelford's law of tolerance, ecotype, ecological niche.

**Unit 2: Ecology of population, community and ecosystem (Lectures 15)**

Concept of population, characteristics of population; density, dispersion, natality, mortality, life table, survivorship curve, age structure, population growth, limits to population growth, population interactions; parasitism, mutualism, commensalism, symbiosis, Community characteristics: species richness, dominance, diversity, abundance. Concept of ecosystem; structure and function of ecosystem; producer, consumers, decomposers, energy flow, food chain, food web and ecological pyramids.

**Unit 3: Introduction to Wildlife and habitat evaluation (Lectures 10)**

Values of wildlife: ecological, economic, cultural, ethical; Conservation ethics and importance; Causes of depletion: habitat loss, poaching, climate change; Habitat analysis: physical (topography, soil, water) and biological (food, cover, forage); Tools: bio-telemetry, remote sensing, GIS; Concept of habitat restoration: succession management, prescribed fire, grazing, genetic diversity preservation

**Unit 4: Wild life population Estimation Techniques and Conservation Strategies in India Lectures 10**

Census methods: pug marks, transects, camera traps; faecal analysis for ungulates and carnivores; Role of citizen in monitoring; In-situ conservation: Protected Area Networks, National Parks, Wildlife Sanctuaries; Ex-situ conservation: zoos, captive breeding, rescue centres; Ecotourism and community participation; Wildlife laws and policies (Wildlife Protection Act, 1972; Biodiversity Act, 2002)

**Unit 5: Lab Course: Lectures 15**

1. Identification of mammalian fauna, avian fauna, herpeto- fauna, fish fauna
2. Demonstration of basic equipment needed in wild life studies by pictures.

3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method).
4. Study on camouflages.
5. Breeding and parental care in Amphibia/Fish
6. Observation of animal architects: Termites, wasp, Harvester ant and any bird.

**Suggested Reading**

1. Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
3. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole Robert Leo Smith Ecology and field biology Harper and Row publisher
4. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron PresCaughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
5. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co-existence? Cambridge University.
6. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5 th edition. The Wildlife Society, Allen Press.
7. Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
8. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

**SEMESTER VI**

**Title of the Course : Animal Taxonomy and Systematics**
**Course Code : CORE XV**
**Nature of the Course : Core**
**Total Credits : 04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

COs:

1. Discuss the concept of taxonomy, identification keys and characters
2. Demonstrate taxonomic relations
3. Analyze molecular taxonomy and phylogeny
4. Evaluate taxonomic keys for identification and classification

Learning Outcomes

1. Understand taxonomic keys and characters for identification of species
2. Apply molecular taxonomy and classical tools for classification of organisms

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | | | |
| Procedural | | | CO2 | CO3 | CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit 1: Introduction (Lectures 12)**

Animal Taxonomy and systematics: Taxon and Phenon, Chemotaxonomy, cytotaxonomy and molecular taxonomy. Taxonomic categories. Taxonomic keys. Taxonomic characters- morphological, behavioural, ecological and geographical.

**Unit 2: Species concept (Lectures 10)**

Species concept- Typological, nominalistic, biological and evolutionary. Mechanism of speciation.

**Unit 3: Zoological Nomenclature (Lectures 11)**

International Code of Zoological Nomenclature (ICZN), Principles, functions and importance of Code of nomenclature, principle of priority, homonymy and synonmymy, principle of typification and use of types for specimens.

**Unit 4: Phylogeny (Lectures 12)**

Characters (ancestral vs derived), homology and analogy, parallelism and convergence, monophyly, polyphyly, paraphyly; representing phylogenies- Rooted and unrooted phylogenetic trees; clades, cladograms and Phenograms.

**Unit 5: Lab Activities (Lectures 15)**

1. To identify and distinguish species of insects/fishes/amphibians/reptiles/birds using appropriate taxonomic keys.
2. Morphometry and meristic study of fish.
3. Preparation and study of skeleton of fish.
4. Preparation, Mounting and stuffing of Indian Major Carps.
5. To identify crytic, sympatric, allopatric species.
6. To study molecular taxonomic variation using RFLP/ RAPD.
7. DNA barcoding of insect/fish species.

Suggested Readings:

- Kapoor VC (2019). Theory and practice of animal taxonomy, 8th Edition, Oxford and IBH Publishing
- Simpson GG (2012). Principles of Animal taxonomy, Scientific Publishers.
- Mayr E (2022). Principles of Systematic Zoology, United Book prints

**SEMESTER VI**

**Title of the Course : Animal Physiology: Controlling and Co-ordinating System**
**Course Code :Minor-XI**
**Nature of the Course : Minor**
**Total Credits :04**
**Distribution of Marks : (30+10 =40) (IA) + (45+15= 60) (END) = 100**

**COs:**

1. Analyze the internal working of organs and organ systems.
2. Evaluate the functioning of various organ systems such as muscular, nervous, and blood in vertebrates.
3. Evaluate the endocrine system and its role in integration.

Learning Outcome:

1. Describe the organ systems and their functions.
2. Discuss about the role of endocrine system.

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | CO1 | | CO2, CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Submission of practical record book
- Viva-voce examination

**Unit 1: Muscle and Blood (Lectures 12)**

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus. Components of blood and their functions; Structure and functions of haemoglobin, Haemostasis: Blood clotting system, Blood grouping and transfusion: ABO typing, Rh factors.

**Unit 2: Nervous System (Lectures 12)**

Types of nerves and nervous system, Structure of neuron, resting membrane potential, Origin of action potential and its propagation in the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission and, Neuromuscular junction; Reflex action and its types - reflex arc

**Unit 3:Structure and Physiology of hearing and vision (Lectures 5)**

Structure of eye and ear. Physiology of hearing and vision.

**Unit 4: Endocrine System (Lectures 16)**

Comparative account of endocrine glands in vertebrates, Histology of pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them and their mechanism of action; Classification of hormones; Mode of hormone action, Hypothalamus and principal nuclei involved in neuroendocrine control of endocrine system, feedback mechanism.

**Unit 5: Lab Course (Lectures 15)**

1. Preparation of haemin and haemochromogen crystals
2. Recording of simple muscle twitch with electrical stimulation (or Virtual)
3. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
4. Examination of sections of mammalian nerves, different types of muscles.
5. Study of permanent slides of Bone, Cartilage, Tissues, Neurons, Pituitary, Pancreas, Adrenal,Thyroid, Hypothalamus and Parathyroid

## SUGGESTED READINGS

• Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.

• Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.

• Tortora, G.J. - and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley & Sons, Inc.

• Widmaier, E.P., Raff, H. and Strang, K.T. (2008) Vander 's Human Physiology, XI Edition., McGraw Hill

• Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition,Harcourt Asia Pvt. Ltd/ W.B. Saunders Company

• Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.

## Semester VII

**Title of the Course : Environmental Biology**
**Course Code : Core XVI**
**Nature of the Course: CORE**
**Total Credits : 04**
**Distribution of Marks: 100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10Lab)**

**COs:**
1. Analyze ecological concepts and population dynamics
2. Evaluate environmental issues
3. Evaluate legislative measures and strategies for achieving SDGs.

**Learning Outcomes:**
1. Apply concepts of ecology to understand issues

2. Analyze problems and legislative measures

3. Apply strategies for SDG

**Mapping of CO withBloom Taxonomy**

| Knowlege Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | CO2,CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 1.57 |
| CO2 | 2 | 3 | 1 | 2 | 2 | 1 | 1 | 1.71 |
| CO3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 2.3 | 2.67 | 1.33 | 2.0 | 2 | 1.33 | 1.33 | 2.3 |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

- Internal examination,
- Viva-voce/Home assignments,

**Attainment strategy:**

- Continuous evaluation through in and end semester examinations,
- Submission of assignments

9 lectures

**Unit 1: Scope of ecology;** concepts of ecological factors; Ecosystem dynamics and management: structure and function, energy flow concept, the productivity concept and methods of measurement of productivity; diversity, stability and complexity of ecosystem; nutrient cycling with special reference to carbon, nitrogen & phosphorus cycles

11 lectures

**Unit 2: Population dynamics**: population attributes, biotic potential and environmental resistance, population growth forms, age structure, survivorship curves, population fluctuations, interactions and regulation of population; concept of ecological niche, fundamental and realized niche; niche width and overlap; concept of meta population, demes and dispersal.

8 lectures

**Unit 3: Environmental degradation and management:** Global environmental issues (deforestation, greenhouse effect, depletion of ozone layer); Concept of EIA; Use of GPS, GIS and remote sensing in environmental management.

9 lectures

**Unit 4: Sustainable Development Goals**: India's National Action Plan on Climate Change; concept of ecotoxicology; International agreements and programmes: Earth Summit, UNFCCC, Montreal and Kyoto protocols.

8 lectures

**Unit 5: Environment legislation in India**: Wildlife Protection Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act 1980; Air (Prevention & Control of Pollution) Act, 1981; Environment Protection Act, 1986; Biological Diversity Act, 2002; Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

15 lectures

**Unit 6: Lab Course:**

1. To record the atmospheric temperature, relative humidity (RH), light intensity.
2. To study the physical and chemical characteristics of soil (C, N, content, base deficiency and pH of soil by rapid soil test method.

3. To determine the minimum size and number of the quadrat necessary for sampling the flora and fauna by "species - area – curve" method.
4. To determine the frequency, density and abundance of the primary producers of a grassland community by quadrat method.
5. To determine the abundance and density of soil fauna.
6. To determine the standing crop biomass of a grassland ecosystem by harvest method.
7. Basic exercise to Calculate and Assess carbon footprint/ Solid waste generation/ water consumption for a specific duration at individual/ family/ University/ locality level.
8. Estimation of TS, TSS and TDS of water samples.

Estimation of Turbidity, acididy, alkalinity of water samples

**Suggested readings:**

1. Concepts of Ecology-by E.J. Karmondy
2. Ecology -by C. Krebs
3. Ecology Work Book - by R. Misra.
4. Environmental Chemistry-by A.K.Dey
5. Fundamentas of Ecology - by E.P. Odum.
6. General Animal Ecology by Ananthakrishnan, T.K.and T.R.Viswanathan (1978).
7. Climate and Plant Distribution – Woodword
8. Soil Conservation in India – Gupta & Whytri
9. Tropical Ecosystems: Ecology & Management – Shing & Singh
10. Field Biology and Ecology- Benthon & Weaver
11. Environmental Pollution – S.M. Shafi.
12. Remote Sensing – Sahu & Solanki
13. Handbook of Agricullture – ICAR
14. Modern Concept of Ecology-by H.D. Kumar
15. Plant Ecology and Soil sciences-by Sukla and Sandal
16. Population Ecology-by M. Begon & M. Mortimer.
17. Practical methods in Plant Ecology and Environmetal Sciences- by R.K. Trivedy.

