To, Date: **12 June 2024**

The Academic Registrar
Bodoland University

Subject: Submission FYIMP syllabus for Zoology under NEP, 2020

Dear Sir,

I am writing to inform you that the syllabus prepared by the Syllabus Preparation Subcommittee for FYIMP syllabus under Bodoland University has been approved by all members. We are pleased to submit the finalized syllabus for consideration and implementation by the university authority.

The subcommittee, consisting of experienced faculty members and subject matter experts, dedicated considerable time and effort in developing a comprehensive syllabus that aligns with the academic standards and objectives set by the university. The syllabus encompasses all the necessary components, including the course content, learning outcomes, and recommended resources, to ensure an enriching learning experience for the students.

Throughout the process, the subcommittee members thoroughly discussed and deliberated on various aspects of the syllabus to ensure its relevance, coherence, and adherence to the curriculum guidelines. We believe that the approved syllabus will effectively cover the essential knowledge, skills, and competencies required for the successful completion of the course.

We trust that the university authority will recognize the efforts put forth by the subcommittee and the value this syllabus will bring to the academic program.

We would like to express our gratitude to the university authority for entrusting us with the responsibility of developing the syllabus.

Yours sincerely,

(Dr. Kushal Choudhury)
Convenor
FYIMP syllabus sub-committee
Bodoland University

Meeting Proceeding – June 9, 2024

Date: June 9, 2024 Department of Zoology, Bodoland University

Proceedings:

The meeting was called to order at 3.30 pm by Convenor of NEP FYIMP syllabus sub-committee. The purpose of the meeting was to discuss and finalize the proposed syllabus prepared by the committee members. The attendees consisted of undermentioned sub-committee members responsible for preparing the syllabus.

During the meeting, the committee members showed the proposed syllabus, outlining the changes and updates made based on previous discussions and suggestions. The sub-committee members expressed their agreement with the proposed syllabus, acknowledging that it aligns well with the desired learning outcomes and addresses the key objectives of the curriculum.

After a thorough discussion and deliberation, it was unanimously agreed upon by all the sub-committee members present that the proposed syllabus is comprehensive, well-structured, and suitable for the intended academic program. They commended the committee members for their diligent efforts in preparing the syllabus and acknowledged the inclusivity of diverse perspectives throughout the development process.

The sub-committee members further decided to submit the proposed syllabus to the relevant authority for further review and approval.

Conclusion

With the agreement and support of all the sub-committee members, the proposed syllabus prepared by the committee members will be submitted to the authority. The meeting adjourned at 4.30 pm with a sense of accomplishment and optimism for the positive impact of the revised syllabus on the academic program.

NAME AND DESIGNATION OF THE FYIMP SYLLABUS SUB-COMMITTEE MEMBERS

Sl. no.	Name of Faculties	Designation	Institution
1	Prof. Dhiraj Saha	Subject Expert	Department of Zoology University of North Bengal West Bengal, India
2	Dr. Pradip Sarma, Associate Professor	Subject Expert	Department of Zoology Bhattadev University, Assam, India
3	Dr. Kushal Choudhury	Convenor	Department of Zoology Bodoland University, Assam, India
4	Prof. Hilloljyoti Singha	Member	Department of Zoology Bodoland University, Assam, India
5	Dr. Dulur Brahma	Member	Department of Zoology Bodoland University, Assam, India
6	Dr. Ananta Swargiary	Member	Department of Zoology Bodoland University, Assam, India
7	Mr. Bihung Basumatary	Member	Department of Zoology Bodoland University, Assam, India

UNIVERSITY OF NORTH BENGAL

ACCREDITED BY NAAC WITH GRADE B++

DEPARTMENT OF ZOOLOGY

DST-FIST & UGC SAP Sponsored

P.O. North Bengal University
Raja Rammohunpur, Dist. Darjeeling
West Bengal, India, PIN - 734013

समानो मन्त्रः समितिः समानी

Ref: Zoo/1316/2024

Date: 18th June, 2024

To
The Head
Department of Zoology
Bodoland University, Assam

Sub: Report on PG syllabus of Zoology as per NEP-2020, Bodoland University, Assam

Sir

In reference to the above, I am to state that the PG syllabus has been prepared with utmost care focussing the main theme of NEP-2020. The syllabus meets the standard focuses the learning flexibility, skill development, employability, and entrepreneurship skills. It has followed prescribed format of NEP-2020.

This is for your kind information and necessary action.

Thanking you.

18/06/24

Prof. Dhiraj Saha
Head and Professor
Department of Zoology
University of North Bengal

Head
Department of Zoology
University of North Bengal
Dist. Darjeeling, Pin- 734013

DEPARTMENT OF ZOOLOGY * N.B.U. *

Bodoland University
Kokrajhar, Assam

As per National Education Policy -2020
Syllabus for Theory and Practical for FYIMP syllabus under NEP, 2020

Subject: Zoology, 2024

Under auspices of Department of Higher Education
Assam

SEMESTER-WISE TITLES OF THE PAPERS IN FYIMP

YEAR	SEMESTER	PAPER CODE	PAPER TITLE	CREDITS TH+PR	Marks TH+PR+IN	TOTAL MARKS
UG Certificate in Zoological Techniques with internship of 4 credits						
1	1	ZOOMAJ1014	Cell Biology and Histology	3+1	50+20+30	100
	1	ZOOMIN1014	Cell and Molecular Biology	3+1	50+20+30	100
	1	ZOOIDC1013	Environmental Studies and Wildlife Conservation	2+1	40+10	50
	1	ZOOSEC1013	Non-Mulberry Sericulture	2+1	40+10	50
	1	ZOOVAC1014	Basic Ecotourism	2+2	50	50
	I	ZOOINT1014	Summer Internship	4		
	2	ZOOMAJ2014	Biological Techniques	3+1	50+20+30	100
	2	ZOOMIN2014	Biostatistics and Bioinstrumentation	3+1	50+20+30	100
	2	ZOOIDC2013	Basic Lab Safety & Techniques	2+1	40+10	50
	2	ZOOSEC2013	Aquaculture	2+1	40+10	50
	2	ZOOVAC2014	Vermicompost Technology	2+2	50	50
UG Diploma in Zoological Techniques with internship of 2 years						
2	3	ZOOMAJ3014	Basics of Biochemistry	3+1	50+20+30	100
	3	ZOOMAJ3024	Principles of Ecology and Animal Behaviour	3+1	50+20+30	100
	3	ZOOMIN3014	Evolutionary Biology and Genetics	3+1	50+20+30	100
	3	ZOOIDC3013	Human-Wildlife Conflict and Management	2+1	40+10	50
	3	ZOOSEC3013	Animal Husbandry and Livestock Management	2+1	40+10	50
	4	ZOOMAJ4014	Physiology: Life-sustaining systems	3+1	50+20+30	100
	4	ZOOMAJ4024	Principles of Genetics	3+1	50+20+30	100
	4	ZOOMAJ4034	Animal Biotechnology	3+1	50+20+30	100
	4	ZOOMIN4014	Physiology and Biochemistry	3+1	50+20+30	100
	4	ZOOINT4014	Internship	2		
Bachelor's Degree in Zoology						
3	5	ZOOMAJ5014	Basic systematic and Diversity of life-I (Non-chordates)	3+1	50+20+30	100
		ZOOMAJ5024	Developmental Biology	3+1	50+20+30	100
		ZOOMAJ5034	Organic Evolution	3+1	50+20+30	100
		ZOOMAJ5044	Biochemistry of metabolic processes	3+1	50+20+30	100
		ZOOMIN5014	Taxonomy and Diversity of life-I (Non-chordates)	3+1	50+20+30	100

		ZOOINT5014	Internship	4		
	6	ZOOMAJ6014	Diversity of life-II (Chordates)	3+1	50+20+30	100
		ZOOMAJ6024	Comparative Anatomy of Vertebrates	3+1	50+20+30	100
		ZOOMAJ6034	Molecular Biology	3+1	50+20+30	100
		ZOOMAJ6044	Biostatistics & Bioinformatics	3+1	50+20+30	100
		ZOOMIN6014	Diversity of life-II (Chordates)	3+1	50+20+30	100
Bachelor Degree in Zoology with Honours						
4	7	ZOOADL7014	Cell Structure and Function	3+1	50+20+30	100
		ZOOADL7024	Overview of Immune System	3+1	50+20+30	100
		ZOOADL7034	Endocrinology and Hormonal Regulation	3+1	50+20+30	100
		ZOOADL7044*	Ecology & Environmental Biology	3+1	50+20+30	100
		ZOOREM7014	Research Methodology	3+1	50+20+30	100
		ZOOMIN7014	Ecology & Environment	3+1	50+20+30	100
	8	ZOOADL8014	Fundamental Biostatistics	3+1	50+20+30	100
		ZOOADL8024	Ethnozoology	3+1	50+20+30	100
		ZOOADL8034	Reproductive & Developmental Biology	3+1	50+20+30	100
		ZOOADL8044	Fundamental Animal Physiology	3+1	50+20+30	100
		ZOOADL8054	Biochemistry	3+1	50+20+30	100
		ZOOMIN8014	Introduction to Developmental Biology	3+1	50+20+30	100
Bachelor Degree in Zoology with Research						
	8	ZOOADL8014	Fundamental Biostatistics	3+1	50+20+30	100
		ZOODISS80112	Dissertation	12		
Total Credits				**160**		

2ND YEAR

SEMESTER IX (2-Year PG/1-Year PG)

Specialization: Cell and Molecular Biology

Option A – Only Coursework

Paper Code	Paper Name	Credits	T+P	External	Internal	Marks
ZOOSPL25014	Genes and Genomics	4	4+0	70	30	100
ZOOSPL25024	Molecular Biology of the Cell	4	4+0	70	30	100
ZOOSPL25034	Advanced Techniques in Molecular Biology	4	4+0	70	30	100
ZOOSPL25044	Practical CMB 1	4	0+4	70	30	100
ZOOSPL25054	Practical CMB 2	4	0+4	70	30	100

SEMESTER X (2-Year PG/1-Year PG)

Paper Code	Paper Name	Credits	T+P	External	Internal	Marks
ZOOSPL25064	Proteomics and Genetic Engineering	4	4+0	70	30	100
ZOOSPL25074	Molecular Genetics	4	4+0	70	30	100
ZOOSPL25084	Bioinformatics and Computational Biology	4	4+0	70	30	100
ZOOSPL25094	Practical CMB 3	4	0+4	70	30	100
ZOOSPL25104	Practical CMB 4	4	0+4	70	30	100

SEMESTER IX (2-Year PG/1-Year PG)

Specialization: Entomology

Option A – Only Coursework

Paper Code	Paper Name	Credits	T+P	External	Internal	Marks
ZOOSPL25014	Fundamentals of Insect Taxonomy and Classification	4	4+0	70	30	100
ZOOSPL25024	Insect Morphology	4	4+0	70	30	100
ZOOSPL25034	Insect Physiology	4	4+0	70	30	100
ZOOSPL25044	Practical ENT 1	4	0+4	70	30	100
ZOOSPL25054	Practical ENT 2	4	0+4	70	30	100

SEMESTER X

(2-Year PG/1-Year PG)

Paper Code	Paper Name	Credits	T+P	External	Internal	Marks
ZOOSPL25064	Insect Ecology	4	4+0	70	30	100
ZOOSPL25074	Forest and Agricultural Entomology	4	4+0	70	30	100
ZOOSPL25084	Insect Toxicology and Pest Control	4	4+0	70	30	100
ZOOSPL25094	Practical ENT 3	4	0+4	70	30	100
ZOOSPL25104	Practical ENT 4	4	0+4	70	30	100

SEMESTER IX (2-Year PG/1-Year PG)

Specialization: Fish and Fishery Science

Option A – Only Coursework

Paper Code	Paper Name	Credits	T+P	External	Internal	Marks
ZOOSPL25014	Fish Taxonomy, Diversity and Adaptation	4	4+0	70	30	100
ZOOSPL25024	Aquatic Ecology and Environmental Management in Fisheries	4	4+0	70	30	100
ZOOSPL25034	Applied Fisheries Science and Management	4	4+0	70	30	100
ZOOSPL25044	Practical FFSc 1	4	0+4	70	30	100
ZOOSPL25054	Practical FFSc 2	4	0+4	70	30	100

SEMESTER X

(2-Year PG/1-Year PG)

Paper Code	Paper Name	Credits	T+P	External	Internal	Marks
ZOOSPL25064	Anatomy and Physiology of Fish	4	4+0	70	30	100
ZOOSPL25074	Immune Responses and Preservation Techniques	4	4+0	70	30	100
ZOOSPL25084	Integrated Aquaculture: Breeding, Nutrition, and Biotechnology	4	4+0	70	30	100
ZOOSPL25094	Practical FFSc 3	4	0+4	70	30	100
ZOOSPL25104	Practical FFSc 4	4	0+4	70	30	100

SEMESTER IX (2-Year PG/1-Year PG)

Specialization: Wildlife Ecology

Option A – Only Coursework

Paper Code	Paper Name	Credits	External	Internal	Marks
ZOOSPL25014	Fundamentals of Wildlife Ecology	4	70	30	100
ZOOSPL25024	Applied Research Methodology	4	70	30	100
ZOOSPL25034	Wildlife in Human Perspective	4	70	30	100
ZOOSPL25044	Practical WE 1	4	70	30	100
ZOOSPL25054	Practical WE 2	4	70	30	100

SEMESTER X

Paper Code	Paper Name	Credits	External	Internal	Marks
ZOOSPL25064	Biogeography and Habitat Ecology	4	70	30	100
ZOOSPL25074	Ecology of Major Wildlife Taxa	4	70	30	100
ZOOSPL25084	Conservation Ecology and Wildlife Management	4	70	30	100
ZOOSPL25094	Practical WE 3	4	70	30	100
ZOOSPL25104	Practical WE 4	4	70	30	100

* Research Methodology is compulsory for Degree in Zoology with Research. Whereas all theory papers are compulsory for Degree with Hons.

*2 credit of VAC may be Yoga education/sports and fitness/community engagement, NSS/NCC etc.

In 4th year (Semester IX + X) there will be three options -

Option 1: Semester IX (Coursework) and Semester X (Coursework)

Option 2: Semester IX (Coursework) and Semester X (Dissertation)

Option 3: Semester IX (Research) and Semester X (Research)

Curricular Components	PG Programme (One Year) for 4-yr UG (Hons. /Hons. With research) Minimum Credit			
	Course Level	Coursework	Research thesis	Total credit
Coursework + Research	500	20	20	40
Coursework	500	40		40
Research			40	40

Programme Outcomes (POs)

PO 1: This will improve both the fundamental theoretical understanding and practical knowledge of Zoology.

PO 2: This will assist students in developing the foundational concepts necessary for future projects and advanced studies.

PO 3: It will promote an understanding of the evolutionary foundations of diverse animal species and their development, while also addressing the current state of animal diversity.

PO 4: It will enable students to comprehend the principles related to different applied sciences.

PO 5: It will contribute to the conservation of wild animals and enhance the economic value of the zoological content present in the environment.

PO 6: All the above POs will lead to a mind that can develop modern technologies to address the problems and to give solution to it.

SEMESTER I

Cell Biology and Histology

Paper Code: ZOOMAJ1014

No. of Credits 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objects

The course aims to develop a comprehensive understanding of cell structure and function, histology principles, and practical skills for cellular analysis and tissue identification.

Course Outcomes

Upon completion of the course, students will have acquired sufficient knowledge on the fundamental structure, function, and biochemistry of the cell.

Course Contents

Theory **Credit: 03**

Unit I

Cell Biology: Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure, Active and Passive transport, Facilitated-transport, cell junctions; Cell Division: Mitosis, Meiosis, Cell cycle and its regulation and Cell Signaling: Receptors (types) and signaling molecules.

Unit II

Structure and Function of different cell components: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Mitochondria and Peroxisomes, Microtubules, Microfilaments and Intermediate filament; Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus, Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome).

Unit III

Histology: Structure of epithelium, connective tissue, cartilage, bone, smooth, striped and cardiac muscles, nervous tissue; Histology of organs: gonads, liver, lung, pancreas and kidney in mammals; Basic principles of fixation and staining: Classification, Composition and properties of dye, Use of mordants and metachromatic dyes; Principle and procedure of histological staining of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Practical C**redit: 01**

1. Study of prokaryotic and eukaryotic cells.
2. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
3. Study of various stages of meiosis in grass hopper testis.

4. Preparation of permanent slide to show the presence of Barr body in human female blood cells/buccal epithelial cell.
5. Study of different tissue through permanent slides: Epithelial (simple, squamous, cuboidal, columnar Compound, stratified, transitional) muscular tissue, Connective tissue (bone, cartilage, areolar, tendon, adipose, reticular) and nervous tissue.

SUGGESTED READINGS

1. De Roberties, E. D. P. *et al. Cell and Molecular Biology* TMH
2. Bhaskaran, K. K. &Biju Kumar, A. *Cell Biology, Genetics & Molecular Biology*.
3. Karp G. (2005). *Cell and Molecular Biology*.4 e, John Wiley & Sons, Inc.
4. Sadava, D. E. *Cell Biology*. Jones & Bartlett Publishers, London
5. Sheeler, P. and Bianchi D. E. *Cell Biology - Structure, Biochemistry and Functions*.
6. Verma, P. S. &Agarwal, V. K. *Cytology*. S. Chand & Co.
7. Vijayakumaran Nair, K. & Jayaprakash, M. *Cell Biology, Genetics, Molecular Biology*, Academica.

Semester I

Cell and Molecular Biology

Paper Code: ZOOMIN1014

No. of Credits 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objects

The course aims to develop a comprehensive understanding of cell structure and function, histology principles, and practical skills for cellular analysis and tissue identification.

Course Outcome

Upon completion of the course, students will have acquired sufficient knowledge on the fundamental structure, function, and biochemistry of the cell.

Course Contents

Theory **Credits: 03**

Unit I

Overview of Cells: Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions; Plasma Membrane: Various models of plasma membrane structure; Transport across membranes: Active and Passive transport, Facilitated transport.

Unit II

Endomembrane System: Structure and Functions of Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Mitochondria, Peroxisomes; Cytoskeleton: Structure and Functions of Microtubules, Microfilaments and Intermediate filaments; Nucleus: Structure and Function; Chromatin: Euchromatin and Heterochromatin; Cell Division: Mitosis, Meiosis, Cell cycle and its regulation

Unit III

Nucleic Acids: Salient features of DNA and RNA, Watson and Crick model of DNA; DNA Replication: Replication in prokaryotes and eukaryotes, mechanism of DNA replication, Semi-conservative, bidirectional and semi-discontinuous replication; Transcription: RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes.

Practical **Credits: 01**

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
2. Study of various stages of meiosis
3. Preparation of permanent slide to show the presence of Barr body in human female blood
4. cells/cheek cells.

5. Study of Polytene chromosomes from Chironomus / Drosophila larvae

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. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

Semester I

Environmental Studies and Wildlife Conservation

Paper Code: ZOOIDC1013

No. of Credits 3: {2(T) + 1(P)}

Total hours: 30 (Theory) (2 hour/ Week)

Objective

The objective of studying the anthropogenic impact on the environment is to understand the detrimental effects of human activities on ecosystems and biodiversity.

Course outcome

The outcome of such studies is to foster a sense of responsibility and encourage sustainable practices for the preservation and conservation of the environment. This knowledge can help in formulating policies and strategies to mitigate the damage caused by human activities and work towards achieving a more harmonious relationship between man and nature.

Course content

Theory **Credits: 02**

Unit I

Anthropogenic impact on environment: Man, as an animal species in the ecosystem. Population explosion. carrying capacity, exploitation of resources due to urbanization, industrialization and agricultural practices. Pollution of air, water, soil and noise; radioactive pollution. Eutrophication. Deforestation; Threats to biodiversity, Extinction of species. Greenhouse effect and global warming; climate change; Shrinking of glaciers. Threats to sustainable development.

Unit II

Value of wildlife and its conservation: Definition, value and importance of wildlife; Types of ecosystems. Causes of depletion of wildlife; Factors responsible for the extinction of animals; Biodiversity conservation– In-situ e.g., Sanctuaries, National Parks, Biosphere Reserves, World Heritage Sites; Ex-situ e.g., botanical gardens, gene banks, cryopreservation etc.; Rainwater harvesting, groundwater water recharge.

Practical **Credits: 01**

1. Visit to an area to document environmental assets including natural resources/flora/fauna, etc.
2. To determine the chemical conditions of water: pH, temperature, conductivity, dissolved oxygen and carbon-di-oxide, hardness etc.

Suggested readings

1. Odum, E.P, 1971. Fundamentals of Ecology. W.B. Saunders Co. USA 57
2. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
3. Wilson, E. O. 1985. The Biological Diversity Crisis. BioScience 35: 700-706.
4. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. Climate Change and India. Universities Press, India.
5. Gaston, K J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.
6. Primack, R.B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.

Semester I
Non-Mulberry Sericulture
Paper Code: ZOOSEC1013
No. of Credits – 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective
By the end of this section, students will have a clear understanding of sericulture, its historical significance, and the current status of mulberry and non-mulberry sericulture.

Course outcome
They will also have knowledge of the life cycles of Eri and Muga silkworms, the structure of silk glands, and the characteristics of silk. Additionally, readers will be informed about the food plants suitable for Eri and Muga silkworm rearing. Overall, this section will lay a strong foundation for understanding the subsequent topics related to sericulture.

Course contents

Theory **Credits: 02**

Unit I
Sericulture: Definition, history and present status of Mulberry and Non-Mulberry Sericulture; Silk route; Varieties of Silk; Life cycle of silkworm- Eri and Muga; Structure of silk gland and Nature of Silk; Food plants of Eri and Muga Silkworm; Rearing Operation: Rearing house/Site and rearing appliances. Disinfectants: Formalin, bleaching powder. Rearing technology: Early age and Late age rearing; Environmental conditions in rearing: temperature, Humidity, Light and Air. Harvesting and storage of cocoons; Spinning and Reeling of silk

Unit II
Pests and Diseases: Pests of eri and muga silkworm. Pathogenesis of eri and muga silkworm diseases: Protozoan, viral, fungal and bacterial. Prevention and control measures of pests and diseases. Entrepreneurship in Non-Mulberry Sericulture: Varieties of Non-Mulberry Silk products and economics in India Prospectus of Non-Mulberry Sericulture in India: Non-Mulberry Sericulture industry in different states, employment generation and potential.

Practical **Credit: 01**
1. Study of life cycle of Muga and Eri silkworm.
2. Visit to various sericulture Govt. /Private Farm/ Centers and report submission.

Suggested readings
1. F.A.O. (1984). Manual on Sericulture published by Food and Agriculture Organization

2. S.B. Dandin, J. Jayaswal and K. Giridhar (2001). Handbook of Sericulture Technologies. Publisher-Central Silk Board, Bangalore.
3. Muga Culture. 2013. Author: RN Singh, CM Vaspayi, A. Tikader and B. Sarat Chandra. Publisher – APH Publishing Corporation, New Delhi.
4. Ericulture- A comprehensive Profile. Authors: MC Sarmah, BN Sarkar, SA Ahmed and J Dewry. 2013.
5. Directorate of Sericulture, BTC, Silkworm Egg Production. 1997. Publisher – Oxford and IBH Publishing Co. Pvt. Lt.
6. Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

Semester I

Basic Ecotourism

Paper Code: ZOOVAC1014

No. of Credits – 4: {2(T) + 2(P)}

Total hours: 30 (Theory) (2 hour/ Week)

Objective

The objective of this course is to provide a comprehensive understanding of tourism as a concept and its basic components.

Course outcome

- Students will understand the concepts of tourism demand and supply and will be able to identify the unique features of the tourism industry.
- Overall, this course will equip students with a solid foundation in tourism studies, enabling them to analyze and understand the various aspects and impacts of the industry.

Theory **Credits: 02**

Unit I

Definition of Tourism; Basic Components and types of Tourism: accessibility, attraction and accommodation; Motivation for Tourism; scope; leisure, recreation and tourism, and their interrelationship. Components of Tourist Resources: Tourist oriented resources, resident oriented resources, background of tourism resources and retrieval tourist resources. Tourism Demand and Supply: concept, unique features, constraint and opportunity in creating ideal destination; Ethnic hospitality: nature and dimensions.

Unit II

Economic impacts of Tourism: income and employment; Socio-cultural impacts of Tourism; Ecological and Environmental impacts of Tourism; Tourism planning: Concept, nature and type of tourism planning; Tourism policy of Assam; Planning for the development of a tourist destination; Definition and types of Tour operator and Travel agency; Marketing: concept and definition and its significance in tourism industry; Basic concept of need, demand and services. Definition and types of tourist guide, Job description, duties and responsibilities of tourist guide: Importance of tourist guide in tourism industry; Income source of a tourist guide.

Practical **Credits: 02**

1. Visit to important wetland or forest and report preparation related to ecotourism
2. Tour programme preparation
3. Tour operating Broucher preparation

Suggested readings

1. Introduction to Tourism : A. K. Bhatia
2. Tourism System: Mill R.C & Morrison
3. Tourism Development: R. Garther

4. Successful Tourism Management: Pran Nath Seth

Semester II
Biological Techniques
Paper Code: ZOO MAJ 2014
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objectives of the course are to understand the principles, techniques, and applications of various bio-instrumentation methods and to gain knowledge of diagnostic methods used for blood and urine analysis, including detection and prevention of diabetes and hypertension.

Course Outcome

- After completing the objectives related to Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure, Active and Passive transport, Facilitated-transport, Cell junctions, Structure and Function of different cell components, Cell Division, and Cell Signaling, students will be able to demonstrate a comprehensive understanding of the structure, function, and processes involved in cellular biology.
- Upon achieving the objectives related to Histology and Bio-instrumentation, students will acquire the ability to apply principles and techniques of microscopy, histological staining, and diagnostic methods for blood and urine analysis. They will also develop skills in utilizing various bio-instrumentation tools and methods for research, analysis, and diagnostic purposes in the field of biology.

Course Contents

Theory **Credits: 03**

Unit I

Principles and Techniques of Microscopy; Magnification and Resolution Parameters of Light, Simple Microscope, Compound Microscope; Types of Compound Microscopes: Bright Field, Dark Field, Phase Contrast Microscope, Scanning & Transmission Electron Microscope and; Microtome.

Unit II

Principle & Applications of Centrifuge machine, pH Meter, distillation plant, hot-air oven, Colorimetry; Introduction to Chromatography: Mobile phase, stationary phase, solvent system, Rf value; Paper Chromatography, Thin Layer Chromatography, Column Chromatography: Gas Chromatography, Ion Exchange, Affinity Chromatography, HPLC; Basics of Electrophoresis.

Unit III

Diagnostics Methods Used for Analysis of Blood: Blood composition, Preparation of blood smear and cell count using haemocytometer, Blood grouping; Urine Analysis: Physical characteristics, Abnormal constituents; Diagnosis and prevention of Diabetes (Type I and Type II), Testing of blood glucose.

Practical **Credits: 01**

1. Preparation of blood smear and cell counting
2. Detection of blood Group
3. Detection of sugar in urine
4. Demonstration of instrumentations
5. Detection of pH level from different samples

SUGGESTED READINGS

1. Wilson, K. and Walker, J. Principles and Techniques of Practical Biochemistry Cambridge University Press.
2. Scopes, R. Protein Purification - Principles and Practices. Springer Verlag.
3. Pattabhi V and Gautham N. Biophysics, Kluwer Academic Publishers.
4. Narayanan P. Essentials of Biophysics, New Age International Pvt Ltd.
5. Volkenshtein, M.V. General Biophysics Academic Press, Inc.
6. Daniel, M. Basic Biophysics for biologists Agrobios.

Semester II
Biostatistics and Bioinstrumentation
Paper Code: ZOOMIN2014
No. of Credits 3: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
The objective of this course on Introduction to Biostatistics and Laboratory Techniques is to provide students with a foundational understanding of biostatistics and key laboratory techniques used in biological research.

Course Outcome
- By the end of this course, students will have a solid understanding of the principles and concepts of biostatistics. They will be able to utilize appropriate terminology, symbols, and statistical methods to analyze and interpret biological data.
- Additionally, students will gain practical knowledge of laboratory techniques such as microscopy, centrifugation, spectrophotometry, various chromatography techniques, electrophoresis, and PCR. Overall, this course will equip students with the necessary statistical and laboratory skills to conduct and analyze biological research effectively.

Couse Contents

Theory **Credits: 03**

Unit I
Introduction to Biostatistics: Research and Types of Research, sampling design, Applications of Statistics in Biological Research; Data, Collection and Representation of Data (Pie Chart, Bar Diagram, Histogram, Frequency Polygon), Measures of Central Tendency (Mean, Median, Mode), Variance, Coefficient of Variation, Standard Deviation, Standard Error of Mean,

Unit II
Analysis of Variation (ANOVA): One Way ANOVA and Two-Way ANOVA. Measures of Dispersion, Distribution Patterns (Binomial, Poisson & Normal), Tests of Significance ('T' Test, 'F' Test & Chi-Square Test); Probability; Correlation and Regression Analysis.

Unit III
Principles and Techniques of Microscopy; Magnification and Resolution Parameters of Light, Simple Microscope, Compound Microscope; Types of Compound Microscopes: Bright Field, Dark Field, Phase Contrast Microscope, Scanning & Transmission Electron Microscope; Principle & Applications of Centrifuge machine, pH Meter, Spectrophotometry, Paper Chromatography, Column Chromatography, Thin Layer Chromatography, Gas

Chromatography, Ion Exchange, Affinity Chromatography and Introduction to HPLC.