**Semester VII**

**Title of the Course : Advanced Molecular Biology**

**Course Code : Core XVII**
**Nature of the Course: CORE**
**Total Credits : 04**
**Distribution of Marks: 100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10Lab)**

**COs:**

1. Analyze the organization of genome in prokaryotes and eukaryotes
2. Evaluate molecular processes
3. Evaluate the expression of genes is regulated, the role of DNA repair and recombination

**Learning Outcomes:**

1. Discuss the structural and functional organization of genomes, mechanisms of DNA replication, transcription, translation, and gene regulation in both prokaryotic and eukaryotic systems.
2. Analyze the molecular mechanisms of DNA repair, recombination, and post-transcriptional/post-translational modifications, along with their significance in genome stability and cellular function.
3. Describe key molecular biology techniques such as DNA/RNA isolation, PCR, electrophoresis, cloning, and gene expression analysis, and apply them in research and biotechnological applications.

**Mapping of CO with Bloom Taxonomy**

| Knowlege Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | CO2, CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination,

- Viva-voce/Home assignments,

**Attainment strategy:**

- Continuous evaluation through in and end semester examinations,
- Submission of assignments

**Unit 1: Genome organization and replication (9 lectures)**

Genome organisation in prokaryotes and eukaryotes, nucleosome, histone proteins. Genome complexity: C-value paradox, Structural and regulatory genes; Enzymology of DNA replication, fidelity in replication, replication of single stranded circular DNA end replication problem, DNA synthesis by reverse transcriptase.

**Unit 2: Transcription and regulation of gene expression (11 lectures)**

DNA-dependent synthesis of RNA, Regulatory elements, promoter, operators; Transcription and regulation of *lac, trp,* and *ara* operons. Eukaryotic promoters and enhancers, Transcription factors, Activators and repressors.

RNA processing and splicing, Transcriptional and post-transcriptional gene silencing, ribozyme, RNA editing. Genetic imprinting, Regulatory RNAs: Ribo-switches, RNA interference, miRNA, siRNA

**Unit 3: Protein synthesis and degradation (9 lectures)**

Genetic code and its features, the translation machinery, the structure and functions of tRNA and ribosomes. Mechanism of protein biosynthesis and its regulation, fidelity and proofreading in protein synthesis, direction of chain growth. Co- and Post-translational modifications, co-translational transport and degradation of proteins. Protein purification, sequencing.

**Unit 4: DNA Repair and Recombination (9 lectures)**

Alteration in DNA molecule, repair of incorrect bases, DNA repair enzymes, repair of thymine dimers, recombination repair, SOS repair.

Recombination: homologous and non- homologous recombination, site specific recombination, Holliday structure.

**Unit 5: Basic methodologies of DNA and gene manipulation (7 lectures)**

Cutting, separating and visualising DNA, blotting techniques, Southern blotting, foot printing, RFLP, DNA sequencing, polymerase chain reaction.

**(15 lectures)**

**Unit 6: Lab Course**

1. Estimation of RNA in biological samples by orcinol method
2. Estimation of DNA in biological samples by diphenylamine method
3. Isolation of DNA from biological samples.
4. To perform Agarose gel electrophoresis for the detection of DNA
5. Calculate molecular mass of unknown DNA and protein fragments from gel pictures
6. Restriction digestion analysis of DNA using agarose gel electrophoresis

## Suggested Readings


- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *TheWorld of the Cell.* VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: *Molecular Biology of the Cell*, IVEdition.
- CooperG.M.andRobertE.HausmanR.E.*TheCell:AMolecularApproach***,**V Edition, ASM Press and Sinauer Associates.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Karp, G. (2010) *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons.Inc.
- Lewin B. (2008). *Gene XI*, Jones and Bartlett McLennanA.,BatesA.,Turner,P.andWhiteM.(2015).*Molecular Biology*IV Edition. GS, Taylor and Francis Group, New York and London.

**SEMESTER VII**

**Title of the Course : Advanced Cell Biology**
**Course Code. : Core XVIII**
**Nature of the Course : CORE**
**Total Credits :04**
**Distribution of Marks. :100 [60 End (Theory: 45, Practical: 15) +40IA(30+10Lab)]**

**COs:**

1. Examine the internal structure and working of various cellular organelles.
2. Evaluate the concept of cell communication and cell signaling.
3. Explain Classical genetics and Population Genetics.

**LearningOutcomes:**

- Discuss the working of cell organelles
- Analyze the functioning cell communication and cell signaling
- Describe the concept of classical genetics and population genetics.

**Mapping of CO with BloomTaxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | CO2, CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end semester examinations
- Submission of assignments

**Unit 1: Membrane structure and function 10 Lectures**

Membrane structure and function: Molecular organisation of the plasma membrane; Membrane lipids & Membrane fluidity, Membrane transport: diffusion, facilitated diffusion, active transport; Carriers & Channel Proteins: ATP-driven pumps, Aquaporins, Ion channels; electrical properties of the plasma membrane

**Unit 2: Cytoskeletons 6 Lectures**

Elements of the cytoskeleton, dynamics of microfilaments; Role of actin & microtubule cytoskeleton in cell shape, intracellular motility, motor proteins, mitosis & locomotion; Functions of intermediate filaments.

**Unit 3: Cell communication and Integration of cellular macromolecules 10 Lectures**

General principles of cell communication, cell adhesion and the role of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Regulation of hematopoiesis

Protein sorting and transport to the endoplasmic reticulum, Golgi body and lysosomes; protein glycosylation within the Golgi body and protein secretion.

**Unit 4: Cell cycle, and cell signaling : 10 Lectures**

**Cell cycle**: Phases of the cell cycle, checkpoints and regulators of cell cycle progression in eukaryotes, Cell death ( Programmed apoptosis and necroptosis), mechanisms of cell cycle regulation.
**Cell signaling**: Principles of cellular signaling mechanism: Types of signals. Cell surface Receptors (Ion channel, G-proteins and enzyme-linked), GTPase cycle and its regulation, signal transduction pathways (GPCR, Cytokine, Integrin): second messengers, signaling pathways and regulation; Calcium and NO in signal transduction.

**Unit 5: Introduction to Cancer Biology 09 Lectures**

Genetic rearrangement in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, Oncogenesis; initiation, promotion, progression, cell behavior in oncogenesis, virus-induced cancer, carcinogens, metastasis, interaction of cancer cell with normal cells,

apoptosis, therapeutic intervention of uncontrolled cell growth.

**Unit 6: Lab Course** **15 lectures**

1. Localization of neutral mucopolysaccharides in cell by periodic acid Schiff reaction.

2. Localization of general lipid by Sudan Black B method.

3. Study of cancer cells through permanent slides.

4. Localization of metachromatic substances in cells by Toluidine blue/Congo red technique.

5. Microtubules in vesicle transport in fish chromatophore.

6. Assignment on cell communication and signaling.

**SUGGESTED READINGS**


- **Molecular Biology of the Cell** – Alberts B., Johnson A., Lewis J., Raff M., Roberts K., and Walter P. (Garland Science, 6th Edition, 2014)
- **Cell Biology** – Pollard T.D., Earnshaw W.C., Lippincott-Schwartz J., and Johnson G.T. (Elsevier, 3rd Edition, 2016)
- **The Cell: A Molecular Approach** – Cooper G.M. and Hausman R.E. (Sinauer Associates, 7th Edition, 2018)
- **Lodish Molecular Cell Biology** – Lodish H., Berk A., Kaiser C.A., Krieger M., Bretscher A., Ploegh H., Amon A., and Martin K.C. (W.H. Freeman, 9th Edition, 2021)
- **Karp's Cell Biology** – Iwasa J., Marshall W., and Karp G. (Wiley, 9th Edition, 2023)

## SEMESTER VII

**Title of the Course : Research Methodology and Research Ethics**
**Course Code : RM**
**Nature of the Course : Core**
**Total Credits : 04**
**Distribution of Marks : 40 (IA) + 60 (END) = 100**

**COs:**

1) Apply research concepts for survey and data collection
2) Evaluate collected data through statistical tools
3) Discuss ethics of research and publication

**Learning Outcomes:**

1) Discuss research concepts for data collection
2) Analyze data through statistical tools
3) Understand research ethics and publication guidelines

**Mapping of CO with Bloom's taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO3 | CO1 | | CO2 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| AVERAGE | 3 | 3 | 3 | 3 | 3 | 3 | 3 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**MODES OF IN-SEMESTER ASSESSMENT:**

- One Theory exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination

**Unit 1: Fundamentals of Research Methodology 15 lectures**

Introduction to Research in Life Sciences, Types of Research: Basic and Applied, Formulating Research Questions and Hypotheses, Literature Review and Meta-Analysis

**Unit 2: Experimental Design, Data Collection and Analysis 15 lectures**

Principles of Experimental Design, Sampling Techniques and Sample Size Determination, Data Collection Methods: Surveys, Observations, and Experiments, Use of Statistical Tools and Software. Data Analysis and Interpretation

**Unit 3: Research Ethics 15 lectures**

Ethical Principles in Life Sciences Research, Responsible Conduct of Research (RCR), Avoiding Plagiarism and Misconduct, Guidelines for Animal and Human Research.

**Unit 4: Publication Ethics and Communication 15 lectures**

Writing Research Papers and Reports, Peer Review Process and Responding to Reviewers. Open Access Publishing and Predatory Journals. Presenting Research: Posters, Oral Presentations, and Conferences

**Suggested Readings:**


- CSIR Guidelines for Ethics in Research and in Governance - CSIR (2019)
- Ethics in Science Education, Research and Governance- Kambadur Muralidhar, Amit Ghosh, Ashok Kumar Singhvi - INSA (2019)
- Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W Creswell and J. David Creswell
- Research Methodology: A Step-by-Step Guide for Beginners by Ranjit Kumar
- Research Methology : methods and techniques by CR Kothari & Gaurav Garg
- Introducing Research Methodology: A Beginner′s Guide to Doing a Research Project by Uwe Flick

## SEMESTER VII

**Title of the Course :Advanced Analytical Techniques**
**Course Code :Minor-7**
**Nature of the Course : MINOR**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40IA(30+10Lab)**

**COs:**

1. Analyze and compare different nucleic acid extraction and sequencing techniques
2. Investigate biological samples through the application of different bioimaging and biophysical tools and techniques
3. Examine genomic DNA and products of ts amplification

**Learning Outcomes:**

- Demonstrate various analytical techniques used in biological sciences
- Evaluate biological samples with the use of various analytical tools and techniques
- Describe DNA structure and amplification

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | CO2 | |
| Procedural | | | | | CO3 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end semester theory examination
- Submission of assignment on relevant topic
- Practical demonstration of the major analytical equipments
- Submission of practical record book
- Hands on activities in operating equipment
- Viva-voce examination

**11 lectures**

**Unit 1: Nucleic acid extraction and visualization:** Extraction process**,** Agarose Gel Electrophoresis. Polymerase Chain Reaction (PCR)- principle and types, Plasmid isolation and purification.

**12 lectures**

**Unit 2: Bioimaging techniques-** electron microscopy principle, uses and sample preparation, fluorescent microscopy principle and uses, Flow cytometry – principle and application, Fluorescence in-situ hybridization, Genomic in-situ hybridization and Fluorescence-Activated Cell Sorting (FACS)

**13 lectures**

**Unit 3: Biophysical Methods:** High Performance Liquid Chromatography (HPLC), Fourier Transform Infrared Spectroscopy (FTIR), Nuclear Magnetic Resonance Spectroscopy (NMR), X-ray diffraction (XRD), Gas chromatography (GC), Mass Spectroscopy (MS)

**9 lectures**

**Unit 4: DNA sequencing techniques-** Pyrosequencing, Nextgen sequencing, Genome editing – CRISPR

**Unit 5: Lab Course:** **15 lectures**

1. Nucleic acid extraction from biological samples
2. Visualization of DNA by Agarose gel electrophoresis
3. Nucleic acid amplification by PCR
4. Demonstration of HPLC, FTIR, NMR, XRD, etc.

**Suggested Readings:**


- Principles of Biochemistry and Molecular Biology by K. Wilson and J. Walker, Cambridge University Press.
- Principles of Instrumental analysis by D. A. Skoog and J. J. Leary, Saunders College Publishing, Philadelphia.

- Textbook of Structural biology by Anders Lilgas, Lars Lilgas, JuiPiskur et al, World Scientific Publisher

## SEMESTER VIII

**Title of the Course :Intermediary Metabolism**
**Course Code : Core XIX**
**Nature of the Course : CORE**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40IA(30+10Lab)]**

**COs:**

1. Analyze the concept of bioenergetics and energy metabolism.
2. Evaluate the role of co-ordinated regulation of metabolism.
3. Explain the importance of metabolic pathways and regulation in the biological system.

**Learning Outcomes:**

- Discuss the mechanisms involved in energy metabolism
- Analyze lipid, nitrogen and nucleotide metabolism
- Describe the integration and regulatory strategies of metabolic pathways in the biological system.

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | CO2, CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end semester examinations
- Submission of assignments

**Unit 1: Bioenergetics and energy metabolism: 11 lectures**

Concept of energy transduction process, Biological oxidation-reduction reactions, reduction potential and free energy, Structure of ATP and its phosphoryl transfer potential, Electron transport chain, ATP Synthesis and Chemiosmosis; Phosphorylation: substrate level and oxidative phosphorylation and its regulation. Photophosphorylation and carbon fixation reactions in chloroplast; C3, C4 and C2 plants, photorespiration.

**Unit 2: Lipid metabolism: 10 lectures**

Overview of fatty acid transport, β-oxidation in mitochondria and peroxisomes, and its energetics, oxidation of saturated, and unsaturated fatty acids (odd and even number carbon atoms), Omega oxidation. Biosynthesis of fatty acid (Palmitate), chain elongation and desaturation, biosynthesis of eicosanoids, ketone bodies, and cholesterol, and their physiological significance.

**12 lectures**

**Unit 3: Amino acids and nucleotide metabolism:** Overview of nitrogen fixation in biological system, biosynthesis of amino acids (phenylalanine, arginine, histidine, tryptophan), Cofactors of amino acid metabolism. Metabolism of purine and pyrimidine(de novo and salvage pathway), regulation of nucleotide biosynthesis, and degradation of nucleotides, inborn errors of metabolism.

**12 lectures**

**Unit 4: Integration and regulatory strategies of metabolic pathways:** Citric acid cycle as metabolic hub; amphibolic and anaplerotic reactions. Co-ordinated regulation- glycolysis and gluconeogenesis, glycogen synthesis and breakdown; Co-ordinated regulation of fatty acid oxidation and biosynthesis; hormonal regulation of fatty acid and carbohydrate metabolism, allosteric and covalent modifications. Interlinking between carbohydrate, lipid and protein metabolism.

**Unit 5: Lab Course: 15 lectures**

1. Fractionation of tissue by differential centrifugation.
2. Estimation of protein, carbohydrate, free phosphate in biological samples.
3. Estimation of ascorbic acid (Colourimetric).
4. Estimation of cholesterol.
5. Estimation of urea in biological samples.
6. Separation of protein and determination of molecular mass by SDS-PAGE.

**Suggested Readings:**


- Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
- Principles of Biochemistry (2013) 4th ed., Voet, Donald,Voet, Judith &Pratt, charlotte.

Wiley & Sons, Inc. (New Jersey), ISBN:978-1-11809244-6.
- Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New Jersey), ISBN:978-0-470-28173-4.
- Berg, J.M., Tymoczko, J.L. and Stryer L., (2012) W.H. Biochemistry (7th ed.), Freeman and Company (New York), ISBN:10: 1-4292-2936-5, ISBN:13:978-1-4292-2936-4.

## SEMESTER VIII

**Title of the Course : Advanced Genetics & Plant Breeding**
**Nature of course : CORE**
**Code : XX**
**Total Credits : 04**
**Distribution of Marks: 100 [60 End (Theory: 45, Practical: 15) + 40IA(30+10Lab)]**

Course outcomes

CO1: Evaluate classical and molecular genetic mechanisms, including Mendelian deviations, extranuclear inheritance, molecular mutational pathways, mutagens, and cellular DNA repair systems.

CO2 : Apply principles of population and evolutionary genetics to calculate allele and genotype frequencies using the Hardy–Weinberg equilibrium, while evaluating the evolutionary impacts of selection, drift, and gene flow.

CO3: Assess human genetic principles and biomedical applications, analyzing genetic disorders, karyotypes, genetic counseling, and the frameworks of eugenics, euphenics, euthenics, and pharmacogenomics.

CO4: Utilize advanced experimental designs and mixed statistical models—such as Best Linear Unbiased Prediction (BLUP)—to characterize plant genetic resources, evaluate diversity, and conserve germplasm.

Mapping of CO with Bloom Taxonomy

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | CO1 | CO4 |
| Procedural | | | CO2 | CO3 | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| AVERA | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GE | | | | | | | | |

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

## Attainment strategies of Cos:

1. **Continuous evaluation through in and end-semester theory and practical examinations**
    2. Laboratory practices
    3. Practical record book/field book
    4. Seminar/group discussion

**Unit-I: Deviations of Mendelism** **08 classes**

Deviations of Mendelism, Sex Determination, Sex related characters, Extranuclear inheritance, Significance of Crossing over. Mutation at molecular level, Spontaneous and induced mutation, Mutagens & their action, DNA damage & repair.

**Unit-II: Population Genetics, Human Genetics, and Genomics** **15 classes**

Concept of population genetics and the Hardy-Weinberg law. Human genetics: genetic disorders and syndromes; euthenics, eugenics, and euphenics. Genetic counselling. Basic idea on the human genome project (HGP), genomic library, and gene targeting. Evolutionary genetics: Genetic drift, gene flow, and natural selection.

**Unit-III: Plant breeding** **07 Classes**

Introduction to plant breeding: genetic resources, genetic variation, types and conservation

Experimental designs in plant breeding: BLUP, mixed design models

**Unit- IV : Genetic tools in plant breeding** **15 classes**

Genetic tools in plant breeding; QTL mapping, MAS; types and applications. Genomic breeding, Genome-Wide Association Studies (GWAS) and genomic prediction, pharmacogenomics. Metagenomics, gene editing, CRISPR-Cas9, application of gene editing in agriculture and medicine

**Lab activities: 15 classes**

- . Calculation of allelic and genotypic frequencies based on Hardy-Weinberg equilibrium using population datasets.
- Karyotype analysis: Identification of normal human chromosomes and common numerical/structural aberrations from prepared photographs.
- Studies on physical and chemical mutagens
- Photographs/animation of CRISPR-Cas9
- Study on QTL mapping

## SEMESTER VIII

**Title of the Course : Bioethics and IPR**

**Course Code : Minor-8**
**Nature of the Course : MINOR**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40IA(30+10Lab)]**

CO:

1. Analyze biosafety and ethical perspectives in research.
2. Discuss various types of IPRs, Agreements and treaties
3. Discuss inferential tools of Biostatistics
4. Apply the knowledge for patent application and biostatistical analysis.

Learning Outcome:

1. Understand the concept of biosafety and bioethics.
2. Analyze the IPR types.
3. Analyze the agreement and treaties.
4. Apply and evaluate the patent filling process.

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO3 | CO4 | CO1 | CO2 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO | PO | PO | PO | PO | PO | PO | AVERAGE |
|---|---|---|---|---|---|---|---|---|

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| AVERAGE | 2 | 2 | 2 | 2 | 2 | 2 | 2 | |

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end semester examinations
- Submission of assignments

12 lectures

UNIT I:
Concepts in Bioethics: Historical perspective of Bioethics, Conflicting issue: GMO, GMP, Cloning, environmental hazards. Biosafety in Laboratories. Principles and guidelines for research in human and animals: Nuremberg code, ICMR guidelines for research using animal 1980 and amendments. Cruelty to Animal Act 1960

UNIT 2: 12 lectures
Concept of Intellectual Property Rights (IPR) and its significance. Types of IPR- Patents, Patent Cooperation Treaty, copyright, trademarks, industrial design, trade secrets and geographical indication.

UNIT 3: 12 lectures
Agreement and treaties: GATT & TRIPs Agreement, Madrid Agreement, Hague Agreement, WIPO Treaties. Indian Patent Act 1970 and recent amendments. Patent filing and granting procedure.

UNIT4: 9 lectures
Biopiracy and bioprospecting: Concept of biopiracy, Nagaya Protocol, Biodiversity Act 2002 Indigenous Knowledge System, concept of bioprospecting. Scope of bioprospecting with examples.

UNIT 5: 15 lectures
Lab course
Proxy filing for a patent application
Survey of indigenous knowledge with respect to NE India and report submission.

**Suggested Readings:**


- M K Sateesh . Bioethics and Biosafety. Kindle Edition
- Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013
- Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000
- Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition)
- Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006

## SEMESTER VIII

**Title of the Course :Climate Change and Biological Adaptation**
**Course Code : DSE 1**
**Nature of the Course : DSE**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40IA(30+10Lab)]**

**COs:**

1) Analyze Climate change and biological responses to it.
2) Evaluate biodiversity and impact of human interference
3) Evaluate conservation strategies, GIS and remote sensing tools

Learning Outcomes:

1) Discuss biological changes in response to climate change
2) Apply the GIS and remote sensing tools for evaluation of biodiversity
3) Analyze conservation measures

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | CO1 | CO2,CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end semester examinations
- Submission of assignments

**Unit-I: Fundamentals of Climate Change 11 lectures**

Introduction to climate systems and climate change, Greenhouse gases and Global warming, Climate change indicators and feedback loops, Historical climate patterns and predictions.

**Unit-II: Biological Responses to Climate Change 11 lectures**

Physiological adaptations in plants. Behavioural and physiological adaptations in animals. Evolutionary adaptations and natural selection, Phenological shifts (e.g., migration, flowering times)

**Unit-III: Ecosystem level impacts 11 lectures**

Changes in biodiversity and species distribution, Ecosystem resilience and vulnerability, Impact on aquatic and terrestrial ecosystems, Role of keystone species

**Unit-IV: Human Influence and Conservation, GIS & remote sensing 11 lectures**

Anthropogenic drivers of climate change, Conservation strategies for threatened species, Restoration ecology and habitat management, Policy and international agreements (e.g., Paris Agreement)

Introduction to Remote Sensing and GIS techniques: Satellites, Sensors, Platforms and Resolutions, Infrared and Microwave Remote Sensing: Principles and Applications, Interpreting Optical Remote Sensing Images, Projection of climate change scenarios and Tools for mapping and monitoring

GIS applications based on model outputs and GIS databases, Remote sensing technologies to monitor climate change processes (vegetation biomass, monitoring flooding, soil moisture and depth, surface micro topography etc.)