Practical **Credits: 01**

1. To learn graphical representations of statistical data with the help of computers.
2. To calculate mean, median and mode of a given data
3. To perform a "two-sample t- test" for a given set of data
4. Demonstration of instrumentations

SUGGESTED READINGS

1. Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc. and Dorling Kindersley Publishing Inc.USA.
2. Antonisamy, B., Christopher S. and Samuel, P. P. (2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.

Semester II
Basic Lab Safety & Techniques
Paper Code: ZOOIDC2013
No. of Credits 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective
The objective of the course on Introduction to Laboratory Safety is to provide students with a comprehensive understanding of laboratory safety principles and practices.

Course outcome
- Understand the importance of laboratory safety and the consequences of inadequate safety practices.
- Recognize their roles and responsibilities as laboratory personnel in maintaining a safe working environment.
- Identify and assess common laboratory hazards, including chemical, biological, and physical hazards.

Course contents

Theory **Credits: 02**

Unit I
Introduction to Laboratory Safety: Importance of laboratory safety, Roles and responsibilities of laboratory personnel, Regulatory agencies and guidelines; Hazard Identification and Risk Assessment: Common laboratory hazards (chemical, biological, physical), Hazard communication and labeling, Risk assessment and mitigation strategies; Personal Protective Equipment (PPE): Selection and proper use of PPE (e.g., gloves, lab coats, goggles), PPE maintenance and disposal, PPE for specific hazards (e.g., respiratory protection, cryogenic protection).

Unit II
Chemical Safety: Safe handling and storage of chemicals, Hazardous chemical waste management, Chemical spill response and cleanup procedures; Biological Safety: Handling and disposal of biological materials, Biosafety levels and containment practices, Safe use of biological safety cabinets and other equipment; Physical Safety: Fire safety and emergency procedures, Electrical safety and equipment usage, Ergonomics and injury prevention; Equipment and Instrument Safety: Proper operation and maintenance of laboratory equipment, Calibration and validation of instruments, Safety precautions for specific equipment (e.g., centrifuges, autoclaves); Emergency Preparedness and Response: Emergency evacuation procedures, First aid and medical emergencies.

Practical **Credits: 01**

1. Handling of equipment and chemicals.
2. Handling of First aid.
3. Visit to an advance laboratory.

Suggested Readings

1. Fuscaldo, AA, Erlick, BI, Hindman, B. Laboratory Safety: Theory and Practice. New York: Academic Press, 1980.
2. CRC Handbook of Laboratory Safety. **(**A. Keith Furr, ed.). 5th ed.: CRC Press, 2000.
3. Laboratory Biosafety Manual. Edition: 2nd ed.: World Health Organization, 1993.

Semester II
Aquaculture
Paper Code: ZOOSEC2013
No. of Credits 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective
The objective of the course on Aquaculture Theory is to provide students with a comprehensive understanding of the principles, practices, and techniques involved in aquaculture.

Course Outcome
- Understand the historical development and current state of aquaculture.
- Identify and describe important aquaculture species.
- Apply principles and criteria for site and species selection in aquaculture.

Course contents

Theory **Credits: 02**

Unit I
Introduction to Aquaculture: History and present state. Important aquaculture species. Site and species selection. Water-quality criteria for Aquaculture. Types of culture systems. Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Integrated fish farming. Aquatic weed management. Sustainable Aquaculture;

Unit II
Fish Seed: natural collection; Bundh breeding, Induced breeding; Construction and layout of fish ponds: Productivity and its measurement; Concept of brood fish pond, hatchery, nursery and grow out ponds. Care and stocking rate; water quality management; Preparation of compound diets for fish; Breeding and culture of carps; Ornamental fish culture: Preparation and maintenance of fish aquarium; Common diseases: Bacterial, viral and parasitic; Application of biotechnology in fish production.

Practical **Credit: 01**
1. Identification and study of some important Indian common cultivable freshwater fish species.
2. Determination of dissolved oxygen, Free CO_2, alkalinity, hardness of given water sample.
3. Study of common phytoplankton and zooplankton from natural resources.

4. Collection and identification of aquatic weeds and aquatic insects.
5. Demonstration of Induced breeding of Indian major carps/catfishes

References

1. Jhingran V.G. 1997. Fish and Fisheries of India. Hindustan Publications, Delhi, India.
2. Srivastava, C.B.L. A Text Book of Fishery Science and Indian Fisheries, Kitab Mahal, Allahabad
3. S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House

Semester II
Vermicompost Technology
Paper Code: ZOOVAC2014
No. of Credits 4: {2(T) + 2(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective
The objective of the course on Introduction to Vermiculture is to provide students with a comprehensive understanding of vermiculture, its definition, history, and economic importance.

Course outcome
- Recognize the economic importance of vermiculture in various sectors.
- Appreciate the value of vermiculture in maintaining soil structure and fertility.
- Comprehend the role of vermiculture in the four R's of recycling: reduce, reuse, recycle, and restore.
- Understand the bio-transformation process of residues generated by human activities through vermiculture.

Course contents

Theory **Credits: 02**

Unit I
Introduction to vermiculture: definition, meaning, economic importance, maintenance of soil structure; role as four Rs of recycling: reduce, reuse, recycle, restore. Role in bio-transformation: residues generated by human activity, production of organic fertilizers; Selecting the right worm: Ground population, transformation process in organic matter.

Unit II
Useful species of earthworms: Local and Exotic species of earthworms, Identification keys the species of earthworms; Biology of suitable species for vermicompost (i.e. *Eisenia fetida, Eudrilus eugeniae*); Small Scale Earthworm farming for home gardens— Earthworm compost for home gardens, Conventional commercial composting; Enemies of Earthworms.

Practical **Credits: 01**
1. Key to identify different types of earthworms
2. Field trip- Collection of native earthworms & their identification
3. Study of Systematic position, habits, habitat & External characters of studied earth worms
4. Micro vermicompost preparation.
5. Study of Life stages & development of studied earth worms

6. Field visit

Suggested readings

1. Bhatt J.V. & S.R. Khambata (1959) “Role of Earthworms in Agriculture” Indian Council of Agricultural Research, New Delhi
2. 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.
3. Edwards, C.A. and J.R. Lofty (1977) “Biology of Earthworms” Chapman and Hall Ltd., London.

Semester-III
Basics of Biochemistry
Paper Code: ZOO MAJ 3014
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
A comprehensive understanding of the structures, functions, and significance of carbohydrates, lipids, proteins, and nucleic acids, as well as the ability to apply the knowledge of biological catalysts in analyzing enzyme reactions and their regulation.

Course outcome
- After completing the objectives, the students will understand the structure, classification, and biological significance of carbohydrates, including monosaccharides, disaccharides, polysaccharides, and glycoconjugates, as well as the structure and importance of lipids, such as saturated and unsaturated fatty acids, triacylglycerols, phospholipids, glycolipids, and steroids.
- Besides, they will know about the structure and classification of amino acids, including α-amino acids, and their physiological importance, along with the bonds stabilizing protein structure, levels of organization in proteins, denaturation, introduction to simple and conjugate proteins, as well as the structure of nucleic acids, including purines, pyrimidines, nucleosides, nucleotides, and nucleic acids. Additionally, to understand the nomenclature, classification, specificity, mechanism, kinetics, and regulation of enzyme action as biological catalysts.

Theory **Credits: 03**

Unit I
Carbohydrates: Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates; Lipids: Structure and Significance; Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

Unit II
Proteins and Nucleic acids: Structure, Classification and General properties of α-amino acids; Physiological importance of essential and non-essential α-amino acids; Proteins: protein structure, Levels of organization in proteins, Denaturation, Introduction to simple and conjugate proteins; Nucleic Acids: Structure of Purines and pyrimidines, Nucleosides, Nucleotides, Types of Nucleic acids.

Unit III

Biological Catalysts: Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of Km and Vmax, Lineweaver-Burk plot; Enzyme inhibition; Allosteric enzymes and their kinetics.

Practical **Credits: 01**

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Protein Estimation by Lowry's method.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH in salivary amylase enzyme

Suggested Readings

1. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition,W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well,
4. P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
5. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
6. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

Semester-III
Principles of Ecology and Animal Behaviour
Paper Code: ZOO MAJ 3024
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
The objective of this course is to provide students with a basic understanding of ecosystems and their services to mankind.

Course outcome
The course aims to provide students with a basic understanding of ecosystems and their services to mankind. They will learn about the interrelationships between living organisms and their environment, and how ecosystems contribute to human well-being.

Course Contents
Theory **Credit: 03**

Unit I
Introduction to Ecology: Autecology and synecology, Levels of organization, Laws of limiting factors, Study of physical factors. Population: Unitary and Modular populations. Unique and group attributes of population: Density, natality, mortality, life tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion, Exponential and logistic growth, equation and patterns, r and K strategies, Population regulation– density-dependent and density-independent factors.

Unit II
Community: Community characteristics: species richness, dominance, diversity, abundance, Ecotone and edge effect; Ecological succession, Climax community. Ecosystem: Types of ecosystems Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains; Food web; Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies.

Unit III
Animal Behaviour: Introduction to Ethology, scope and methods of ethology, stimuli, stimulus filtering; Patterns of Behaviour: Individual behavioural Pattern, Homing behaviour; Genetic basic of behaviour; Neural and hormonal control of behaviour; Circadian rhythm; Motivation: Models of motivation, feeding and drinking; Learning behavior: types of learning, habituation, conditional reflex, insight learning, association learning, Reasoning and Imprinting; Social organization, Animal communications, Social behavior of Insects: dance language of honey bees.

Practical **Credits: 01**

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon- Wiener diversity index for the same community.
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, turbidity/penetration of light, temperature, determination of pH, and Dissolved Oxygen content (Winkler's method), and free CO2.
4. To submit report on a visit to National Park/Biodiversity Park/Wild life sanctuary within N.E. India.
5. Use of apparatus for to study ecological parameters (eg. pH meter, Hygrometer, Maximum & minimum thermometer)
6. Students are required to submit a brief project report on animal behavioural study with appropriate photographs, drawings etc. conducted on domestic animals/ pets).

SUGGESTED READINGS

1. Colinvaux, P. A. (1993). Ecology. I 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
4. Robert Leo Smith. Ecology and field biology Harper and Row publisher
5. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.

Semester-III

Evolutionary Biology and Genetics

Paper Code: ZOOMIN3014

No. of Credits 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

It aims to familiarize individuals with the historical development of evolutionary concepts, the evidences supporting evolution, and the various mechanisms that drive genetic variation and inheritance. Additionally, it aims to explore the role of mutations, chromosomal aberrations, and genetic elements in shaping the genetic makeup of organisms.

Course outcome

- The outcome of studying these topics is to equip individuals with a solid foundation in evolutionary biology, genetics, and inheritance, enabling them to apply this knowledge to various fields such as medicine, agriculture, and conservation.
- Individuals will develop critical thinking and analytical skills necessary for evaluating scientific evidence and conducting further research in these areas.

Course contents

Theory **Credits: 03**

Unit I

Evolution of eukaryotes; Evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism; Evidences of Evolution: Fossil record, Molecular evolution, molecular clock; Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution, Natural selection: types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. Genetic Drift, founder's effect, bottleneck phenomenon; Role of Migration and Mutation in changing allele frequencies.

Unit II

Mendelian Genetics and its Extension: Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked inheritance. Linkage, Crossing Over and Chromosomal Mapping: Linkage and crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two-factor and three-factor crosses, Interference and coincidence, Somatic cell hybridization. Mutations: Types of gene mutations and chromosomal aberrations.

Unit III

Chromosomal mechanisms of sex determination in Drosophila and Man. Extra-chromosomal Inheritance: Criteria for extra-chromosomal inheritance. Polygenic inheritance with suitable

examples. Recombination in Bacteria and Viruses: Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposable Genetic Elements: Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans.

Practical **Credit 01**

1. To study the Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from *Drosophila* crosses.
4. Study of human karyotype (normal and abnormal).
5. Study of fossils from models/ pictures
6. Study of homology and analogy from suitable specimens
7. Study and verification of Hardy-Weinberg Law by chi square analysis

Suggested readings

1. Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett Publishers.
2. Campbell, N.A. and Reece J.B. (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
3. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
4. Snustad. S. Principles of Genetics.

Semester-III
Human-Wildlife Conflict and Management
Paper Code: ZOO IDC 3013
No. of Credits 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (3 hour/ Week)

Objective
This paper deals with the conflicts that have arisen as a result of shrinkage of wildlife habitats and the same being shared by human communities. It raises questions about the moral obligations of humans, need for conservation, and social impacts of conflicts. The paper aims at introducing the students to the scientific and social perspective of conservation.

Course outcome
- The course provides students with a comprehensive understanding of the evolution of wildlife management, the importance of conservation efforts, the significance of protected areas, and the socio-economic aspects of conflicts and coexistence between humans and wildlife.
- Students will develop critical thinking skills and gain insights into the complexities of wildlife conservation and sustainable development.

Course contents
Theory **Credit: 02**

Unit I
Evolution of the concept of wildlife management: Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; understanding wildlife management, conservation and policies regarding protected areas in 21st century; positive values of wildlife conservation (monetary, recreational, scientific and ecological benefits). The role of government, wildlife biologists and social scientists in conservation.

Unit II
Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves; concept of core and buffer area in a protected range); IUCN categories of protected areas, Natural World Heritage sites; brief introduction to Wildlife Protection Act of 1972. Socio-economic and legal basis of conflicts: Concepts of development and encroachment, Impact of conflict on humans and wildlife, impact of habitat fragmentation; social inequality in terms of forest conservation: forest produce as a need vs. forest exploitation; introduction to tribal rights in India. Human wildlife coexistence: Symbiotic relationship between tribals and forest, community participation in forest management, Chipko movement, India's Bishnoi community and their conservation practices.

Practical **Credit: 01**

1. Visit to a fringe village to a protected area and interview with the local community.
2. Socio-economic survey around a protected area.

Suggested readings

1. Woodroffe, R. 2005. People and Wildlife: Conflict and Coexistence. Cambridge.
2. Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. People and Wildlife, Conflict or Coexistence? (No. 9). Cambridge University Press. Conover, M. 2001. Resolving Human Wildlife Conflicts, CRC Press.
3. Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation 13: 458-466.
4. Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. International Biodeterioration & Biodegradation 45: 97-102.
5. Paty, C. 2007. Forest Government and Tribe. Concept Publishing Company.
6. Treves, A. & Karanth, K. U. 2003. Human---carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17: 1491-1499.

Semester III

Animal Husbandry and Livestock Management

Paper Code: ZOO SEC 3013

No. of Credits 3: {2(T) + 1(P)}

Total hours: 30 (Theory) (3 hour/ Week)

Objective

The objective of the course "Introduction to Poultry Husbandry" is to provide participants with a comprehensive understanding of poultry farming.

Course outcome

- Demonstrate proficiency in housing management, providing appropriate facilities for the comfort, health, and productivity of dairy cattle.
- Understand the principles and practices of meat production, abattoir management, and processing of meat and milk products.
- Comprehend the importance of animal welfare and apply relevant guidelines to ensure the ethical treatment of dairy cattle.

Course contents

Theory **Credit: 02**

Unit I

Introduction to poultry husbandry: Different species of poultry, Housing management, Feeds Management, Management of chicken, Selection of eggs and hatchery management, Diseases of poultry, economics of poultry farm, Sanitation and hygiene of farm, management of waste disposal; Introduction to Diary Farming: cattle breeds, Farm management – feed, fertility, newborn and pregnant animal management, housing management, milk and milk products, Zoonotic diseases, Animal welfare, and food safety guidelines.

Unit II

Introduction to piggery sector in India and Assam, Scientific piggery farming, Types of pig breeds and its selection, Breeding management, Care during pregnancy and farrowing, Piglet care, Creep feeding, Orphan pigs, Feeding management; Housing: Important points for pig housing, Diseases and health Care; Livelihood with piggery, Sanitation and hygiene of farm, management of waste disposal.

Practical **Credits: 01**

1. Identification of locally available poultry breeds.
1. Identification of locally available cattle breeds.
2. Identification of locally available pig breeds.
3. Designing of housing for local small pig breeders
4. Visit of nearby poultry/dairy/pig farm and submission of a project report.

Suggested Readings

1. Das D, Das BC and Nayak N (2021). Text Book on Poultry Management. Publisher: Narendra Publishing House
2. Singh RA. (2009). Poultry Production. Publisher: Kalyani Production
3. Prasad J. (2016). Principles and Practices of Dairy Farm Management
4. Eri Board (2008). Hand Book of Pig Farming. Publisher: Engineers India Research Institute
5. Sharda DP. (2005). Swine Production. Publisher: ICAR, New Delhi
6. Training Manuals provided by different Govt. Departments.

Semester-IV
Physiology: Life-Sustaining Systems
Paper Code: ZOO MAJ 4014
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of the course is to provide students with a fundamental understanding of the physiology of digestion, respiration, renal function, blood, and the heart.

Course outcome

- Students will be gaining knowledge on important life sustaining systems.
- Students will have detail knowledge on important processes of animal body.
- Students will have laboratory-oriented knowledge for handling some of important physiological& biochemical tests.

Course contents

Theory **Credits: 03**

Unit I

Physiology of Digestion: Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food. Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins. Hormonal control of secretion of enzymes in Gastrointestinal tract. Physiology of Respiration: Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning.

Unit II

Renal Physiology: Structure of kidney and its functional unit (Nephron); Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance. Blood: Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Kallikrein-Kinninogen system, Fibrinolytic system, Haemopoiesis, Blood groups: Rh factor, ABO and MN.

Unit III

Physiology of Heart: Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses Cardiac cycle; Cardiac output and its regulation, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation.

Practical **Credits: 01**

1. Determination of ABO Blood group.

2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Estimation of haemoglobin using Sahli's haemoglobinometer
4. Preparation of haemin and haemochromogen crystals
5. Recording of blood pressure using a sphygmomanometer.
6. Examination of permanent slide of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.

Suggested readings:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
3. Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills.

Semester IV
Principles of Genetics
Paper Code: ZOO MAJ 4024
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
The course aims to provide students with a comprehensive understanding of Mendelian genetics and its extensions, equipping them with the knowledge to analyze and interpret complex genetic phenomena.

Course outcome
- Demonstrate a comprehensive understanding of the principles of inheritance and the various extensions of Mendelian genetics, including incomplete dominance, co-dominance, multiple alleles, lethal alleles, epistasis, pleiotropy, sex-linked inheritance, linkage, crossing over, chromosomal mapping, mutations, sex determination, extra-chromosomal inheritance, polygenic inheritance, recombination in bacteria and viruses, and transposable genetic elements.
- Apply their knowledge to analyze and interpret complex genetic phenomena, enabling them to explain patterns of inheritance, predict outcomes of genetic crosses, and understand the molecular basis of genetic mutations.
- Develop critical thinking and problem-solving skills in the field of genetics, allowing them to approach genetic research and practical applications with a solid foundation of knowledge and analytical abilities.

Course Contents
Theory **Credits: 03**

Unit I
Mendelian Genetics and its Extension: Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked inheritance. Linkage, Crossing Over and Chromosomal Mapping: Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two-factor and three-factor crosses, Interference and coincidence, Somatic cell hybridization.

Unit II
Mutations: Types of gene mutations, Types of chromosomal aberrations, Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: ClB method, attached *X*-method. Sex Determination: Chromosomal mechanisms of sex determination in Drosophila and Man. Extra-chromosomal Inheritance: Criteria for extra-chromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces,* Infective heredity in *Paramecium* and Maternal effects.

Unit III

Polygenic Inheritance: Polygenic inheritance with examples; Recombination in Bacteria and Viruses: Conjugation, Transformation, Transduction; Complementation test in Bacteriophage; Transposable Genetic Elements: Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans.

Practical **Credits: 01**

1. To study the Mendelian laws and gene interactions.
2. Chi-square analyses using seeds/beads/*Drosophila*.
3. Linkage maps based on data from conjugation, transformation and transduction.
4. Linkage maps based on data from *Drosophila* crosses.
5. Study of human karyotype (normal and abnormal).
6. Pedigree analysis of some human inherited traits.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India
2. Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition. Benjamin Cummings
4. Russell, P. J. (2009). *Genetics- A Molecular Approach.* III Edition. Benjamin Cummings
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co
6. Fletcher H. and Hickey I. (2015). *Genetics.* IV Edition. GS, Taylor and Francis Group, New York and London.

Semester IV
Animal Biotechnology
Paper Code: ZOO MAJ 4034
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
Introduce students to biotechnology concepts and molecular techniques in gene manipulation.

Course outcome
- Students will have a concept and aids of technology on biological study.
- They will learn culture techniques and their application.

Course contents
Theory **Credits: 03**

Unit I
Molecular Techniques in Gene manipulation: Restriction enzymes: Nomenclature, detailed study of Type II; Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, artificial vectors (M13, BAC, YAC, MAC); Genomic and cDNA libraries; Expression vector and cloning.

Unit II
Gene Transfer Techniques: DNA microinjection: Calcium chloride method and electroporation; screening by colony and plaque hybridization; Southern, Northern and Western blotting; PCR; DNA sequencing: Sanger method and Maxam-Gilbert method, DNA Fingerprinting; DNA and RNA micro array.

Unit III
Genetically Modified Organisms: Transgenic animals: Nuclear Transplantation, Retro-viral Method; Applications of transgenic animals: Production of pharmaceuticals, knock-out mice; Production of transgenic plants; Applications of transgenic plants: insect and herbicide resistant plants; Culture Techniques and Applications: Animal cell culture, Molecular diagnosis of genetic diseases (e.g., cancer); rDNA technology in medicines: Recombinant insulin and human growth hormone, Gene therapy.15

Practical **Credits: 01**
1. Genomic DNA isolation from *E. coli.*
2. Estimation of DNA by colorimetric method.
3. Restriction digestion of plasmid DNA.
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques through photographs:
    a) Southern Blotting

b) Northern Blotting
c) Western Blotting
d) DNA Sequencing (Sanger's Method)
e) PCR
f) DNA fingerprinting

Suggested Readings

1. Brown, T.A. (1998). *Molecular Biology Labfax II: Gene Cloning and DNA Analysis*. II Edition, Academic Press, California, USA.
2. Glick, B.R. and Pasternak, J.J. (2009). *Molecular Biotechnology - Principles and Applications of Recombinant DNA*. IV Edition, ASM press, Washington, USA.
3. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). *An Introduction to Genetic Analysis*. IX Edition. Freeman and Co., N.Y., USA.
4. Snustad, D.P. and Simmons, M.J. (2009). *Principles of Genetics.* V Edition, John Wiley and Sons Inc.

Semester IV

Physiology and Biochemistry

Paper Code: ZOO MIN 4014

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of the course is to provide students with a fundamental understanding of the physiology of digestion, respiration, renal function, blood, and the heart.

Course outcome

- Students will be gaining knowledge on important life-sustaining systems.
- Students will have detail knowledge on important processes of animal body.
- Students will have laboratory-oriented knowledge for handling some of important physiological& biochemical tests.

Course contents

Theory **Credits: 03**

Unit I

Physiology of Digestion: Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins. Physiology of Respiration: Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Control of respiration.

Unit II

Renal Physiology: Structure of kidney and its functional unit (Nephron); Mechanism of urine formation. Blood: Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Blood groups: Rh factor, ABO and MN. Structure of mammalian heart, Origin and conduction of cardiac impulses Cardiac cycle, Blood pressure and its regulation.

Unit III

Biomolecules of Life: Structure and Biological importance of Monosaccharides, Disaccharides, Polysaccharides; Structure and Significance of lipids, saturated and unsaturated fatty acids, Tri-acylglycerols; Proteins and Nucleic acids: Structure and Classification; Enzymes and Cofactors; Specificity of enzyme action; Mechanism of enzyme action; Enzyme kinetics; Factors affecting enzyme-catalyzed reactions; Allosteric enzyme; Enzyme inhibition.

Practical **Credits: 01**

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.

2. Protein Estimation by Lowry's method.
3. Determination of ABO Blood group.
4. Preparation of haemin and haemochromogen crystals
5. Recording of blood pressure using a sphygmomanometer.

Suggested readings

1. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
2. Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills.
3. Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.
5. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc

Semester V

Basic Systematics and Diversity of Life-I (Non-Chordates)

Paper Code: ZOO MAJ 5014

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

To provide the students the basic knowledge in Taxonomy& systematics and to provide knowledge on diversity of Non-chordates.

Course outcome

By the end of the course, students will have acquired a strong foundation in animal taxonomy, enabling them to understand and apply systematic principles, perform taxonomic procedures, and classify various organisms accurately. They will also gain insight into the diversity of life and the evolutionary significance of different animal groups.

Course Contents

Theory **Credits: 03**

Unit I

Introduction to Animal Taxonomy: Definition, Basic concepts and importance of Systematics and Taxonomy. Concepts of different conventional taxonomy, alpha(α) and beta (β) taxonomy. Newer aspects in biosystematics: Chemotaxonomy, Cytotaxonomy, Molecular taxonomy. Taxonomic procedures: taxonomic collection, preservation, Components of classification. Taxonomical hierarchy - taxon, category and rank, Linnaean hierarchy, Concepts of taxonomic terms. Nomenclature: Principles of nomenclature. International Code of Zoological Nomenclature (ICZN). Rules of nomenclature. Binominal and trinominal nomenclature. Mention taxonomic aids.

Unit II

Diversity of Life: Protista, Parazoa and Metazoa: General characteristics and Classification up to classes. Study of *Euglena*, *Amoeba* and *Paramecium* Locomotion and Reproduction in Protista. Evolution of symmetry and segmentation of Metazoa. Porifera Cnidaria & Ctenophora: General characteristics and Classification up to classes. Canal system and spicules in sponges. Metagenesis in *Obelia,* Polymorphism in Cnidaria, Corals and coral reefs. Evolutionary significance of ctenophora. Platyhelminthes & Nemathelminthes: General characteristics and Classification up to classes. Life cycle and pathogenicity of *Fasciola hepatica, Taenia solium, Ascaris lumbricoides* and *Wuchereria bancrofti*. Parasitic adaptations in helminthes.

Unit III

Annelida: General characteristics and Classification upto classes, Excretion in Annelida. Arthropoda & Onychophora: General characteristics and Classification upto classes. Vision, and Respiration in Arthropoda. Evolutionary significance of onychophoran. Mollusca & Echinodermata. General characteristics and Classification up to classes. Respiration in

Mollusca. Torsion and detorsion in Gastropoda, Pearl formation in bivalves. Water-vascular system in Asteroidea, Affinities of echinoderms with Chordates.

Practical **Credits: 01**

1. Observation on morphological characters of Cockroach as a part of taxonomical study. Students will note down and draw mouth parts and wing venation of cockroach.
2. To perform morphometric and meristic study of locally available fish.
3. Study of whole mount of *Euglena, Amoeba* and *Paramecium,* Binary fission and Conjugation in *Paramecium.*
4. Study of *Sycon* (T.S. and L.S.), *Hyalonema, Euplectella, Spongilla*
5. Study of *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora*
6. One specimen/slide of any ctenophore
7. Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/microphotographs)
8. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)
9. Museum specimen: *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria* Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer*, *Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta,* termites and honey bees Onychophora - *Peripatus* Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus* Echinodermates - *Pentaceros*/*Asterias, Ophiura, Clypeaster, Echinus, Cucumaria* and *Antedon*
10. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm
11. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta.*

Suggested readings

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science

Online Tools and Web Resources:

3. Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology) ·
4. ePGPathshala (MHRD) Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35.

Semester V

Developmental Biology

Paper Code: ZOO MAJ 5024

No. of Credits –4: {4(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

Acquiring Knowledge on Embryonic Development:

Course outcome

- Students will be able to acquire knowledge on embryonic development of sexually reproducing animals.
- They also obtain knowledge on metamorphic changes and the role of placenta in mammals.

Course contents

Theory **Credits: 03**□5

Unit I

Basic concepts: Phases of embryonic development: zygote, morula, blastula, gastrula, archenteron; Cell-Cell interaction; Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division.

Unit II

Early Embryonic Development: Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Fate maps; Early development of frog and chick up to gastrulation; Embryonic induction and organizers; Late Embryonic Development: Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, structure and function of Placenta.

Unit III

Post Embryonic Development: Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration; Ageing: Concepts and Theories; Implications of Developmental Biology: Teratogenesis: Teratogenic agents and their effects on embryonic development; In vitro fertilization, Stem cell (ESC), Amniocentesis.

Practical **Credits: 01**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)

2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture
4. Study of different sections of placenta (photomicropgraph/ slides)
5. Project report on *Drosophila* culture/chick embryo development

Suggested readings

1. Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
2. Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press
3. Carlson, R. F. Patten's Foundations of Embryology
4. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers
5. Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press.

Semester V

Organic Evolution

Paper Code: ZOO MAJ 5034

No. of Credits 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the origins and processes of life on Earth.

Course outcome

- Students will be able to acquire knowledge on origin of life
- They also obtain knowledge micro evolutionary of the life forms on earth.

Course contents

Theory **Credit: 03**

Unit I

Life's Beginnings: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes; Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse, Molecular evolution: molecular clock, globin gene family, rRNA, cyt c.

Unit II

Population genetics: Hardy-Weinberg Law, Evolutionary forces affecting H-W equilibrium; Natural selection: concept of fitness, selection coefficient, dominant allele, genetic load; heterozygous superiority; kin selection; adaptive resemblances; sexual selection; Genetic drift: Founder's effect, Bottleneck phenomenon; Role of Migration and Mutation in changing allele frequencies.

Unit III

Product of evolution: Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation — allopatric, sympatric, adaptive radiation / macroevolution; Extinctions: mass extinctions (causes and effects), K-T extinction; Origin and evolution of man: Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular aspect of human origin.