**Unit V: Lab Course: 15 lectures**

1. Effect of temperature in plant growth and germination
2. Effect of pH on aquatic ecosystem (plankton diversity and DO)
3. Study of insect diversity in different habitats
4. Study on the process of remote sensing & GIS (demonstration)
5. Study of plant adaptations in xeric and aquatic environment
6. Study of ant behavior in different temperature gradients
7. Study of life cycle of any insect under different temperature conditions

**Suggested Reading:**

1. "Climate Change Biology" by Lee Hannah

2. "The Sixth Extinction: An Unnatural History" by Elizabeth Kolbert

3. Research papers on climate change and adaptation from journals like Nature and Science.

## SEMESTER VIII

**Title of the Course : Computational Biology**
**Course Code : DSE-2**
**Nature of the Course : DSE**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40IA(30+10Lab)]**

**COs:**

1) Analyze biological databases and interpret data.
2) Evaluate protein structure and conformations
3) Analyze ligand properties
3) Evaluate protein ligand interactions

Learning Outcomes:

1) Apply the concepts of computational biology to interpret data
2) Analyze protein structure, predict structure and conformational changes
3) Describe pharmacokinetic properties of ligands
4) Analyze protein ligand interactions through docking and simulation

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | | | |
| Procedural | | | | CO1, CO3 | CO2,CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end semester examinations
- Submission of assignments

8 classes

**UNIT 1: Scope of Computational Biology and Bioinformatics.** Major biological databases and information retrieval. Conversion of file types. BLAST analysis and Primer designing. Computational Phylogenetic analysis.

8 classes

**UNIT 2: Protein structure, protein folding and Ramachandran plot analysis.** Protein structure prediction tools, homology modeling and structure validation. Molecule visualization tools.

12 classes

**UNIT 3: Computer Aided Drug Designing-** Pharmacokinetics and Pharmacodynamics, ADMET properties, Lipinski rule of 5, Molecular Docking analysis and QSAR. **C**oncept of Molecular dynamics simulation – protein preparation, ligand preparation, forcefields, energy minimization. Steps of MD simulation. RMSD, RMSF

7 classes

**UNIT4:**. **Genomics and Systems Biology-** Sequencing technologies, Sanger vs NGS, Genome assembly basics, gene finding, biological networks, KEGG pathways, STRING database.

**UNIT 5: LAB ACTIVITIES** 15 classes

1) Retrieval of sequences of nucleotides and amino acids, structure of proteins from databases
2) BLAST analysis
3) Phylogenetic tree construction
4) Primer designing
5) Protein structure prediction and validation
6) ADMET screening and Lipinski analysis
7) Active site detection
8) Protein ligand docking analysis
9) Gene Regulatory Network analyses
10) Gene finding

**Suggested Reading:**


- Bioinformatics: Principles and Applications by Z. Ghosh and B. Mallick, Oxford University Press.
- Bioinformatics: Sequence and Genome Analysis by D.W. Mount, Cold Spring Harbor Laboratory
- Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins by A.D. Baxevanis and B.F.F. Ouellette, Wiley-interscience.
- Understanding Bioinformatics by Marketa Zvelebil and Jeremy Baum, Garland Science.

**SEMESTER VIII**

| | | |
|---|---|---|
| **Title of the Course** | **:** | **Dissertation** |
| **Course Code** | **:** | **Dissertation** |
| **Nature of the Course** | **:** | |
| **Total Credits** | **:** | **08** |

# Course Structure

**Note:**

## SEMESTER IX

**Title of the Course :Reproductive Physiology**
**Course Code : DSC-I**
**Nature of the Course : DSC**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

**COs:**

1. Explain the endocrine and physiological mechanisms regulating reproductive processes
2. Analyze the role of hormones, and environmental cues in controlling gonadal activity, breeding cycles, and reproductive aging.
3. Evaluate assisted reproductive technologies, fertility regulation methods, and prenatal diagnostic approaches in the context of reproductive health and management.
4. Demonstrate practical skills in assessing reproductive parameters and interpreting experimental observations related to gamete physiology and reproductive cycles.

**Learning Outcomes:**

1. Describe the structure, function, and endocrine regulation of reproductive organs and hormonal pathways involved in male and female reproduction.
2. Interpret the physiological events associated with implantation, pregnancy, lactation, reproductive aging, and seasonal breeding in animals.
3. Assess the principles and applications of fertility control, cryopreservation, assisted reproductive technologies, and prenatal diagnosis.
4. Perform and analyze laboratory techniques related to reproductive physiology, including estrous cycle determination, sperm motility assessment, and identification of maturity stages in fish.

**Mapping of CO with Bloom's Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2 | CO3 | |
| Procedural | | | | | CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**Unit 1:** **12 lectures**

Gonadal steroids: Chemistry, Sexual dimorphism of brain and role of gonadal steroid. Onset of puberty-pubertal activation of hypothalamic-pituitary-testicular axis, Reproductive cycles in mammals- Estrus cycle, Major events in the menstrual cycle, Endocrine regulation of menstrual cycle, Menstrual disorders – Precocious, delayed or absent puberty; Amenorrhea, Reproductive aging

**Unit 2:** **12 lectures**

Physiology of implantation: Placental hormones, Hormonal profile during pre and post implantation period, hormonal control of pregnancy, parturition and lactation. Corpus luteum in pregnancy-structure and function, luteolysis. Growth factor in implantation, Reproductive health

**Unit 3:** **9 lectures**

Fertility and its control: Methods of fertility regulation in male and female; contraceptive devices - oral, IUD; collection and cryopreservation of gametes and embryos; superovulation, in vitro fertilization (IVF) and embryo transfer, Birth defects and prenatal diagnosis

**Unit 4:** **12 lectures**

Hormones and reproduction: Seasonal and continuous breeder, regulation of gonadal activity, hypothalomo-hypophysical gonadal axis; Pineal gland – Melatonin and circadian rhythmicity, Role of Pineal gland in regulation of breeding cycles in animals. Eicosanoids, structure of prostaglandin (PGF2a & PGE) and their role in reproduction, Epigenetics of reproduction.

**Unit 5:** **12 lectures**

**Lab courses:**

1. Determination of maturity stage in fish.
2. Castration and Ovariectomy in albino rat through video learning
3. Study of Estrous cycle in rats
4. Study of sperm mobility and survivality.
5. Cryopreservation techniques for gametes and embryos (demonstration/video-based learning).
6. Case studies on menstrual disorders, infertility, and assisted reproductive technologies

(ART).

7. Histological examination of ovary and testes of freshwater fishes.

Suggested readings

1. Review of Medical Physiology, Ganong . Lang.
2. Textbook of Medical Physiology, Guyton . W.B. Saunders.
3. Samson Wrights' Applied Physiology, Keele et al .Oxford Press.
4. Harpers' Biochemistry, Murray et al Appleton & Lange
5. Best & Taylor's Physiological Basis of Medical Practice, West .William & Wilkins.
6. Physiology of Reproduction Vol I & II. Knobil & Neil (ed) .Acadimic press

**SEMESTER IX**

**Title of the Course :Molecular Endocrinology**
**Course Code : DSC-II**
**Nature of the Course : DSC**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

**COs:**

1. To explain the concept of neuroendocrinology
2. To discuss biosynthetic pathways of hormones
3. To explain signaling pathways of hormone action
4. To integrate hormonal roles in explaining homeostasis

**Learning Outcomes:**

1. To understand the concept of neuroendocrinology
2. To analyse hormone biosynthesis and signaling pathways
3. To apply knowledge of endocrinology in neurodegenerative diseases

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1, CO3 | | CO2, CO4 | | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**Unit 1** **6 lectures**

**Neurotransmitters and Signaling:** Information flow in the brain: neuronal connections and synapses. Chemical nature and classification of neurotransmitters-amine, amino acid, and peptide neurotransmitters. Mechanism of neurotransmitter synthesis, storage, release, and signal transduction. Receptor types and signaling pathways involved in neuroendocrine communication.

**Unit 2** **11 lectures**

Neuroendocrine System in Vertebrates: Organisation of the neuroendocrine system in vertebrates: neurosecretory cells; Anatomy of the endocrine hypothalamus. Chemistry and physiology of hypothalamic releasing and inhibiting hormones. Role of the Hypothalamic–Pituitary–Adrenal axis in stress response. Basic concepts of neuroendocrine–immune interactions, including key mediators and their role in stress and immune function. Clinical aspects of neuroendocrine and neuropsychiatric disorders, including Parkinson's disease, Alzheimer's disease, and depression.

**Unit 3:** **6 lectures**

Hormone biosynthesis: Chemistry and biosynthesis of steroid, amino acid-derived, peptide , farnesoid hormones. Insect hormones: chemistry, synthesis, and mechanism of action .

**Unit 4:** **12 lectures**

Hormone action, Hormone receptors-physico-chemical properties; membrane receptors: structure, signal transduction and desensitisation, Activation and inhibition of adenyl cyclase mechanism of tyrosine kinase receptor action, Insulin receptor signalling and EGF receptor signaling. Structural domains, receptor binding proteins, SH2/SH3 domains. Steroid hormone receptor structure, receptor protein complexes involved in gene transcription, Positive and negative regulation of gene expression by steroid receptor/transcription factor interactions.

**Unit 5:** **10 lectures**

Neuroendocrine system in insects: hormones of insect neurosecretory cells, their sources, chemistry and function. Hormonal regulation of insect growth and metamorphosis. Hormonal regulation of glucose, calcium, electrolyte and water homeostasis in vertebrates. Hormone agonist/antagonists and therapeutic significance.

**Unit 6:** **15 lectures**

**Lab Course**

1. Dissection of neuroendocrine system of cockroach, Dysdercus

2. Study of Histological preparations of endocrine gland of vertebrates (Fish/Mammal/Birds)

3. Standardization of solvent combination for invertebrate/vertebrate hormone detection using TLC/HPLC

4. Effect of hormones/hormone analogues on biochemical parameters in invertebrate (insects).

5. Effect of hormones/hormone analogues on biochemical parameters in vertebrate.

**Suggested Reading**

An introduction to Neuroendocrinoloyg: Michael Wilkinson and Richard E Brown (2015), Cambridge University Press, UK

2. Introduction to Behavioral Neuroendocrinology (5th edition), Randy J. Nelson and Lance J. kriegsfeld (2016) Oxford University press.

3. Progress in Molecular Biology and translational science, Vol.143 gonadotropins from benside to bedside, edited by T. Rajendra Kumar, 2016 ISBN:978-0-12-801058-7, Elsevier Inc. 2018

4. Signal transduction 3red edition, Author: Ijsbrand Kramer, ISBN: 9780123948038 Academic press, 2015

**SEMESTER IX**

**Title of the Course :Developmental Biology**
**Course Code : DSC-II**
**Nature of the Course : DSC**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

**COs:**

1. Explain the cellular, molecular, and genetic mechanisms underlying embryonic development, differentiation, and organogenesis in animals.
2. Analyze the role of signaling pathways, gene regulation, and environmental factors in normal development and developmental abnormalities.
3. Evaluate contemporary concepts and experimental approaches in developmental biology, including stem cell biology, regeneration, and reproductive technologies.
4. Apply practical and analytical skills to interpret developmental processes and experimental data relevant to developmental and evolutionary biology.