Practical **Credits:01**

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

using simulation studies

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. Ridley, M (2004) Evolution III Edition Blackwell publishing
2. Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition.Jones and Barlett Publishers.
3. Campbell, N.A. and Reece J.B. (2011).Biology. IX Edition. Pearson, Benjamin, Cummings.
4. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
5. Snustad. S Principles of Genetics.
6. Pevsner, J (2009). Bioinformatics and Functional Genomics. II Edition Wiley-Blackwell

Semester V

Biochemistry of Metabolic Processes

Paper Code: ZOOMAJ5044

No. of Credits 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the principles and processes involved in metabolism, focusing on catabolism and anabolism.

Course outcome

- Students will have acquired a comprehensive understanding of the fundamental principles and processes involved in metabolism.
- They will be able to explain and analyze the various metabolic pathways, their regulation, and the interconnections between different metabolic processes.
- Students will also develop the ability to apply this knowledge to understand the metabolic basis of various physiological and pathological conditions.

Course Contents

Theory **Credits: 03**

Unit I

Overview of Metabolism: Catabolism *vs* Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as “Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

Unit II

Carbohydrate Metabolism: Glycolysis, Citric acid cycle, pentose phosphate pathway, Gluconeogenesis, Glycogenolysis, glycogenesis; Oxidative Phosphorylation: mitochondrial respiratory chain, Redox potential; Chemiosmotic process, proton motive force, Inhibitors of electron transport chain.

Unit III

Lipid Metabolism: β-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis; Protein Metabolism: Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

Practical **Credits: 01**

1. Estimation of total protein in given solutions by Lowry’s method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue.
3. To study the enzymatic activity of Trypsin and Lipase.
4. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.

Suggested readings

1. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
4. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.

Semester V

Taxonomy and Diversity of Life-I (Non-chordates)

Paper Code: ZOOMIN 5014

No. of Credits 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objectives

To provide the students the basic knowledge in Taxonomy& systematics along with the knowledge on diversity of Non-chordates.

Course outcome

By the end of the course, students will have acquired a strong foundation in animal taxonomy, enabling them to understand and apply systematic principles, perform taxonomic procedures, and classify various organisms accurately. They will also gain insight into the diversity of life and the evolutionary significance of different animal groups.

Course contents

Theory **Credits:03**

Unit I

Introduction to Animal Taxonomy: Definition, Basic concepts and importance of Systematics and Taxonomy; Alpha (α) and beta (β) taxonomy; Molecular taxonomy; Taxonomic procedures: taxonomic collection, preservation, Components of classification; Nomenclature: Principles of nomenclature; International Code of Zoological Nomenclature (ICZN); Rules of nomenclature: Binominal and trinominal nomenclature.

Unit II

Diversity of Life: Protista, Parazoa and Metazoa: General characteristics and Classification up to classes; Study of *Euglena*, *Amoeba* and *Paramecium* Locomotion and Reproduction in Protista; Evolution of symmetry and segmentation of Metazoa; Porifera, Cnidaria & Ctenophora: General characteristics and Classification up to classes; Canal system and spicules in sponges; Metagenesis in *Obelia,* Polymorphism in Cnidaria; Corals and coral reefs; Evolutionary significance of Ctenophora; Platyhelminthes & Nemathelminths: General characteristics and Classification up to classes; Life cycle and pathogenicity of *Taenia solium;* Parasitic adaptations in helminths.

Unit III

Annelida: General characteristics and Classification upto classes, Excretion in Annelida. Arthropoda & Onychophora: General characteristics and Classification upto classes; Vision, and Respiration in Arthropoda. Evolutionary significance of onychophoran. Mollusca & Echinodermata. General characteristics and Classification up to classes; Respiration in Mollusca. Torsion and detorsion in Gastropoda. Water-vascular system in Asteroidea, Affinities of echinoderms with Chordates.

Practical **Credits:01**

1. Observation on morphological characters of any specimen as a part of taxonomical study.
2. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*, Binary fission and Conjugation in *Paramecium.*
3. Study of *Sycon* (T.S. and L.S.)
4. Study of *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora*
5. One specimen/slide of any ctenophore
6. Study of adult *Taenia solium*
7. Museum specimen: *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria* Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta,* termites and honey bees Onychophora - *Peripatus* Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus* Echinodermates - *Pentaceros*/*Asterias, Ophiura, Clypeaster, Echinus, Cucumaria* and *Antedon*
8. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm
9. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta.*

Suggested readings

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
3. **Online Tools and Web Resources**:
4. Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology) ·
5. ePGPathshala (MHRD) Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35.

Semester VI
Diversity of Life-II (Chordates)
Paper Code: ZOO MAJ 6014
No. of Credits 4: {4(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objectives

- To learn the general characteristics and classification of different classes of vertebrates.
- To understand the vertebrate evolutionary tree.
- To understand general aspects of applied interest in relation to vertebrates.

Course outcome

- By the end of the course, students will have acquired a strong foundation in animal taxonomy, enabling them to understand and apply systematic principles, perform taxonomic procedures, and classify various organisms accurately.
- They will also gain insight into the diversity of life and the evolutionary significance of different animal groups.

Course contents

Theory **Credits: 03**

Unit I

Diversity of Life: Salient features and outline classification (up to order) of various chordate groups as covered under respective taxonomic groups. Protochordata: Salient features of body organisation and systematic position of *Balanoglossus* and *Amphioxus* as a type and its affinities. Agnatha**:** External features of *Petromyzon*.

Unit II

Pisces: Scales and fins in fishes. Parental care in fishes. Fishes in relation to man. Amphibia: General characters and affinities of Gymnophiona. Parental care in Amphibia. Reptilia: A brief knowledge of extinct reptiles. Poisonous and non- poisonous snakes. Poison apparatus of snake. Snake venom and anti-venom. Adaptive radiation in reptiles. Adaptations of reptiles to desert life.

Unit III

Aves: Flightless birds and their distribution. Flight adaptations in birds. Mammalia: General organisation, distribution and affinities of Prototheria. Economic importance. Adaptive radiation with particular reference to aquatic mammals.

Practical **Credits: 01**

1. Study of the following specimens: *Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo,Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Hemidactylus, Chamaeleon,*

Draco, Vipera, Naja, Crocodylus, Gavialis, Any six common birds from different orders, Bat, Funambulus, Loris.

2. Key for Identification of poisonous and non-poisonous snakes.
3. Preparation of permanent slides of fish scales.
4. To prepare an "**animal album**" containing drawing photographs, cut outs, with appropriate write up about the above-mentioned taxa. Different taxa/ topics may be given to different sets of students for this purpose.

Suggested Readings

1. Hickman, Roberts & Hickman: Integrated principles of Zoology (7^{th}) ed Times- mirror, Mosby
2. Kotpal R.L: Modern Textbook of Zoology: Invertebrates. Rastogi
3. Nigam: Biology of Non-Chordates, Nagin Chand.
4. Parker TJ & haswell WA: Textbook of zoology Vol I & II, Mcmillan.
5. Hyman L: Invertebrate Series, Academic Press

Semester VI
Comparative Anatomy of Vertebrates
Paper Code: ZOO MAJ 6024
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
The objective is to acquire a comprehensive understanding of the structure, function, and evolutionary significance of the integumentary system, skeletal system, digestive system, respiratory system, circulatory system, urinogenital system, nervous system, and sense organs.

Course outcome
- Students will be gaining knowledge on development and modifications of important anatomical structures in vertebrates.
- Students will have detail knowledge body organization in terms of different tissues.
- Students will have laboratory-oriented knowledge to study microscopic structure of tissues and cells.

Course contents
Theory **Credit: 03**

Unit I
Integumentary System: Structure and derivatives of integument, functions of skin. Skeletal System: Outline of axial and appendicular skeleton: basic plan of bones of skull, girdles and limbs. Classification of vertebrae, structure of a typical vertebra, Jaw suspensorium, Visceral arches. Digestive System: Brief account of alimentary canal and digestive glands, dentition.

Unit II
Respiratory System: Skin, gills, lungs and air sacs; swim bladder and Accessory respiratory organs. Circulatory System: General plan of circulation, Evolution of heart and aortic arches. Urinogenital System: Succession of kidney, Evolution of urinogenital ducts Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

Unit III
Nervous System: Comparative account of brain; Autonomic nervous system, Spinal cord, Cranial nerves in Mammals; Sense Organs: Types and Classification of receptors; Brief account of visual and auditory receptors in man.

Practical **Credit: 01**
1. Disarticulated skeleton of fowl and rabbit
2. Study of different types of beaks found in birds.
3. Mammalian skulls: One herbivorous and one carnivorous animal.

4. Study of different tissue through permanent slides: Epithelial (simple, squamous, cuboidal, columnar Compound, stratified, transitional) muscular tissue, Connective tissue (bone, cartilage, areolar, tendon, adipose, reticular) and nervous tissue.

Suggested readings

1. Kardong, K.V. (2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IVEdition. McGraw-Hill Higher Education.
2. Kent, G.C. and Carr R.K. (2000). *Comparative Anatomy of the Vertebrates*. IX Edition,The McGraw-Hill Companies.
3. Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*, John Wiley and SonsWalter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishing House.

Semester VI
Molecular Biology
Paper Code: ZOO MAJ 6034
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
The objective of this course is to provide students with a comprehensive understanding of the fundamental principles and concepts in genetics.

Course outcome
- By the end of the course, students will have acquired a comprehensive understanding of the history, development, and scope of genetics.
- They will be able to explain the nature of genetic material, including DNA and RNA, understand the processes of DNA replication, transcription, and translation, and comprehend the concepts of gene expression and gene regulation.
- Students will also gain knowledge about the genetic code, its deciphering, and the contributions of key scientists in the field of genetics.

Course contents
Theory **Credit: 03**

Unit I
Introduction: Nature of genetic material: Search for the genetic material, Griffith's experiment, transformation experiment, Avery, MacLeod and McCarty, Hershey & Chase experiment; Watson - Crick model of DNA, clover leaf model of tRNA, different types of DNA and RNA; DNA replication in prokaryotes and eukaryotes, Stahl experiment, replication machinery and mechanism; modification and repair of DNA.

Unit II
Gene Expression: One gene-one enzyme hypothesis, one genome polypeptide hypothesis, central dogma of Molecular Biology, co-linearity of genes and gene products; Genetic code - deciphering / cracking the genetic code, characteristics of genetic code, codon assignment and wobble hypothesis; Transcription of RNA, post-transcriptional modifications of mRNA, reverse transcription, Translation - machinery and mechanism; post translational modification of proteins.

Unit III
Gene regulation: Prokaryotes (inducible and repressive systems); Operon concept - Lac operon and Trp operon; Bacterial Recombination: transformation, conjugation and transduction (general and specialized transduction)

Practical **Credit: 01**

1. Models of ribosome structure
5. Preparation of DNA by Feulgen reaction.
6. Study of Polytene chromosomes from Chironomous / Drosophila larvae.
7. Identification of male and female Drosophila.
8. Study and interpretation of electron micrographs/ photograph showing
   a) DNA replication b) Transcription.
9. Study of genetic syndromes and abnormal karyotypes of human (Klinefelter's syndrome. Turner's syndrome. Down syndrome and Edward syndrome (Through diagrams)

Suggested readings

1. Alberts, B. et al. Molecular Biology of the Cell. Garland Pubg. Inc., New York
2. Karp G. (2005). *Cell and Molecular Biology*.4 e, John Wiley & Sons, Inc.
3. Kleinsmith, L. J. & Kish, V. M. (1995). *Principles of Cell and Molecular Biology*. Harper Collins College Pubs
4. Sheeler, P. and Bianchi D. E. *Cell Biology - Structure, Biochemistry and Functions*.
5. Veera Bala Rastogi. (2006). *Fundamentals of Molecular Biology* 1 e. Ane Books, India
6. Watson, J.D. *et al., Molecular Biology of the Gene*, 4e, Benjamin Cummings.

Semester VI
Biostatistics & Bioinformatics
Paper Code- ZOO MAJ 6044
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the fundamental concepts and principles of genetics.

Course outcome

- By the end of the course, students will have acquired a solid understanding of genetics, enabling them to analyze genetic patterns, interpret pedigrees, and understand the molecular basis of inheritance.
- They will be able to apply their knowledge to real-world situations and make informed decisions regarding genetic testing, genetic engineering, and ethical considerations in genetics.

Course contents

Theory **Credits: 03**

Unit I

Biostatistics: Introduction to Biostatistics, Research and Types of Research, sampling design, Applications of Statistics in Biological Research; Data, Collection and Representation of Data (Pie Chart, Bar Diagram, Histogram, Frequency Polygon), Measures of Central Tendency (Mean, Median, Mode), Variance, Coefficient of Variation, Standard Deviation, Standard Error of Mean, Analysis of Variation (ANOVA); One Way ANOVA and Two-Way ANOVA. Measures of Dispersion, Distribution Patterns (Binomial, Poisson & Normal), Tests of Significance ('T' Test, 'F' Test & Chi-Square Test); Probability; Correlation and Regression Analysis.

Unit II

Bioinformatics: Introduction to Bioinformatics: Importance, Goal, Scope; Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny; Applications and Limitations of Bioinformatics. Applications of Bioinformatics: Structural Bioinformatics (3-D protein, PDB), Functional genomics (genome- wide and high throughput approaches to gene and protein function), Drug discovery method (Basic concepts).

Unit III

Biological Databases: Introduction to biological databases; Primary, secondary and composite databases; Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB); Metabolic pathway database (KEGG, EcoCyc, and MetaCyc); Small molecule databases (PubChem, Drug Bank, ZINC, CSD). Data Generation and Data Retrieval: Generation of data (Gene sequencing, Protein

sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin,Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal,Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez); Basic Concepts of Sequence Alignment: Types of sequence alignment; Local and global alignment, pair wise and multiple sequence alignments; Similarity, identity and homology of sequences.

Practical **Credits: 01**

1. Accessing biological databases
2. Retrieval of nucleotide and protein sequences from the databases.
3. To perform pair-wise alignment of sequences (BLAST) and interpret the output
4. Predict the structure of protein from its amino acid sequence.
5. To perform a "two-sample t- test" for a given set of data
6. To learn graphical representations of statistical data with the help of computers.

Suggested Readings

1. Ghosh Z and Mallick B. (2008). Bioinformatics: Principles and Applications, Oxford University Press.
2. Pevsner J. (2009). Bioinformatics and Functional Genomics, II Edition,
3. Wiley Blackwell. Zvelebil, Marketa and Baum O. Jeremy (2008). Understanding Bioinformatics, Garland Science, Taylor and Francis Group, USA.
4. Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc. and Dorling Kindersley Publishing Inc. USA.
5. Antonisamy, B., Christopher S. and Samuel, P. P.(2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.
6. Pagana, M. and Gavreau, K. (2000). Principles of Biostatistics, Duxberry Press, USA

Semester VI
Diversity of Life-II (Chordates)
Paper Code: ZOOMIN6014
No. of Credits 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

To provide the students with an in-depth knowledge of the diversity in form, structure and habits of Chordates.

Course outcome

- To learn the general characteristics and classification of different classes of vertebrates.
- To understand the vertebrate evolutionary tree.
- To understand general aspects of applied interest in relation to vertebrates.

Theory **Credit: 03**

Unit I

Diversity of Life: Salient features and outline classification (up to order) of various chordate groups as covered under respective taxonomic groups. Protochordata: Salient features of body organisation and systematic position of *Balanoglossus* and *Amphioxus* as a type and its affinities. Agnatha**:** External features of *Petromyzon*.

Unit II

Pisces: Scales and fins in fishes. Parental care in fishes. Fishes in relation to man. Amphibia: General characters and affinities of Gymnophiona. Parental care in Amphibia. Reptilia: A brief knowledge of extinct reptiles. Poisonous and non- poisonous snakes. Poison apparatus of snake. Snake venom and anti-venom. Adaptive radiation in reptiles. Adaptations of reptiles to desert life.

Unit III

Aves: Flightless birds and their distribution. Flight adaptations in birds. Mammalia: General organisation, distribution and affinities of Prototheria. Economic importance. Adaptive radiation with particular reference to aquatic mammals.

Practical **Credits: 01**

1. Study of the following specimens: Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo,Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis, Any six common birds from different orders, Bat, Funambulus, Loris.
2. Key for Identification of poisonous and non-poisonous snakes.
3. Preparation of permanent slides of fish scales.

4. To prepare an "**animal album**" containing drawing photographs, cut outs, with appropriate write up about the above-mentioned taxa. Different taxa/ topics may be given to different sets of students for this purpose.

Suggested readings

1. Hickman, Roberts & Hickman: Integrated principles of Zoology (7^{th}) ed Times- mirror, Mosby
2. Kotpal R.L: Modern Textbook of Zoology: Invertebrates. Rastogi
3. Nigam: Biology of Non-Chordates, Nagin Chand.
4. Parker TJ & Haswell WA: Textbook of zoology Vol I & II, McMillan.
5. Hyman L: Invertebrate Series, Academic Press

Semester VII

Cell Structure and Function

Paper Code: ZOOADL7014

No. of Credits 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

The course aims to explore cell organization, including classification, metabolic evolution, viral and bacterial structure, eukaryotic origin, and cellular modeling, alongside investigating the cell membrane's composition, transport mechanisms, and the structure and function of the nucleus and nucleolus.

Course outcome

Upon completion, students will be able to

- classify cells based on morphology and function,
- comprehend viral and bacterial structures, analyze the structure and function of the nucleus and nucleolus
- explain transport mechanisms across cell membranes, and

Course contents

Theory **Credit 03**

Unit I

Cell Organization: Cell classification, cell variability (size, shape, complexity, functions); Prokaryotes - origin and evolution of metabolism, Viruses - structure and replication; Bacteriophage (Lambda phage, phi x 174), Animal DNA virus (SV 40), Retroviruses (HIV); Bacteria - Structure and reproduction of E. coli; Plasmid and their functions, Eukaryotes – origin of eukaryotes, development of multicellular eukaryotes; cells as experimental models

Unit II

Cell Membrane and Transport System: Models of cell membrane; fluid mosaic model of membrane; composition and organization of lipid bilayer and membrane proteins, Fluidity of cell membrane; transport across cell membrane – Channels and transporters, Diffusion, osmosis and measurement of osmotic pressure, Ionic concentration and membrane potential; Active transport and ion transports- types, ATP powered pumps, Co-transport by symporters and antiporters; transcellular transport.

Unit III

Nucleus and Nucleolus: Structure and organization of nucleus - nuclear membrane, nuclear lamina, and nuclear pore complex – structure and function, Organization of nuclear membrane during cell division, chromosome territory inside nucleus, selective transport of

molecules into and out of the Nucleus, Nucleo-skeleton and nuclear matrix; Nucleolus and its structure; Assembly and biogenesis of ribosomes.

Practical **Credit 01**

1. Differential staining techniques (Wright-Giemsa) for morphological studies of the cell
2. Differential centrifugation to separate cellular organelle
3. Identification of organelle (mitochondria, nuclei) by using biochemical assay
4. Trypan blue cytotoxicity assay
5. Staining of cells with fluorescent dyes (immunofluorescence)

Suggested readings

1. Lodish et al: Molecular Cell Biology. 8th edition 2016, W. H. Freeman and Company
2. Alberts et al: Molecular Biology of the Cell. 5th edition, 2008, Garland Science
3. Cooper and Hausman: The Cell. 4th edition, 2007; Sinauer Associates, USA
4. Lynne Cassimeris et al.: Lewin's cells. 3rd edition, 2015. Jones & Bartlett Learning, USA

Semester VII

Overview of Immune System

Paper Code: ZOOADL7024

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hours/ Week)

Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

The objective of this course is to provide students with a comprehensive understanding of the immune system, its components, functions, and the various aspects related to immunology.

Course Outcomes

- By the end of the course, students will have acquired a thorough understanding of the immune system, its components, and their functions. They will be able to explain the principles of innate and adaptive immunity, antigen-antibody interactions, and the roles of immunoglobulins, cytokines, and complement in immune responses.
- Students will also gain knowledge about hypersensitivity reactions, major histocompatibility complex (MHC), and the different types of vaccines. They will be equipped with the ability to apply their knowledge to analyze and interpret immunological processes and their significance in disease prevention, diagnosis, and therapeutics.

Course contents

Theory **Credit 03**

Unit I

Overview of Immune System: Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system. Innate and Adaptive Immunity: Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity, Immune dysfunctions (brief account of autoimmunity with reference to Rheumatoid Arthritis and tolerance, AIDS).

Unit II

Antigens: Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes. Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA and RIA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

Unit III

Major Histocompatibility Complex: Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigen processing and presentation. Cytokines: Properties and functions of cytokines, Therapeutics Cytokines; Complement System: Components and

pathways of complement activation; Hypersensitivity: Gell and Coombs' classification and types of hypersensitivities. Vaccines: types of vaccines.

Practical **Credit 01**

1. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of blood cells.
4. Ouchterlony's double immuno-diffusion method.
5. ABO blood group determination.
6. Cell counting and viability test from splenocytes of farm bred animals/cell lines.
7. Demonstration of:
   a. ELISA
   b. Immuno electrophoresis

Suggested Readings

1. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). *Immunology*, VI Edition. W.H. Freeman and Company.
2. David, M., Jonathan, B., David, R. B. and Ivan R. (2006). *Immunology*, VII Edition, Mosby, Elsevier Publication.

Semester VII

Endocrinology and Hormonal Regulation

Paper Code: ZOOADL7034

Paper credit: 04 (3T+1P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

- Understand hormone biochemistry and molecular mechanisms of action.
- Describe the endocrine physiology of major vertebrate glands.
- Explain hormonal regulation of reproduction and environmental responses.
- Analyze endocrine disorders and prostaglandin physiology.
- Demonstrate practical skills in endocrine organ identification and functional assays.

Course Outcome

- Make students proficiency in hormone biochemistry and physiology.
- Identification and understanding of major endocrine glands.
- Competence in reproductive and environmental hormonal regulation.
- Analysis of endocrine disorders and prostaglandin roles.
- Practical skills in endocrine organ study and functional assays.

Course contents

Theory **Credit 03**

Unit I

Characteristic and Transport of Hormones, Neurosecretions and Neurohormones, Chemical nature and classification of hormones, endocrine, paracrine and autocrine hormones; hormone receptors and target organs; Hormones as 2nd messengers, molecular basis of hormone action: structure and signal transduction mechanisms (steroid and peptide hormones); Hormonal regulation of ovulation: gestation, parturition and lactation, Hormonal regulation of spermatogenesis.

Unit II

Endocrine physiology in vertebrates: Pituitary, thyroid, parathyroid, adrenal and pancreas, hormones of islets of Langerhans and their functions, insulin and glucagon in carbohydrate metabolism, calcium regulating hormones, Biosynthesis of T3, T4, epinephrin and nor-epinephrin, melatonin, steroid hormone and, their metabolic functions. Chemical structure and function of JH, JH as a gonadotropin, Prothoracic gland and ring gland, Role of Juvenile hormone analogues and ecdysteroids in pest control.

Unit III

Neuroendocrine systems in vertebrates, Tropic hormones and their feedback system and response to various stimuli (tolerance to temperature, stress, osmotic regulation); Pathophysiology of pituitary dwarfism, gigantism and acromegaly; Grave's disease; Prostaglandins: Source, chemical nature, structure, functions, physiological significance and clinical implications; gastrointestinal hormones and their regulation and functions.

Practical **Credit 1**

1. Demonstration of endocrine organs in vertebrates.
2. Dissection and display of pituitary gland of mouse/fish
3. Dissection and display of thyroid and parathyroid gland of mouse/chicken
4. Histological study of pituitary, adrenal, testis, ovary, corpus luteum, pancreas and thyroid gland (Permanent slide)
5. Assess the roles of insulin and glucagon in carbohydrate metabolism through glucose tolerance tests or insulin sensitivity assays.

Suggested readings

1. Norris: Vertebrate Endocrinology (2nd Edition) Lea & Febriger. 1997.
2. Text book of Medical Physiology 11th Edition. By C. Guyton, M.DJohn E. Hall (2006)
3. Mammalian Endocrinology (4th edition), NCBA, by Ashoke kumar Boral (2011).
4. Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead. Oxford: BIOS Scientific Publishers; 2001.
5. Hadley, M.E. and Levine J.E. 2007.Endocrinology, 6th Edition.Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
6. Insect Physiology and Biochemistry, 3rd Edition by James L. Florida, U.S.A. (2015)

Semester VII
Ecology & Environmental Biology
Paper Code: ZOOADL7044
Paper credit: 04(3T+1P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

The objective of studying Introduction to Ecology is to provide individuals with a strong foundation in ecological principles and processes. This knowledge can be applied to various aspects of ecological research, conservation efforts, and environmental management to contribute to the understanding and preservation of our natural world.

Course outcome

- The outcome of studying Introduction to Ecology is to develop a foundational understanding of ecological principles and processes.
- This knowledge can be applied to various aspects of ecological research, conservation efforts, and environmental management.

Course contents

Theory **Credits: 03**

Unit I

Population interactions: intra-specific and inter-specific interaction; Competitive Exclusion principle, Gause's experiment, Lotka-Volterra model for competition and Predation; Concept of niche: types of niches, niche dimension, fundamental and realized niche. Community concept; Individualistic and organismic nature of communities; Qualitative and quantitative characters of community.

Unit II

Soil Ecology: structure of soil, soil formation, soil fertility, soil profile, physical properties of soil (soil colour, texture, bulk density and porosity); Carbon storage and sequestration: Carbon management through biotic sequestration: forest ecosystems, agroforestry systems, wetlands; Soil carbon sequestration.

Unit III

Restoration Ecology: Definition and scope, The Society for Ecological Restoration (SER), principles of restoration ecology, types of eco-restoration, components of restoration. Restoration in conservation biology. Global warming, greenhouse effect.

Practical **Credits: 01**

1. Plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Wiener diversity index for the same community

3. Study of an aquatic ecosystem: Phytoplankton and zooplankton study, Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO_2
4. Study on soil soil colour, texture, bulk density and porosity.
5. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary

Suggested Readings

1. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
2. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
3. Robert Leo Smith Ecology and field biology Harper and Row publisher
4. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.
5. Begon, M., Harper, J.L. and Townsend, C.R. (2006). Ecology: Individuals, Populations and Communities. Blackwell Scientific Publications.
6. Kormondy, E. J. (1996). Concepts of Ecology (4^{th} eds.). Prentice-Hall of India Pvt. Ltd.
7. Dash, M.C. and Dash, S.P. (2009). Fundamentals of Ecology (3^{rd} eds.). Tata McGraw-Hill Publishing Co., New Delhi.
8. Brady, N.C. and Weil, R. (2008) The Nature and Properties of Soils (14thedn.). Pearson International.
9. Coleman, D.C., Crossley, D.C.and Hendrix, P.F. (2004) Fundamentals of Soil Ecology (2ndedn.). Elsevier.
10. Miller, R.W. and Gardiner, D.T. (2007) Soils in Our Environment (11thedn.). Prentice Hall of India, New Delhi.
11. George D. Gann, Tein McDonald, Bethanie Walder, James Aronson, Cara R. Nelson, Justin Jonson, James G. Hallett, Cristina Eisenberg, Manuel R. Guariguata, Junguo Liu, Fangyuan Hua, Cristian Echeverría, Emily Gonzales, Nancy Shaw, Kris Decleer, Kingsley W. Dixon. International principles and standards for the practice of ecological restoration. Second edition. September 2019. https://doi.org/10.1111/rec.13035.

Semester VII

Research Methodology

Paper Code: ZOOREM7014

Paper credit: 04 (3T+1P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

It aims to familiarize individuals with different types of research, approaches, and research design principles. Additionally, it aims to equip individuals with the necessary skills to critically analyze scientific literature, effectively communicate research results, and adhere to ethical standards in scientific publishing.

Course outcomes

- Individuals will develop the ability to critically evaluate scientific literature, communicate research results through various scientific writing formats, and adhere to ethical guidelines and standards in scientific publishing.
- This knowledge and skillset will contribute to the advancement of scientific knowledge, promote intellectual honesty, and foster a culture of integrity in scientific research.

Course contents

Theory **Credits: 03**

Unit I

Meaning of research, types of research, approaches; concept of Research Design: meaning, criteria of a good research design; types of research designs: experimental, observational, survey, and qualitative. Defining aim & objectives. Research Questions and Research hypotheses generation. Data collection methods: primary and secondary data; qualitative and quantitative survey, experimental research protocols.

Unit II

Reading and critical analysis of scientific literature; Writing various forms of scientific articles: structure of writing report, short communication, review article, original research article; citations and references. Citation databases: Web of Science, Scopus, Journal matrix.

Unit III

Research Ethics: science and research, intellectual honesty and research integrity; Scientific misconducts: redundant publications, duplicate and overlapping publications, selective reporting and misrepresentation of data; Publication Ethics: definition, introduction and importance; conflict of Interest; predatory publishers and journals. Open access publication. Plagiarism in research.

Practical **Credit: 1**

1. Research proposal writing exercise: identification of a research problem; generate research questions and hypotheses; develop aim and objectives; justification.
2. Research design and methodology: preparation of data sheet, preparation of experimental protocol.
3. Review of literature from selected literature and writing a review article including abstract.
4. Micro Research: students will choose a topic of research feasible to be carried out within short period and write a mini article.