**Learning Outcomes:**

1. Describe the major stages of animal development, including gametogenesis, fertilization, cleavage, gastrulation, and organogenesis.
2. Interpret the molecular and genetic mechanisms that regulate cell fate determination, pattern formation, and tissue differentiation.
3. Assess developmental anomalies and the role of stem cells, regeneration, and environmental influences in developmental processes.
4. Demonstrate the ability to analyze developmental stages and experimental observations using microscopic, histological, and molecular approaches.

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | CO4 | CO2 | CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**Unit I: Principles of Development and Gametogenesis 10 lectures**

Experimental embryology: contributions of Roux, Driesch, Spemann; Germ cell development; Molecular basis of gametogenesis and fertilization; Blastulation and blastocyst formation; Gastrulation: morphogenetic movements; Organizer concept and primary embryonic induction

**Unit II: Molecular Basis of Development 12 lectures**

Cell-cell communication during development; Concepts of determination: mechanism of cellular determination; Gene regulation during development: Maternal-effect genes, Homeotic & Hox genes; gene clusters; Major developmental signaling pathways: Wnt signalling, Hedgehog signaling

**Unit III: Organogenesis and Differentiation 10 lectures**

Principles of cell differentiation; Tissue interactions during development, Development of Limb and Eye, Teratogenesis: Teratogenic agents and their effects on embryonic development; Epigenetic regulation in development

**UNIT IV: 13 lectures**

Metamorphosis and its hormonal regulation in amphibians and insects; Regeneration: brief concept of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: concepts and theories

**UNIT V: Lab Course 15 lectures**

1. Study of gametogenesis and fertilization stages through microscopy image.
2. Study of cleavage patterns in amphibian, fish, bird and mammalian embryos.
3. Observation of blastula and gastrulation in amphibian, fish and bird through microscopy image.
4. Whole-mount chick embryo preparations- (24, 36, 48, 72 and 96 hours).
5. Histological examination of developing tissues (heart, kidney, liver and brain of fish/frog).
6. Study of life cycle and developmental stages of fish.
7. Study of developmental stages of chick embryo through window's method.
8. Study of teratogenic effects using image-based datasets.

**Suggested Reading**

1. An introduction to embryology – B.I. Balinsky, W.B.Saunders Co. Philadelphia.
2. An introduction to embryology – William A. Blanc, American academy of Pediatrics.
3. Principles of development and differentiation – C.H. Waddington. Collier Macmillan Ltd.
4. Chemistry and Physiology of fertilization – Aebert Monray. Holt, Rinehart and Wintson publisher Newyork.
5. Analysis of development – Willer, Weiss, Bamburger.
6. Regeneration –Elizabeth D. Hay. Holt, Rinehart and Wintson publisher Newyork.
7. Molecular and Cellular aspect of development – Engene Bell. Harper and Row, Newyork.
8. Oogenesis – C.P.Raven. Pergamon press.
9. Laboratory manual of embryology – Robert Rugh. Burgess publishing Co.
10. Experimental embryology Robert Rugh. Burgess publishing Co.
11. Selected topics in development – Barth. Addison-Wesley Pub. Co.
12. Foundation of embryology – B.M.Patten & B.M.Carlson. McGraw-Hill Book Company.
13. Practical studies of animal development – E.S.Billet & A.E. Wild Chapman & Hall,

## SEMESTER IX

**DSE 1:**

**Biochemistry-I: Protein Chemistry and Enzymology**

**OR**

**Entomology-I: Insect Physiology and Toxicology**

**OR**

**Fish and Fisheries -I: Fish and Fisheries I: Integrated Fish Biology**

**SEMESTER IX**

**Title of the Course :Biochemistry-I: Protein Chemistry and Enzymology**
**Course Code : DSE-I**
**Nature of the Course : DSE**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

**COs:**

1. Explain the relationship between protein structure and biological function, including protein biosynthesis, folding, and post-translational modifications.
2. Analyze the thermodynamics and mechanisms of protein folding and evaluate the role of molecular chaperones in maintaining protein conformation and function.
3. Apply principles of enzyme kinetics and catalytic mechanisms to determine kinetic parameters and interpret enzyme-catalyzed reactions.
4. Assess the regulation of enzyme activity and metabolism through allosteric mechanisms, enzyme inhibition, cooperativity, and multi-enzyme systems.
5. Demonstrate practical skills in protein isolation, purification, characterization, and enzyme assays using modern biochemical techniques.

**Learning Outcomes:**

1. Describe the structural organization of proteins, methods of amino acid sequence determination, and the molecular basis of protein stability and biological activity.
2. Explain the mechanisms of protein biosynthesis, folding pathways, thermodynamics of folding, and the role of molecular chaperones in assisted protein folding.
3. Perform quantitative and qualitative analyses of proteins and amino acids using biochemical techniques such as Bradford assay, chromatography, electrophoresis, and enzyme assays.
4. Interpret enzyme kinetic data and determine kinetic parameters
5. Evaluate mechanisms of enzyme regulation, allosteric interactions, cooperativity, enzyme inhibition, and the role of enzymes in metabolic regulation and signal transduction.
6. Explain the mechanisms of action of protein and steroid hormones and analyze the roles of second messengers.

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | CO3 | CO2 | CO4 | |
| Procedural | | | | | CO5 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1.42 |
| CO2 | 2 | 2 | 1 | 2 | 3 | 1 | 1 | 1.71 |
| CO3 | 2 | 2 | 1 | 2 | 3 | 1 | 1 | 1.71 |
| CO4 | 2 | 3 | 1 | 2 | 3 | 1 | 1 | 2.28 |
| CO5 | 2 | 2 | 1 | 2 | 3 | 2 | 2 | 1.9 |
| AVERAGE | 2.20 | 2.20 | 1.0 | 1.8 | 2.6 | 1.2 | 1.2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**UNIT 1:** 7 classes

Structure of protein in relation to their biological functions-fibrous and globular. Concept of protein conformation, motif, domain. Maintainance of secondary and tertiary structure and role of amino acids in protein conformation.

Isolation and purification of proteins. Mechanism and thermodynamics of Protein Folding, Anfinsen's classical experiment; Types of protein folding and intermediates; Models of protein folding; Assisted protein folding: Role of molecular chaperones.

**UNIT 2:** 10 classes

Mechanism and types of of enzyme-catalyzed reaction, ping-pong reaction, multi-substrate enzyme catalysed rreaction, mechanism of enzyme action. Kinetics of enzyme catalysed reaction, Michaelis Menten equation and determination of kinetics parameters using Lineweaver-Burk, Hill plot, Significance of enzyme kinetics parameters (Km, Vmax, Kcat, Kcat/Km).

**UNIT 3:** 12 classes

Regulation of enzyme activity, restriction enzymes, Enzyme as biosensor, Isoenzyme, Ribozyme. Regulatory enzymes. Allosteric enzymes, symmetrical and sequential model, Hill's coefficients, cooperativity, positive and negative, hemoglobin as a model for

cooperativity. Enzyme induction and inhibition (competitive, non-competitive and uncompetitive).

**UNIT 4:** 6 classes

Mechanism of protein and steroid hormone action, role of cAMP and G-protein in metabolism, prostagandins

**UNIT 6: LAB ACTIVITIES** 15 classes

**Lab Course:**

1. Estimation of protein by Bradford method.
2. Estimation of amino acids
3. Determination of pK and $I^{PH}$
4. Separation of amino acids by Thin Layer Chromatography
5. Assay of activity of an enzyme in biological samples
6. Electrophoretic separation of protein using PAGE
7. Purification of proteins using column chromatography.

**Suggested Readings:**

1. Introduction to Protein Structure: Second Edition by Carl Branden and John Tooze
2. Proteins: Structures and Molecular Properties by Thomas E. Creighton
3. Physical Biochemistry by K.E.van Holde, C. Johnson, P. S. Ho
4. Structure in Protein Chemistry by Jack Kyte
5. Principles of Biochemistry, 6th Edition by Albert L Lehninger; David L Nelson; Michael M Cox
6. Introduction to Proteins: Structure, Function, and Motion, 2nd Edition (2018) by Amit Kessel & Nir Ben-Tal
7. Biochemistry, 9th Edition (2019) by Lubert Stryer; Jeremy Berg; John Tymoczko; Gregory Gatto

## SEMESTER IX

**Title of the Course:** **Entomology-I: Insect Physiology and Toxicology**
**Course Code** **: DSE I**
**Nature of the Course** **: DSE**
**Total Credits** **:04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40IA(30+10Lab)]**

**COs:**

1) Explain the basic bioprocesses of the insect body
2) Analyze insect response to pathogens
3) Explain insecticide groups, their mode of action
3) Analyze and evaluate the impact of toxic action and adverse effects

Learning Outcomes:

1) Understand the basic physiological processes of insect
2) Analyze immune system of insect
3) Describe the insecticides of different origin and evaluate their toxicity
4) Evaluate adverse impact of insecticides

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | | | | |
| Procedural | | | CO1 | CO2, CO3 | CO2, CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

Unit 1: 9 Lectures

Overview of insect origin, evolution and morphology. Structure of insect Integument, chitin biosynthesis; Physiology of moulting, sclerotisation; Insect blood: Cell types and structure, plasma composition, insect immunity: cellular and humoral immunity; signalling in immune response to pathogenesis.

Unit 2: 06 Lectures

Insect Senses: Insect nervous system, neuromuscular junction, nerve impulse transmission, graded response, Mechanoreceptor, Chemoreceptor, Auditory organ (Chordotonal organ, Johnston's organ and tympanic membrane).

Unit3: 10 Lectures

Digestive and excretory system: Structure and modifications. Salivary and other digestive secretions, physiology of digestion and excretion. Hormonal control of osmoregulation

Unit4: 10 Lectures

Respiratory and reproductive system: Tracheal system and gaseous exchanges, aquatic respiration; Male and female reproductive systems, hormonal control of reproduction, special types of reproduction. Diapause and hormonal control. Vision: structure and physiology.