Suggested readings

1. Baishya, K. (Ed.). (2024). Research and Publication Ethics. National Law University and Judicial Academy, Assam.
2. Emden, Helmut F.van (2008). Statistics for Terrified Biologists. Blackwell Publishing. 343pp.
3. Heard, S. B. (2022). The scientist's guide to writing: How to write more easily and effectively throughout your scientific career. Princeton University Press.
4. International Editions. 718 pp.
5. Kothari, C.R. (2004) Research Methodology: Methods and Techniques. 2nd Edition, New Age International Publishers, New Delhi.
6. Schimel, J. (2012). Writing science: how to write papers that get cited and proposals that get funded. OUP USA.
7. Zar, J.H. (1984). Biostatistical Analysis (Second Edition). New Jersey: Prentice-Hall

Semester VII
Ecology & Environment
Paper Code: ZOOMIN7014
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
The objective of studying Introduction to Ecology is to provide individuals with a strong foundation in ecological principles and processes. This knowledge can be applied to various aspects of ecological research, conservation efforts, and environmental management to contribute to the understanding and preservation of our natural world.

Course outcome
- The outcome of studying Introduction to Ecology is to develop a foundational understanding of ecological principles and processes.
- This knowledge can be applied to various aspects of ecological research, conservation efforts, and environmental management.

Course contents
Theory **Credits: 03**

Unit I
Introduction to Ecology: Autecology and synecology, Laws of limiting factors, study of physical factors. Population: Unitary and Modular populations, Unique and group attributes of population: Density, natality, mortality, life tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion. Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation—density-dependent and independent factors.

Unit II
Community characteristics: species richness, dominance, diversity and its types (alpha, beta, and gamma), abundance, vertical stratification, Distribution of species in different habitats; Ecotone and edge effect; Ecological succession: primary and secondary succession, climax community.

Unit III
Ecosystem: Types of ecosystems, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies Nutrient and biogeochemical cycle. Human-modified ecosystem. Ecology in Wildlife Conservation and Management

Practical **Credits: 01**
1. Plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Wiener diversity index for the same community

3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, temperature, turbidity/penetration of light, determination of pH, Dissolved Oxygen content (Winkler's method), free CO_2.
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.

Suggested Readings

1. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
2. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
3. Robert Leo Smith Ecology and field biology Harper and Row publisher
4. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Pres

Semester VIII
FUNDAMENTAL BIOSTATISTICS
Paper Code: ZOOADL8014
Paper credit: 04(3T+1P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

The objective of this course is to develop skills in analyzing biological data and provide a foundation for designing experiments, conducting research studies, and interpreting findings in a statistical manner.

Course Outcomes

- Studying statistics yields skills in data analysis, interpretation, and decision-making, applicable across various fields from scientific research to business analytics.
- Additionally, it will allow for critical thinking and enhance problem-solving abilities, enabling students to make informed conclusions and predictions based on empirical evidence.

Course Contents

Theory **Credit 03**

Unit I

Descriptive statistics: Concepts of statistical Population and Sample— sampling unit, observation, variable; Simple random sampling. Graphical representation of data: diagrams and graphs - scattergram, simple bar diagram, multiple bar diagram, percentage stack bar diagram, histogram, pie diagram, frequency polygon, frequency curve. Measures of central tendency: mean, median and mode from raw data as well as from frequency distribution; Measures of dispersion: range, mean deviation, standard deviation, variance, standard error; Measures of relative dispersion: coefficient of variance.

Unit II

Probability theory: probability distributions; normal distribution— definition and statement of properties, skewness and kurtosis; bionomial distribution; poisson distribution; critical probability values, confidence limits; Test statistics of significance**:** Test of hypothesis: Null and alternative hypothesis; one-tail test and two-tail test; Type I and Type II errors.

Unit III

Parametric and non-parametric tests: Product moment Correlation test, coefficient of correlation; Regression analysis, regression line, regression coefficient; z-test; t-tests: independent and dependent t-test; F-test, One-way and Two-way Analysis of Variance; Spearman Rank Correlation test; Mann-Whitney U-test; Wilcoxon matched pair test; Chi-square test; Kruskal-Wallis test; Randomized Complete Block Design; Latin Square Design.

Practical **Credit: 1**

1. Graphical representation of data of data collected in the field.
2. Calculating central tendency from data.
3. Generating hypotheses from given topic with one-tail test and two-tail tests.
4. Statistical analyses of qualitative and quantitative data

Suggested readings

1. B.Sc. statistics theory and practicals. Dwijaraj Bhattacharjee.2010. Second edition, Ludhiana: Kalyani Publishers. ISBN: 9788127263980
2. Emden, Helmut F.van (2008). *Statistics for Terrified Biologists*. Blackwell Publishing.
3. Kothari, C.R. (2004) Research Methodology: Methods and Techniques. 2nd Edition, New Age International Publishers, New Delhi.
4. Zar, J.H. (1984). *Biostatistical Analysis (Second Edition)*. New Jersey: Prentice-Hall

SEMESTER VIII
Ethnozoology
Paper Code: ZOOADL8024
Paper credit: 04(3T+1P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

The course is unique in highlighting the comprehensive understanding of ethnozoology, ethno-aquaculture, and traditional sericulture, their cultural and medicinal significance, and the methods used to study these fields.

Learning outcomes

- Explain the historical context, relevance, and current status of ethnozoology, ethno-aquaculture, and traditional sericulture in India.
- Describe the methods used to study ethnozoology and the importance and applications of this field in various cultural and medical contexts.
- Identify and discuss the use of various animal species and their parts for medicinal purposes in Indian traditional medicine.
- Detail traditional fishing techniques and tools, preservation and processing methods, and the medicinal and nutritional uses of aquatic resources.
- Understand the traditional knowledge systems in sericulture, including the cultivation of mulberry trees and silkworm rearing practices, as well as the medicinal and nutritional uses of sericulture products.

Course Contents

Theory **Credit 03**

Unit I

Ethnozoology: Historical Context, relevance, scope and status. Methods to study ethnozoology; Importance and Applications of Ethnozoology. Indian Traditional Medicine: Basic concept of ethnozoological medicine, traditional practices using various animal species and their parts for medicinal purposes: Bones, Skins, Organs, Secretions and Excretions, Whole Animals, etc.; Use of venom or extracts to alleviate pain.

Unit II

Ethno-Aquaculture: Traditional Fishing Techniques and Tools: Handheld Nets, Fishing Traps, Lines and Hooks; Preservation and Processing: Drying and Smoking, Fermentation, Salting and Pickling of fish; shell fish as traditional food; Medicinal and Nutritional Uses: medicinal applications and nutritional importance.

Unit III

Traditional Knowledge Systems (TKS) in Sericulture: Definition and Scope, Cultivation of Mulberry Trees, Silkworm Rearing Practices Medicinal and Nutritional Uses of Sericulture Products; Traditional food practices: Entomophagy; Entomopathy.

Practical **Credit 01**

Field trip to tribal settlement to survey, document and frame hypothesis on people-animal relationship.

1. Collection, processing and preservation of ethnozoological specimens in the institutional repository.
2. Identify and document animal parts used in the preparation of crude drugs/herbal formulations.
3. Collection of Indigenous Fishing Tools.

Suggested readings

1. Traditional Fishery Practices of Assam. S. K. Bhattacharjee, Directorate of Fisheries, Assam, 1998
2. Treditional of Fishe hervesting gears of north east India, ML Khan & SS Mishra, APH Publication, 2001.
3. Unnikrishnan PM. Animals in Ayurveda. J Amruth. 1998:1–15.
4. Trivedi PC. Ethnobotany: an overview. In Ethnobotany edited by: Trivedi PC. Jaipur: Aavishkar publisher; 2002.
5. S.B. Dandin, J. Jayaswal and K. Giridhar (2001). Handbook of Sericulture Technologies. Publisher-Central Silk Board, Bangalore.

SEMESTER VIII

Reproductive and Developmental Biology

Paper Code: ZOOADL8034

Paper credit: 04(3T+1P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

Understanding reproductive physiology involves studying folliculogenesis, steroidogenesis, gametogenesis, and hormonal regulation. Early developmental stages include fertilization, cleavage, blastula formation, gastrulation, and germ layer development. Developmental biology focuses on cell specification, commitment, determination, and differentiation. Model organisms like mammals, C. elegans, Drosophila, and amphibians help analyze these processes. Morphogenetic processes involve morphogen gradients, paracrine factors, and cell adhesion. Insights into reproductive health cover the menstrual cycle, hormonal regulation, and related disorders.

Course outcomes

- Comprehensive grasp of reproductive physiology, including folliculogenesis, steroidogenesis, gametogenesis, and hormonal regulation.
- Proficiency in understanding early developmental processes such as fertilization, cleavage, blastula formation, gastrulation, and germ layer formation.
- Mastery of fundamental developmental biology concepts including cell specification, commitment, determination, and differentiation.
- Ability to analyze developmental processes using various model organisms such as mammals, C. elegans, Drosophila, and amphibians.
- Appreciation of the role of morphogenetic processes including morphogen gradients, paracrine factors, and cell adhesion in guiding tissue patterning, organogenesis, and regeneration.

Course contents

Theory **Credit 03**

Unit I

Ovarian and Testicular Physiology: Folliculogenesis and their control mechanisms, steroidogenesis and its hormonal regulation, menstrual cycle and its hormonal regulation, Female reproductive disorder, estrus cycle and its regulation, sertoli cell: structure and function; function of Leydig cell.

Unit II

Gametogenesis, Fertilization and Early Developments: spermatogenesis and oogenesis, Structure of mammalian gametes mammals, zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers in animals; embryogenesis, organogenesis, Capacitation, Signal transduction pathway in acrosome reaction, Prevention of Polyspermy, contraception; vulva formation in *Caenorhapdits elegans*.

Unit III

Cell commitment and morphogenesis: Commitment, induction, competence; cell fate and cell lineages; imprinting**,** stem cells: Embryonic stem cells and adult stem cells, cell adhesion

molecules, Concept of morphogen gradients, role of paracrine factors in development, Hormonal control of amphibian metamorphosis, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, formation of organ rudiments and nucleo-cytoplasmic interaction in development. Axes and pattern formation in Drosophila, amphibia and chick**;** sex determination.

Practical **Credit: 1**

1. Study of different types of eggs.
2. In vitro culture of chick embryo.
3. Study of developmental stages of frog/chick embryos from permanent slide.
4. Dissection of male/female reproductive system of cockroach/Grasshopper
5. Identification of larval forms of invertebrates.

Suggested Readings

1. Gilbert, S. F. (2014). Developmental Biology. Sinauer Associates.
2. Wolpert, L., Tickle, C., & Martinez Arias, A. (2015). Principles of Development. Oxford University Press. Hall, J. E., & Hall, M. E. (2020).
3. Guyton and Hall Textbook of Medical Physiology E-Book: Guyton and Hall Textbook of Medical Physiology E-Book. Elsevier Health Sciences.
4. Larsen, W. J. (2015). Human Embryology. Churchill Livingstone.
5. Rhoades, R. A., & Bell, D. R. (Eds.). (2012). Medical phisiology: Principles for clinical medicine. Lippincott Williams & Wilkins.
6. Alberts, B., Johnson, A., Lewis, J., et al. (2014). Molecular Biology of the Cell. Garland Science.

SEMESTER VIII
Fundamental Animal Physiology
Paper Code: ZOOADL8044
Paper credit: 04 (3T+1P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

Understanding blood circulation includes haemostasis and haemoglobin's role in gas transport. Analyzing the oxygen dissociation curve and respiratory center functions is key for oxygen delivery. Comprehending cardiac impulse conduction, the cardiac cycle, and ECG interpretation is essential for heart health. Differentiating between neurogenic and myogenic hearts reveals various cardiac mechanisms. Examining skeletal muscle fiber structure and actin-myosin interactions explains muscle function. Understanding macronutrient absorption and gastrointestinal hormone regulation is crucial for nutrition and digestion.

Course outcomes

- Understand blood circulation, haemostasis, and haemoglobin's role in gas transport.
- Comprehend cardiac impulse conduction, the cardiac cycle, and ECG interpretation.
- Analyze skeletal muscle structure, actin-myosin interactions, and muscle contraction mechanisms.
- Grasp macronutrient absorption and gastrointestinal hormone regulation.
- Understand tubular reabsorption, secretion, and hormonal regulation of urine formation.
- Comprehend axonal and synaptic transmission and neurotransmitter roles.

Course contents

Theory **Credit 03**

Unit I

Circulation and Respiration: Blood: Haemostasis, Haemoglobin: Role in oxygen and CO_2 transport, Oxygen dissociation curve and their physiological significance, Heart: Origin and conduction of cardiac impulse, cardiac cycle, ECG, Neurogenic and myogenic hearts; Respiratory centers: organization and function, Surfactant, Basal metabolic rate and its measurement, Respiratory adjustments, Hypoxia, Dyspnea, High altitude: decreased pressure of gas.

Unit II

Muscle, Nutrition and Excretion: Ultra structure of skeletal muscle fibers: Proteins of the myofilaments, actin-myosin interaction, sarcoplasmic reticulum and role of calcium in contraction, energetics of muscle contraction. Absorption of macronutrients, Gastrointestinal hormones and regulation, Obesity and starvation. Tubular reabsorption and secretion, RAS and hormonal regulation of urine formation, regulation of water balance, Acid-base balance and homeostasis.

Unit III

Nervous System, Sensory Perception, and Physiological Responses: Motor neuron and types of neurons, Synaptic transmission, Types of synapses and synaptic knobs, EPSP and IPSP, Chemical transmission, neurotransmitters; Retinal components, Photoreceptors: Ionic basis of potential generation: Basilar membrane, and organ of Corti: Genesis of action potential in afferent nerve fibers; Tactile response: Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization; Stress and adaptation.

Practical **Credit: 1**

1. Analysis of Blood group
2. Quantitative estimation of hemoglobin content.
3. Temporary slide preparation for WBC observation.
4. Estimation of RBCs
5. Blood glucose estimation.
6. Urine glucose estimation.

Suggested Readings

1. Guyton, A. C., & Hall, J. E. (2015). Textbook of medical physiology (13th ed.). Elsevier.
2. Rhoades, R. A., & Bell, D. R. (Eds.). (2012). *Medical Physiology: Principles for clinical medicine*. Lippincott Williams & Wilkins.
3. Marieb, E. N., & Hoehn, K. (2018). Human anatomy & physiology (11th ed.). Pearson Publication.
4. Johnson, L. R. (2015). Essential medical physiology (3rd ed.). Academic Press.
5. Pocock, G., Richards, C., & Richards, D. (2013). Human physiology: The basis of medicine (3rd ed.). Oxford University Press.
6. Schmidt-Nielsen, K. (1997). Animal physiology: Adaptation and environment (5th ed.). Cambridge University Press.

SEMESTER VIII

Biochemistry
Paper Code: ZOOADL8054
Paper credit: 04(3T+1P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objectives
The objectives encompass understanding the structure and function of amino acids, peptides, and proteins, exploring the mechanisms of protein folding and denaturation, and analyzing the roles of carbohydrates and lipids in cellular function. Additionally, they include studying bioenergetics principles and metabolic pathways, learning enzyme catalysis mechanisms and regulation, and investigating metabolic pathways and hormonal regulation to comprehend how cells maintain homeostasis and respond to environmental changes.