Unit5: 10 Lectures

Definition of pesticides, History of pesticide use, mode of action of insecticides, Group characteristics of insecticides, structure and function of organochlorine, organophosphorus, carbamate, pyrethroid, other plant origin as well as bio-insecticides, neonicotinoids, fumigants, and IGRs. Pheromones: production and their use in pest surveillance and management. carcinogenic, mutagenic and teratogenic effects, and evaluation of toxicity. Dose-response relationship: Insecticide resistance and health hazards.Phase I and II of metabolism

Unit6:Laboratory Works Lectures 15

1. Dissection of alimentary canal of honey bee, house fly, bacterial chamber in termite

2. Dissection of male and female reproductive system in moths/cockroach

3. Permanent mount of salivary gland of mosquito/ silk worm , hypopharyngeal gland of honey bee, insect mouth parts, legs, antennae, wings.
4. Dissection of stomatogastric nervous system in cockroach, Nervous system of a house fly
5. Study of haemocytes, hemocyte count (Total and differential)
6. Protein profile in haemolymph by polyacrylamide gel electrophoresis
7. Qualitative estimation of chitin in integument
8. Estimation of LD50 and LC50 using insects.
9. Pesticide residue analysis of contaminated soil, vegetable and water using TLC, GLC
10. Estimation of acetylcholinesterase activity to evaluate the toxicity of insecticides

Suggested Readings:

1. The Principles of Insect Physiology, Wigglesworth, Vincent B, Chapman & Hall Ltd. USA.

2. The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK

3. Physiological system in Insects, Klowden, M. J., Academic Press, USA

4. The Insects, An outline of Entomology, Gullan, P. J., and Cranston, P. S., Wiley Blackwell, UK

5. Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA

6. Toxicology and Risk Assessment: A Comprehensive Introduction, Greim H., and Snyder, R.(ed), John Wiley & Sons, UK

7. The Complete Book of pesticide management, Whitford, F., Wiley Interscience, John Wiley and Sons, UK

8.Safer Insecticides, Hodgson, E,. and Kuhar, R.J.,(ed), Marcel Dekker Inc., New York, USA

9. Pesticide Application methods, Matthews, G, A., Blackwell Science, London, UK

10. Pesticide Biochemistry and Physiology, Wilkinson, C.F., Plenum Press, New York, USA

11.Metabolic pathways of agrochemicals Part II, Robers, T.R., and Hutson, D.H. The Royal Society of Chemistry, UK

12.Fundamentals of Toxicology. Pandey, K, Shukla UP and Tridevi, SP. New

Central Book Agency Limited. 2012

**Title of the Course: Fish and Fisheries-I: Integrated Fish Biology**
**Course Code: DSE I**
**Nature of the Course: DSE**
**Total Credits: 04**
**Distribution of Marks: 100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

### Course Objectives

The course is designed to:

1. Develop a comprehensive knowledge of the origin, evolution, classification, anatomy, and functional morphology of fishes.
2. Explain the physiological mechanisms governing feeding, digestion circulation, osmoregulation, excretion, and endocrine functions in fishes.
3. Provide knowledge of fish nutrition, feed formulation, feed management, and the utilization of alternative feed resources in aquaculture.
4. Introduce modern approaches in fish genetic improvement for sustainable aquaculture development.

## Learning Outcomes

**1.** Student will be able to explain the evolutionary history, diversity, classification, anatomical organization, and functional adaptations of major fish groups.

**2.** Analyze the structure and physiological functions of major organ systems involved in feeding, digestion, respiration, circulation, nervous coordination, endocrine regulation, and osmoregulation in fishes.

**3.** Evaluate nutritional requirements of cultivable fishes and formulate balanced feeds using conventional and non-conventional feed ingredients.

**4.** Assess fish growth patterns, age, reproductive cycles, migratory behaviour, and breeding strategies for effective fishery and aquaculture management.

**5.** Critically evaluate modern genetic and biotechnological approaches such as selective breeding, hybridization, androgenesis, gynogenesis, polyploidy, transgenesis, sex control, and cryopreservation for fish stock improvement.

### Mapping of CO with Bloom Taxonomy

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | CO4 | CO2 | CO3 | |
| Procedural | | | | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**Unit 1**: Origin, Evolution and Distribution of major groups of fishes, Classification of fishes: Various trends in the classification of fishes; General anatomy of fish; Organization of skin and function; Origin and types of scales; Types of muscles, their structure and functions; Role of musculature, fins and tails in locomotion. (**7 Lectures**)

**Unit 2**: Food and feeding habits of cultivable fishes; Modifications of alimentary canal and other organs associated with food and feeding habits; Physiology of digestion, absorption and assimilation; Structure and function of gills; Accessory respiratory organs in fishes; Structure and function of swim bladder. (**8 Lectures)**

**Unit 3**: Requirement of micro and macro-nutrient of cultivable fish species; Effect of malnutrition, basic principle of fish feed formulation, preparation and mode of fish feed storage, use of unconventional feed as source of nutrients. **(5 Lectures)**

**Unit 4**: Heart and circulatory vessels; Components of fish blood; Structure of different parts of brain; Cranial nerves and their functions. Endocrine organs; Osmoregulatory and excretory organs; Physiology of excretion and osmoregulation in fresh water, brackish water and marine fishes. (**7 Lectures)**

**Unit 5**: Absolute and relative growth, growth curve, length- weight relationship, condition factor and their significance; Determination of age in fishes; Sexual dimorphism; Maturity cycle and gonadal development; Reproductive strategies and parental care; Types, causes and mode of migration in fishes. (**7 Lectures)**

**Unit 6**: Fish immune system: organs and cells, innate and adaptive immune responses; Factors affecting immune response; common fish pathogens, symptoms and their aetiology; mechanisms of fish pathogens; prophylactic measures, control and therapeutics; Immunostimulants. (**6 Lectures)**

**Unit 7**: Fish stock improvement through selective hybridization; Androgenesis and gynogenesis; polyploidy; Sex reversal and sterility; Transgenesis; Cryopreservation of gametes and embryos. (**5 Lectures)**

**Unit 8: Practical** (**15 Lectures**)

1. Identification of locally available fishes.
2. Study of museum specimens.
3. Dissection:
(a) Cranial nerves (5th, 7th, 9th& 10th) of cat fishes and carps.
(b) Urino-genital system of male and female fishes.
(c) Weberian ossicles
(d) Afferent and efferent vessels of carps and catfishes.
(e) Digestive system in locally available fishes.
4. Study of Accessory respiratory organ of the following fishes:
(i) *Clarias* (ii) *Heteropneustes* (iii) *Anabas* (iv) *Channa.* (v) *Trichogaster*
5. Studies of gastrosomatic index, RLG, gonadosomatic index, K-factor, length-weight relationship of fecundity and other body parameters.
6. Identification of scales and age determination.
7. Preparation of pelleted fish feed.
8. Estimation of fish serum/plasma/tissue protein.
9. Haematological studies (Haemoglobin, WBC and RBC count).

**Suggested Readings:**

1. G. Helfman, Bruce B. Collette, D.E. Facey, B. W. Bowen: The Diversity of Fishes: Biology, Evolution, and Ecology, John Wiley & Sons
2. R. J. Wootton: Fish Ecology, Springer
3. W. Vishwanath, W.S. Lakra and U.K. Sarkar: Fishes of North East India, NBFGR Publication, Lucknow.
4. D. Kapoor, R. Dayal and A.G. Ponniah: Fish Biodiversity of India, NBFGR Publication, Lucknow.
5. R.H. McConnell: Ecological Studies in Tropical Fish Communities, Cambridge University Press.
6. Matty: Fish Endocrinology.
7. T.K. Govindan: Fish Processing Technology, Oxford & IBH, New Delhi
8. Peter B. Moyle Joseph J. Cech Jr.: Fishes–An Introduction to Ichthyology, Prentice Hall, N.Y .
9. R.K. Rath: Freshwater Aquiculture, Scientific publishers.
10. Hoar and Randall: Fish Physiology, Academic Press, London.
11. Hwett: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News books Ltd. Surrey England.

12. Bardach, Miller and Passino: Ichthyology, John Wiley &Sons, N.Y.
13. H.L. Choudhury & S.B. Singh: Induced Breeding of Carps, ICAR New Delhi
14. W.F. Royce: Introduction to the Practice of Fishery Science, Academic Press, N.Y.
15. V.G. Jhingran:Fish and Fisheries of India, Oxford & IBH, New Delhi.
16. Kyle: The Biology of Fishes.
17. R.G.Wetzel: Limnology,W.G.Saunders, N.Y.
18. M. J. Mannig. and M. F.Tatner: Fish Immunology Academic Press. N.Y.
19. J. S. D. Munshi and G.M.Hughes: Air-breathing fishes of India. Their structure, function and life history. Oxford & IBH. Publishing Co.
20. R.R.Stickney: Principles of Warm Water Aquiculture, John Wiley & Sons, N.Y.
21. CBL Srivastava: A Text Book of Fishery Science and Indian Fisheries, Kitab Mahal , Allahabad.
22. B.A. Whitton: River ecology, University of California Press.
23. G.V. Nikolsky: The Ecology of Fishes, Academic Press, N.Y.
24. S.P.Biswas: Manual of Methods in Fish Biology, South Asian Publishers, New Delhi.
25. S.P.Biswas : Fundamentals of Ichthyology, Narendra Publication House. New Delhi.

**SEMESTER IX**

| | | |
|---|---|---|
| **Title of the Course** | **:** | **Field Study** |
| **Course Code** | **:** | **Project/ Field Based learning** |
| **Nature of the Course** | **:** | |
| **Total Credits** | **:** | **04** |

# Course Structure

**Note:**

## SEMESTER X

**Title of the Course :Immunology**
**Course Code : DSC-IV**
**Nature of the Course : DSC**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

**COs:**

**1.** To develop understanding of the organization, components and mechanisms of innate and adaptive immune responses.

**2.** To explain the molecular and cellular basis of antigen recognition, B-cell and T-cell responses, and immune regulation.

**3.** To provide knowledge of immune effector mechanisms and their applications in diagnosis, immunotherapy and vaccination.

**4.** To develop practical skills for performing basic immunological techniques and interpreting immune-related disorders and laboratory data.

### Learning Outcomes (LO)

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

**1.** Describe the structure, organization and functioning of the immune system.

**2.** Explain antigen recognition, antibody generation, immune activation and effector mechanisms.

**3.** Interpret immune responses in health and disease including autoimmunity, immunodeficiency and vaccination.

**4.** Perform basic immunological laboratory techniques and analyse immunological data and diagnostic reports.

### Mapping of CO with Bloom Taxonomy

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2, CO3 | | |
| Procedural | | | | CO4 | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**Unit 1: Overview of immune system** **8 lectures**

Types of immunity: innate and adaptive immunity; active and passive immunity, Self and non-self recognition, Primary and secondary immune responses, Clonal selection and clonal nature of immune response, Cells of the immune system, Organs of immune system- Primary and secondary lymphoid organs

**Unit 2: Generation of B- cell and T- cell responses** **15 lectures**

Antigens: characteristics, antigenicity and immunogenicity, Factors affecting immunogenicity; B-cell and T-cell epitopes, Haptens, adjuvants and superantigens; Immunoglobulins: structure, classes and functions, monoclonal and polyclonal antibodies; production and applications of monoclonal antibodies; Hybridoma technology Immunoglobulin gene arrangements, Antigen–antibody interactions, Quantification of antigen and antibodies by RID, RIA and ELISA; Major Histocompatibility Complex (MHC): structure and functions of MHC I and MHC II; Antigen processing and presentation-Exogenous pathway and Endogenous pathway; T-cell maturation, activation and differentiation; B- cell generation, activation and differentiation.

**Unit 3: Immune Effector Mechanisms** **11 lectures**

Cytokines- Properties and functions, cytokine receptors, cytokine related disease, therapeutic uses of cytokines. Complement system: components and activation pathways-Classical pathway, Alternative pathway, Lectin pathway; Biological significance of complement activation; Cell mediated effector response; Inflammation; Hypersensitive reaction.

**Unit 4: Immunity in Health and Disease** **11 lectures**

Immune response to infectious disease, Immunological tolerance, Autoimmunity and autoimmune diseases- organ specific and systemic, AIDS and other immunodeficiencies, Principles of vaccination, Types of vaccines, Recent approaches in vaccine development, Immunological basis of graft rejection; Cancer and immune system

**Unit 5: Lab Course** **15 lectures**

1. Preparation and identification of immune cells from peripheral blood smear
2. Determination of blood groups by ABO and Rh typing.
3. Study of antigen–antibody interaction
4. Quantification of antigen/antibody using ELISA.
5. Study of vaccination schedules and immunization records (case study).
6. Interpretation of immunological diagnostic reports.
7. Demonstration of Hybridoma technology and applications (chart/video/model based).

**Suggested Reading:**

1. General Immunology .E. L. Cooper:, Pergamon Press.
2. Essential Immunology .I.M. Roitt:, Blackwell Scientific Publication.
3. Immunology. J. Brostoff and D.K. Grower Medical Publishing.

## SEMESTER X

**Title of the Course :Parasitology**
**Course Code : DSC-V**
**Nature of the Course : DSC**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

**Course Objectives (CO)**

**CO1:** Explain the biology, classification, host–parasite interactions, and significance of parasites of human and veterinary importance.
CO2: Analyse and identify invertebrate parasites
**CO3:** Develop practical skills in parasite identification

**Learning Outcomes (LO)**

After completing the course, students will be able to:
**LO1:** Describe morphology, life cycle, transmission, pathogenicity, and control measures of major parasites.
**LO2:** Identify the parasites and perform basic parasitological assessment techniques.

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2 | | |
| Procedural | | | CO3 | | | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**UNIT 1:** 10 classes

**Introduction to Parasitology**

Introduction to parasitism, parasite, parasitoid and vectors, host-parasite relationship: Recognition and entry processes of different parasites. Ecological factors affecting parasite prevalence. Host parasite defence system with respect to parasitism; Zoonosis. Principles of Prevention and Control of Parasites.

**UNIT 2:**

**Blood parasites** **10 classes**

Public health significance of blood parasites and vectors. Malaria: Life cycle and epidemiology, mode of infection, detection, immunity and immune evasion mechanisms in primary and secondary hosts, drug targets; Filariasis: Life cycle and epidemiology, pathology, role of host (primary and secondary) immunity in protection and pathology, Wolbachia in disease prognosis, drug targets; vaccine strategies.

**UNIT 3:** **10 classes**

**Gastro-intestinal and other parasites**

Public health/economic significance of helminths. Studies of morphology, life cycle, pathogenicity of some Trematodes (flukes), Cestodes (tapeworms) and Nematodes (roundworms) of human importance. Mode of infection, detection, immunity and immune evasion mechanisms, drug targets.

**UNIT 4:**

**One Health** **15 classes**

Parasitic invertebrates of human and veterinary importance: Ectoparasitic Arthropods: ticks, mites, head and body lice; rat, cat and dog fleas, bugs. Endoparasitic Arthropods: botfly, blow fly; Biology, importance and control.

Protozoan diseases in fish: White spot disease (Ichthyophthiriasis); Monogenean infections: Dactylogyrosis. Helminth infections in fishes: Nematodiasis; Crustacean infestations in fishes: Argulosis. Pathogenesis of parasitic infections in fishes. Scope and significance of fish parasites.

**UNIT 5: LAB ACTIVITIES** **15 classes**

1. Study of commonly found fish parasites in NE India.
2. Study of histopathological alterations in parasite-infected fish.

3. Study of morphology and life cycle of *Entamoeba histolytica, Trypanosoma gambiense, Plasmodium vivax* through permanent slides and photographs.
4. Study of morphology and life cycle of *ticks, mites, Pediculus humanus* (Head and Body Louse*), Xenopsylla cheopis, Cimex lectularius* through permanent slides and photographs.
5. Identification of representative helminth parasites using permanent slides/specimens/Photographs.
6. Mounting of parasites.

**Suggested Readings:**

1. Bogitsh, B.J., Carter, C.E. & Oeltmann, T.N. (2012). *Human Parasitology* (4th ed.). Academic Press.
2. Chatterjee, K.D. (2009). *Parasitology: Protozoology and Helminthology* (13th ed.). CBS Publishers & Distributors Pvt. Ltd.
3. Roberts, L.S., Janovy, J. & Nadler, S. (2013). *Foundations of Parasitology* (9th ed.). McGraw-Hill Education.
4. Soulsby, E.J.L. (1982). *Helminths, Arthropods and Protozoa of Domesticated Animals* (7th ed.). Baillière Tindall.

## SEMESTER X

**DSE 2**

**Biochemistry II: Industrial Biochemistry**

**OR**

**Entomology II: Applied Entomology**

**OR**

**Fish and Fisheries II: Fisheries Resources, Aquaculture and Management**

**SEMESTER X**

**Title of the Course :Biochemistry-II: Industrial Biochemistry**
**Course Code : DSE-II**
**Nature of the Course : DSE**
**Total Credits :04**
**Distribution of Marks :100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

**COs:**

1. Explain the principles and scope of industrial biochemistry, including the role of enzymes, microorganisms, bioreactors, and biopharmaceuticals in modern industrial processes
1. Apply concepts and methodologies involved in enzyme production, purification, immobilization, and characterization for diverse industrial applications.
2. Analyze microbial fermentation processes and evaluate strategies for the large-scale production of industrial products, biofuels, and bioremediation of environmental pollutants.
3. Demonstrate laboratory skills related to enzyme kinetics, microbial cultivation, fermentation technology, and enzyme immobilization, and interpret experimental data relevant to industrial biochemistry.

**Learning Outcomes:**

1. Describe the historical development, principles, and industrial significance of biochemistry, enzymes, microorganisms, and recombinant biopharmaceuticals.
1. Perform enzyme extraction, purification, activity assays, kinetic studies, and immobilization techniques, and evaluate factors affecting enzyme stability and efficiency.
2. Explain the design and operation of bioreactors and apply fermentation principles for the production of ethanol, organic acids, amino acids, antibiotics, and biofuels.
3. Analyze strategies used in protein engineering, antibody engineering, mutagenesis, and enzyme optimization to improve catalytic properties and therapeutic applications.
4. Evaluate approaches for discovering novel enzymes and their applications in food, detergent, cosmetic, biosensor, environmental, and pharmaceutical industries.
5. Develop practical competencies in microbial cultivation, monitoring of growth parameters, fermentation processes, and interpretation of enzyme kinetic and inhibition data.

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | CO2 | CO3 | | |
| Procedural | | | | | CO4 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| AVERAGE | 3 | 2 | 2.5 | 2 | 2 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**UNIT 1:** **6 classes**

Introduction to Industrial Biochemistry; Historical development and milestones in industrial biochemistry. Role of enzymes, microorganisms, and bioreactors in industrial processes. Biopharmaceuticals: production of recombinant proteins, antibodies, and vaccines.

**UNIT 2:** **8 classes**

Sources of industrial enzymes: microbial, plant, and animal sources. Production, purification, and immobilization of enzymes. Applications of enzymes in food processing, detergent industry, cosmetics, and biocatalysis.

**UNIT 3:** **10 classes**

Fermentation Technology; Microbial fermentation: production of ethanol and organic acids. Industrial-scale fermentation: bioreactor design, operation, and optimization. Bioremediation of pollutants: microbial degradation of organic pollutants, heavy metals, and xenobiotics. Production of biofuels: biodiesel, bioethanol, and biogas.

**UNIT 4:** **9 classes**

Concept of protein engineering: Improvement of enzyme and stability, specificity and activity. Strategies for the discovery of improved and novel enzymes for industrial applications

(homology and structure based approaches, screening methods, use of mutants). Enzyme immobilization techniques, use of isolated enzymes in industrial processes.

**UNIT 6: LAB ACTIVITIES** **15 classes**

1. Extraction of enzymes from microbial, plant, or animal sources.
1. Purification techniques such as ammonium sulfate precipitation, dialysis, and chromatography (e.g., ion exchange, gel filtration, etc).
2. Quantitative measurement of enzyme activity using spectrophotometric methods.
3. Determination of kinetic parameters (Km and Vmax) using Michaelis-Menten 2 kinetics.
4. Techniques for immobilizing enzymes on various supports (e.g., agarose, alginate beads).
5. Analysis of the stability and activity of immobilized enzymes.
6. Cultivation of microorganisms (e.g., bacteria, yeast) in batch, fed-batch, and continuous modes.
7. Monitoring of growth parameters (e.g., optical density, dry cell weight).
8. Fermentative production of ethanol, lactic acid, citric acid, or antibiotics.

**Suggested Reading:**

1. Biochemical Engineering Fundamentals" by James E. Bailey and David F. Ollis
2. Bioprocess Engineering: Basic Concepts" by Michael L. Shuler and Fikret Kargi
3. Principles of Fermentation Technology" by Peter F. Stanbury, Allan Whitaker, and Stephen J. Hall
4. Industrial Microbiology and Biotechnology" by Michael J. Waites, Neil L. Morgan, John S. Rockey, and
Gary Higton
5. Biochemical Engineering and Biotechnology" by Ghasem D. Najafpour
6. Biotechnology: A Laboratory Course" by Becker, Caldwell, and Zachgo
7. Methods in Industrial Biotechnology" edited by Michael Wink
8. Practical Fermentation Technology" edited by Brian McNeil and Linda M. Harvey
9. Fundamentals of Biochemical Engineering" by Rajiv Dutta
10. Manual of Industrial Microbiology and Biotechnology" edited by Richard H. Baltz, Julian E. Davies,
and Arnold L. Demain
11.Practical Enzymology" by Hans Bisswanger
12.Fermentation and Biochemical Engineering Handbook" edited by Henry C. Vogel and Celeste L. T
13.Practical Biochemistry: Principles and Techniques" by Keith Wilson and John Walker
14.Biotechnology Procedures and Experiments Handbook" by S. Harisha

## SEMESTER X

**Title of the Course:** **:Entomology-II: Applied Entomology**
**Course Code** **: Core**
**Nature of the Course** **: DSE II**
**Total Credits** **:04**
**Distribution of Marks** **:100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10Lab)]**

**COs:**

1. Explain the concept of Vector biology
2. Analyze the mechanism of vector-borne disease transmission and vector control
3. Explain the types of pests and evaluate their control mechanism
4. Analyze the factors behind insect-plant interaction

**LO:**

- Discuss the vectors and their biology
- Apply the knowledge of disease transmission in vector control
- Evaluate the pest control methods
- Apply the factors involved in pest infestation of a host

**Mapping of CO with Bloom Taxonomy**

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | | CO1 | CO2, CO4 | CO3 | |
| Procedural | | | | | CO3 | |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2.0 |
| AVERAGE | 3 | 2 | 2.3 | 1.7 | 1.7 | 2 | 2 | |

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**Sec A: Medical Entomology**:

Unit1: 07 Lectures

Introduction to Vector Biology: Economic importance and control of fleas, lice, bugs, mosquitoes and flies. Vector-parasite interaction, host-pathogen interaction. Classification and biology of fleas, bugs, mosquitoes, lice, and sand flies. Insects transmitting bacteria and viruses of veterinary and agricultural importance.

Unit 2: 10Lectures

Epidemiology of vector-borne diseases of public health importance, Mode and mechanism of transmission and control (Malaria, Japanese encephalitis, Dengue, Filariasis). Vector surveillance: Concept, types, methods of surveillance and sampling. Integrated vector management, Pesticide registration, bioprospecting of plant and animal-based pesticides, scope of start-ups and industries.

**Sec B: Pest ecology and Agricultural entomology**

Unit 3: 10 Lectures

Pest definition, types, factors responsible for achieving the status of pest, Economic injury level, economic threshold, action threshold, pest complex, carrying capacity, secondary pest outbreak, pest surveillance and sampling. Population dynamics of pests in agro-ecosystems, phases and factors of population fluctuation, models of population growth, population size and regulatory mechanisms.

Unit4: 10 Lectures

Pests of paddy, tea, brinjal, potato, citrus, stored grains: identification, classification, biology, seasonal history, nature of damage and control. Different types of pest control, Quarantine, Physical, Cultural, Chemical, Biological control, JH & MH-agonist as pest control agents, genetic and biotechnological methods of control. Bacillus thuriengensis and its mode of action on insects, the development of Bt plants by recombinant DNA technology, insect cell lines. IPM

Unit5: 08 Lectures

Plant resistance to insects: mechanism of resistance-antibiosis, antixeno sis, tolerance, factors mediating resistance, Insect-Plant Interaction - Theory of co-evolution, role of allelochemicals in host plant mediation, tritrophic interaction, host-plant selection by phytophagous insects, Induction of metabolic pathways in host plant by herbivory.

Unit6: 15 Lectures

**Lab activities:**

1. Collection and identification of insects used as biocontrol agents, insect pests of agricultural importance
2. Determination of pest population density and abundance
3. LC50 determination of insecticide by using the filter paper method against stored grain pests
4. Identification of life stages of vectors of medical importance
5. Methods of rearing insects in the laboratory
6. Estimation of phenol and terpene in resistant and susceptible cultivars
7. Protein profiling using gel electrophoresis in herbivorous insect/defense induce plant
8. Assignment on study and submission of life cycle of a pest of local importance
9. Molecular identification of mosquito species
10. Submission of insect pests, vectors and life cycles

**Suggested Readings:**

1.Medical and Veterinary Entomology, Kettle, D. S., Cabi Press, USA
2.Medical Entomology for students, Service, M. Cambridge University Press, UK.
3.Medical and Veterinary Entomology Mullen, G. Durden, L., Academic Press,
4.Chemical Ecology of Insects, Carde, R. T., and Bell, W. J., Chapman & Hall, New York, USA
5.Insect Plant Biology, Schoonhoven, L. M., van Loon, J.A., & Dicke, M., Publisher Oxford University Press, USA
6.Interrelationship between insects and Plants, Jolivet, P., CRC Press, USA
7.Entomology & Pest Management, Pedigo, L. P., Prentice Hall, New Jersey, USA
8.Concepts of IPM, Norris, Caswell-Chen and Kogan, Prentice-Hall, USA
9.Agricultural insect pests of the tropics and their control, Hill, D. S.Cambridge University Press, UK

**Title of the Course: Fish and Fisheries-II: Fisheries Resources, Aquaculture and Management**
**Course Code: DSE II**
**Nature of the Course: DSE**
**Total Credits: 04**
**Distribution of Marks: 100 [60 End (Theory: 45, Practical: 15) + 40 IA(30+10 Lab)]**

## Course Objectives

1. Provide comprehensive knowledge of inland, estuarine, and marine fisheries resources of India.

2. Develop an understanding of ecological principles governing aquatic productivity, pond management, and sustainable aquaculture production systems.

3. Impart theoretical and practical knowledge on induced breeding, hatchery design, seed production, and hatchery management.

4. Introduce principles and practices of fish harvesting, preservation, processing, value addition, and by-product utilization.

5. Develop competency in fisheries resource conservation, fishing technologies, fisheries legislation, and sustainable management practices.

## Learning Outcomes

1. Student will be able to explain the ecological characteristics, fisheries resources, and production potential of inland, estuarine, and marine aquatic ecosystems of India.

2. Evaluate pond ecosystem dynamics, productivity, water quality, and management practices for sustainable aquaculture development.

3. Demonstrate knowledge of induced breeding, hatchery planning, seed production, and nursery management of economically important fish species.

4. Assess fishing crafts, gears, fisheries legislation, conservation measures, and management strategies for sustainable fisheries development.

5. Apply principles of fisheries economics, marketing, transportation, extension education, and technology transfer to enhance fish production and livelihood opportunities.

## Mapping of CO with Bloom Taxonomy

| Knowledge Dimension | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---|---|---|---|---|---|---|
| Factual | | | | | | |
| Conceptual | | CO1 | | CO2 | CO3 | |
| Procedural | | | CO4 | | | CO5 |
| Metacognitive | | | | | | |

**Mapping of Course outcomes to Programme outcomes**

| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | AVERAGE |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.0 |
| CO4 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.28 |
| C)5 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.14 |
| AVERAGE | 3 | 2 | 2.4 | 2 | 2 | 2 | 2 | |

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

**Modes of internal assessment**

- Internal examination
- Viva-voce/Home assignments

**Attainment strategy**

- Continuous evaluation through in and end-semester examinations
- Submission of assignments

**Unit 1**: River systems of India and their fisheries with special reference to the Brahmaputra river system; Ecology of riverine environment; Dams and their effects on fish migration; Fisheries of lakes and reservoirs; Classification and ecology of lakes and reservoirs; Cold water fisheries; Ecology and fisheries of beels. **(7 Lectures)**

**Unit 2**: Definition, origin and classification of estuarine fisheries resources of India with special reference to Chilka lake and backwater lagoons in Kerala; marine fishery activity sites in India; Biology and fisheries of oil sardine, Indian mackerel and Bombay duck. **(6 Lectures)**

**Unit 3**: Ecology of fish pond: Abiotic and biotic components; Food chain; Concept of productivity, methods of measuring productivity, classification of water bodies on the basis of

their productivity; Layout and design of nursery, rearing and stocking ponds; Fertilization; Predatory and weed fishes and their control; aquatic insects and their control.( **7 Lectures)**

**Unit 4**: Culture of air-breathing (*Clarias magur*, *Heteropneustes fossilis*, *Anabas* spp. and Channa), Integrated aquaculture (paddy cum fish culture; duck-cum and pig-cum fish culture; Sewage fed fisheries; Composition of sewage and sludge; Treatment of sewage: physical, chemical and biological processes; Rearing techniques and production in sewage ponds. **(7 Lectures)**

**Unit 5**: Induced breeding: Purpose, technique of induced breeding, influence of abiotic factors, Recent advances in induced breeding; Concept of hatchery, designing of Chinese and cemented hatchery, management of hatcheries. **(5 Lectures)**

**Unit 6**: Fish preservation and by-product: Causes of fish spoilage: biochemical changes during fish spoilage; Principle and practice of fish preservation; By-products of fishes; Indigenous methods of fish preservation. **(4 Lectures)**

**Unit 7**: Present status and scope of development of fishing technology in India; Types of indigenous fishing crafts and gears in marine and inland waters, their maintenance and operation; Management and conservation of inland fisheries resources; Fisheries legislation. **(4 Lectures)**

**Unit 8**: Principles of economics as applied to aqua products; Law of demand and supply, Existing system of fish marketing; Use of modern marketing and transportation for aqua products. Role of cooperatives and Fish Farmer's Development Agencies (FFDA); Fisheries extension and transfer of technology. (**5 Lectures)**

**Unit 9: Practical: (15 Lectures)**

1. Biological survey of pond.
2. Analysis of soil sample: pH, texture and porosity.
3. Analysis of physico-chemical parameters of pond water.
(a) Conductivity (b) turbidity (c) dissolved oxygen (d) current flow (e) alkalinity (f) hardness (g) TDS (h) TSS (i) Nitrate-nitrite and (j)Phosphate.
4. Identification and reports on locally available aquatic weeds.
5. Study of commonly used fishing gears.
6. Observation of induced breeding techniques.
7. Collection of fish parasites, their mounting, and identification.
8. Gut content analysis of *Labeo, Puntius, Channa and Heteropneustes*.
9. Gonadosectomy in fishes.
10. Histological study of guts/gonads.
11. Estimation of fish digestive enzymes (amylase, protease and lipase).
11. Field visit to hatchery and aquaculture farm.

**Suggested Readings**

1. G. Helfman, Bruce B. Collette, D.E. Facey, B. W. Bowen: The Diversity of Fishes: Biology, Evolution, and Ecology, John Wiley & Sons
2. R. J. Wootton: Fish Ecology, Springer

3. W. Vishwanath, W.S. Lakra and U.K. Sarkar: Fishes of North East India, NBFGR Publication, Lucknow.
4. D. Kapoor, R. Dayal and A.G. Ponniah: Fish Biodiversity of India, NBFGR Publication, Lucknow.
5. R.H. McConnell: Ecological Studies in Tropical Fish Communities, Cambridge University Press.
6. Matty: Fish Endocrinology.
7. T.K. Govindan: Fish Processing Technology, Oxford & IBH, New Delhi
8. Peter B. Moyle Joseph J. Cech Jr.: Fishes–An Introduction to Ichthyology, Prentice Hall, N.Y .
9. R.K. Rath: Freshwater Aquiculture, Scientific publishers.
10. Hoar and Randall: Fish Physiology, Academic Press, London.
11. Hwett: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News books Ltd. Surrey England.
12. Bardach, Miller and Passino: Ichthyology, John Wiley &Sons, N.Y.
13. H.L. Choudhury & S.B. Singh: Induced Breeding of Carps, ICAR New Delhi
14. W.F. Royce: Introduction to the Practice of Fishery Science, Academic Press, N.Y.
15. V.G. Jhingran:Fish and Fisheries of India, Oxford & IBH, New Delhi.
16. Kyle: The Biology of Fishes.
17. R.G.Wetzel: Limnology,W.G.Saunders, N.Y.
18. M. J. Mannig. and M. F.Tatner: Fish Immunology Academic Press. N.Y.
19. J. S. D. Munshi and G.M.Hughes: Air-breathing fishes of India. Their structure, function and life history. Oxford & IBH. Publishing Co.
20. R.R.Stickney: Principles of Warm Water Aquiculture, John Wiley & Sons, N.Y.
21. CBL Srivastava: A Text Book of Fishery Science and Indian Fisheries, Kitab Mahal , Allahabad.
22. B.A. Whitton: River ecology, University of California Press.
23. G.V. Nikolsky: The Ecology of Fishes, Academic Press, N.Y.
24. S.P.Biswas: Manual of Methods in Fish Biology, South Asian Publishers, New Delhi.
25. S.P.Biswas : Fundamentals of Ichthyology, Narendra Publication House. New Delhi.

**SEMESTER X**

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|---|---|---|
| **Title of the Course** | **:** | Dissertation (Based on DSE2) |
| **Course Code** | **:** | **Dissertation/ 2 DSE** |
| **Nature of the Course** | **:** | |
| **Total Credits** | **:** | **08** |

# Course Structure

Or

DSE 3: To be opted from SWAYAM

DSE 4: To be opted from SWAYAM