Course outcomes
- Identify biomolecular structures effectively.
- Explain protein function through folding principles.
- Understand carbohydrate and lipid roles in cells.
- Analyze metabolic pathways using bioenergetics.
- Grasp enzyme function and regulation.
- Evaluate metabolic and hormonal interactions.

Course contents
Theory **Credit 03**

Unit I
Classification and structural features of amino acids; Peptides and peptide bonds; Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds), Protein denaturation and folding; Structure and functional significance of mono, polysaccharides and glycoproteins; Glycosylation and its importance; lipid: structure and properties of important members of storage and membrane lipids; lipoproteins.

Unit II
Principles of bioenergetics, Equilibria, free energy; High energy compounds; Phosphoryl Group Transfers and ATP; Biological Oxidation-Reduction Reactions; Reducing power and Redox potential; Glycolytic pathways; Kreb's cycle; Oxidative phosphorylation; electron transport chain; Fo-F1 ATP synthase. Principles of enzyme catalysis; enzyme kinetics and mechanism of enzyme action, Michaelis-Menten kinetics; enzyme inhibition: types and mechanism; regulation of enzyme activity.

Unit III
Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins; Conformation of nucleic acids (A, B, & Z-DNA), t-RNA, micro-RNA); Stability of proteins and nucleic acids; Mammalian fuel metabolism integration and regulation: Hormonal regulation of fuel metabolism, metabolic homeostasis, metabolic disorders.

Practical **Credits 01**

1. Preparation of solutions of different normality, molarity, and dilutions.
2. Preparation of a ‘Good’ buffer.
3. Estimation of protein by Lowry’s method.
4. Enzyme assay of any one enzyme.
5. Physico-chemical or Kinetic characterization of enzyme.
6. Downloading and visualizations of protein structures
7. Study of Ramachandran plot using 3D protein molecules.

Suggested Readings

1. Lehningers Principles of Biochemistry, Nelson and Cox, Sixth Edition or recent edition, Macmillan Press.
2. Principles of Biochemistry, Voet, Voet and Pratt, 5th edition (2012) or recent edition, Wiley International Publications.
3. Harper’s Illustrated Biochemistry, Murray, Granner and Rodwell, (27th Ed.), McGraw Hill, New York, USA.
4. Practical Biochemistry – Principles and Techniques, Wilson and Walker, Cambridge University Press, Cambridge [Latest edition]

Semester VIII
Introduction to Developmental Biology
Paper Code: ZOOMIN8014
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
The objective of studying developmental biology is to equip individuals with a comprehensive understanding of the intricate processes involved in reproduction.

Course outcome
- Students will be able to acquire knowledge on embryonic development of sexually reproducing animals.
- They also obtain knowledge on metamorphic changes and the role of placenta in mammals.

Course contents
Theory **Credits: 03**□5

Unit I
Basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division; Early Embryonic Development: Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes.

Unit II
Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers; Late Embryonic Development: Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

Unit III
Post Embryonic Development: Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories; Teratogenesis: Teratogenic agents and their effects on embryonic development; In-vitro fertilization, Stem cell (ESC), Amniocentesis.

Practical **Credits: 01**
1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)

2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture
4. Study of different sections of placenta (photomicropgraph/ slides)
5. Project report on *Drosophila* culture/chick embryo development

Suggested readings

1. Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
2. Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press
3. Carlson, R. F. Patten's Foundations of Embryology
4. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers
5. Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press.

SEMESTER VIII
(Bachelor Degree in Zoology with Research)

Fundamental Biostatistics
Paper Code: ZOOADL8014
Paper credit: 04(3T+1P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (Theory 50 + Practical 20 + Internal 30)

Objective

The objective of this course is to develop skills in analyzing biological data and provide a foundation for designing experiments, conducting research studies, and interpreting findings in a statistical manner.

Course Outcomes

- Studying statistics yields skills in data analysis, interpretation, and decision-making, applicable across various fields from scientific research to business analytics.
- Additionally, it will allow for critical thinking and enhance problem-solving abilities, enabling students to make informed conclusions and predictions based on empirical evidence.

Course Contents

Theory **Credit 03**

Unit I

Descriptive statistics: Concepts of statistical Population and Sample─ sampling unit, observation, variable; Simple random sampling. Graphical representation of data: diagrams and graphs─ scattergram, simple bar diagram, multiple bar diagram, percentage stack bar diagram, histogram, pie diagram, frequency polygon, frequency curve. Measures of central tendency: mean, median and mode from raw data as well as from frequency distribution; Measures of dispersion: range, mean deviation, standard deviation, variance, standard error; Measures of relative dispersion: coefficient of variance.

Unit II

Probability theory: probability distributions; normal distribution─ definition and statement of properties, skewness and kurtosis; bionomial distribution; poisson distribution; critical probability values, confidence limits; Test statistics of significance**:** Test of hypothesis: Null and alternative hypothesis; one-tail test and two-tail test; Type I and Type II errors.

Unit III

Parametric and non-parametric tests: Product moment Correlation test, coefficient of correlation; Regression analysis, regression line, regression coefficient; z-test; t-tests: independent and dependent t-test; F-test, One-way and two-way Analysis of Variance; Spearman Rank Correlation test; Mann-Whitney U test; Wilcoxon matched pair test; Chi-square test; Kruskal-Wallis test. Randomized Complete Block Design, Latin Square Design.

Practical **Credit: 1**

1. Graphical representation of data of data collected in the field.
2. Calculating central tendency from data.
3. Generating hypotheses from given topic with one-tail test and two-tail tests.
4. Statistical analyses of qualitative and quantitative data

Suggested readings

1. B.Sc. statistics theory and practicals. Dwijaraj Bhattacharjee.2010. Second edition, Ludhiana: Kalyani Publishers. 623pp. ISBN: 9788127263980
2. Emden, Helmut F.van (2008). *Statistics for Terrified Biologists*. Blackwell Publishing. 343pp.
3. Kothari, C.R. (2004) Research Methodology: Methods and Techniques. 2nd Edition, New Age International Publishers, New Delhi.
4. Zar, J.H. (1984). *Biostatistical Analysis (Second Edition)*. New Jersey: Prentice-Hall

Semester VIII
Paper Code: ZOODISS80112
Dissertation

Research thesis/ Project with minimum 1 conference paper. Peer-reviewed research publication should be encouraged.

- Research Thesis/Project: Choose relevant topics, conduct thorough literature reviews, and formulate research questions.
- Conference Papers: Produce a minimum of one paper for reputable conferences.
- Peer-Reviewed Publication: Peer-reviewed research publication should be encouraged.
- Research Methodology: Provide guidance on methodologies, data collection, and analysis.
- Supervision and Support: Assign dedicated supervisors, facilitate regular meetings, and offer additional support.
- Presentation and Defense: Prepare presentations and defend research findings before faculty and peers.
- Evaluation Criteria: Establish clear criteria for assessing originality, depth, clarity, and contribution.
- Ethical Considerations: Educate on research ethics and ensure adherence to ethical guidelines.
- Resources and Support Services: Provide access to research facilities, training, and funding opportunities.
- Timeline and Milestones: Set clear milestones and monitor progress to meet deadlines.

Semester IX

SPECIALIZATION: CELL AND MOLECULAR BIOLOGY

GENE AND GENOMICS
Paper Code: ZOOSPL25014
No. of Credits 4: 4(T) + 0(P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Objective

This course aims to explore the structure and organization of the genome, focusing on nucleic acids as genetic material, the concept of genes and gene families, non-coding genes, introns, the C-value paradox, DNA secondary and tertiary structures, repetitive DNA, DNA packaging, and chromatin structure.

Course Outcome

Upon completion, students will understand

- The diversity of genomes, including those of viruses, bacteria, and organelles,
- The general features of DNA replication, the Stahl and Meselson experiment, DNA repair mechanisms, cellular responses to DNA damage, and
- The molecular mechanisms of DNA recombination, including homologous recombination, site-specific recombination, and transposition.

Course Contents

Theory **Credit: 04**

Unit I

Structure and Organization of the Genome: Nucleic acids as genetic material; DNA vs. RNA as genetic material, concept of gene and gene families; non-coding genes; concept of intron; C-value paradox, Secondary structure of DNA and conformation flexibilities, Repetitive DNA; Tertiary structure and super-coiling of DNA, DNA packaging – nucleosome and higher-order structure of chromatin

Unit II

Genomes and Genome Diversity: Virus and bacterial genomes; organelle genome - mitochondrial genome and chloroplast DNA, RNA-based genomes, General features of prokaryotic and eukaryotic replication; directions and types of replications, Stahl and Meselson experiment, Enzymes of DNA replication; proofreading activity; replication in mt and ct-DNAs; telomere maintenance, telomerase, and aging

Unit III

DNA Recombination and Repair: DNA damage and Errors; types of DNA repair mechanisms; cellular response to DNA damage, Double strand break repairs, General

features of prokaryotic and eukaryotic recombination, Molecular mechanisms of homologous recombination, Site-specific recombination and transposition

Unit IV

Gene Cloning: Basic biology of cloning vectors: restriction enzymes; cutting and joining DNA molecules – Cohesive and blunt end ligation; cloning vectors -plasmids, phages, single stranded DNA vectors, high capacity vectors, retroviral vectors, yeast vectors; expression vectors and other advanced vectors in use; Plant based vectors; Ti and Ri as vectors; Methodologies - Insertion of Foreign DNA into Host Cells; Transformation; creating and screening of DNA library; Isolation of mRNA and total RNA; cDNA and genomic libraries; Jumping and hopping libraries; cDNA and genomic cloning; Southwestern and Far-western cloning; Expression cloning; Principles in maximizing gene Expression; Gene cloning and DNA analysis; Gene cloning in Medicine and forensic

Suggested Readings

1. Watson et al. 2014. Molecular Biology of the Gene, 7th edition
2. Lizabeth A. Allison et al. 2007. Fundamental Molecular Biology. 1st edition
3. T.A. Brown. 2007. Genome 3. 3rd edition
4. Robert F. Weaver. 2012. Molecular Biology. 5th Edition.
5. Jocelyn E. Krebs et al. 2014. Lewin's GENES XI. 11th edition

SEMESTER IX

MOLECULAR BIOLOGY OF THE CELL

Paper Code: ZOOSPL25024

No. of Credits 4: 4(T) + 0(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

This course aims to elucidate the transcription process in both prokaryotic and eukaryotic cells, including the structure and function of RNA polymerases, transcriptional regulation mechanisms such as promoters, enhancers, operons, and transcription factors, as well as exploring post-transcriptional processing events like RNA splicing, editing, and translation initiation, elongation, and termination, overview of cell communication and signaling systems, covering various types of signaling molecules, receptors, and signal transduction pathways.

Course Outcome

Upon completion, students will understand

- the intricacies of transcriptional regulation, post-transcriptional processing, and translation machinery
- the roles of various RNA processing enzymes, the genetic code, and the mechanisms of protein synthesis
- the cell cycle regulation, checkpoints, tumor suppressors, and the molecular mechanisms of apoptosis
- the classification of receptors, their interactions with ligands, and the specificity of signaling
- the mechanisms of action and signal transduction pathways associated with ion channel receptors, GPCRs, enzyme-linked kinase receptors, and miscellaneous receptors

Course Contents

Theory **Credit: 04**

Unit I

Transcription Process: Prokaryotic Transcription; Transcription unit; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Antitermination; Transcriptional regulation-Positive and negative; Operon concept- Lac, Trp, and Gal operons; Transcriptional control in lambda phage, Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase - I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TBP and TAF; Activators and repressors.

Unit II

Post-Transcriptional Processing and Translation: Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing Mechanisms; Trans splicing;

RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA; Transcriptional and post-transcriptional gene silencing by microRNA; Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis.

Unit III

Cell Cycle and Apoptosis: Life cycle of a cell - cell cycle and its regulation; checkpoints in the mammalian cell cycle; tumor suppressors and role of helicases; Regulation of cell proliferation and differentiation by hormones, neuropeptides, and growth factors; cell differentiation; Apoptosis – apoptotic pathways (intrinsic and extrinsic) and their evolutionary conservation; Caspase and apoptosis; role of mitochondria in apoptosis; Pro-apoptotic and antiapoptotic proteins, mutation and mis-regulation of cell growth and cell cycle; Proto-oncogenes, tumor suppressor genes and genome maintenance gene.

Unit IV

Fundamentals to Cell Signaling: Types of cell signaling, signaling molecules, and receptors, Structure, function, and signal transduction of various receptors: ion channel receptors (ligand-gated and voltage-gated), GPCRs, enzyme-linked kinase receptors (RTK, Ras-MAPK, JAK-STAT, PI3K-Akt, PLC gamma), and miscellaneous receptors (TLRs, immunoglobulin superfamily receptors, cytokine receptors, cell adhesion receptors, Nod-like receptors, Notch receptors, Wnt receptors, and scavenger receptors), ligand-receptor interactions, specificity, desensitization, and downregulation, second messengers, protein phosphorylation, and dephosphorylation, feedback mechanisms, ubiquitinoylation, and signal amplification. Application of signaling pathways in both physiological and pathological contexts.

Suggested Readings

1. Watson et al. 2014. Molecular Biology of the Gene, 7th edition
2. Lizabeth A. Allison et al. 2007. Fundamental Molecular Biology. 1st edition
3. T.A. Brown. 2007. Genome 3. 3rd edition
4. Robert F. Weaver. 2012. Molecular Biology. 5th Edition.
5. Jocelyn E. Krebs et al. 2014. Lewin's GENES XI. 11th edition

SEMESTER IX

ADVANCED TECHNIQUES IN MOLECULAR BIOLOGY

Paper Code: ZOOSPL25034

No. of Credits 4: 4(T) + 0(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The main objectives of the content are to impart a thorough understanding of various laboratory techniques and principles in biological sciences. Students will learn the fundamentals of microtomy, microscopy, and separation techniques such as centrifugation and chromatography. Additionally, they will gain proficiency in tools for biological assays, electrophoresis, and molecular biology, preparing them for research and laboratory work.

Course Outcome

By completing the syllabus, students will gain

- Proficiency in a range of laboratory techniques including microtomy, microscopy, and separation methods like centrifugation and chromatography.
- Comprehensive understanding of tools for biological assays, electrophoresis, and molecular biology, enhancing research capabilities.
- Skill development in data analysis, interpretation, and troubleshooting, crucial for experimental success.
- Preparation for diverse careers in academia, industry, and healthcare, with hands-on experience and interdisciplinary knowledge.
- Ability to apply learned principles and techniques in practical settings, contributing to advancements in biological sciences and drug discovery.

Course Contents

Theory **Credit: 04**

Unit I

Microtomy and Microscopy: Basics of Microtomy - Tissue fixation, dehydration, clearing, infiltration, embedding, sectioning, mounting; staining - specific and differential staining; Eosin and Hematoxylin staining; Cryopreservation and Cryotomy; Histochemistry - principles and methodology; Microscopy – Basics of simple and compound microscopes, Types of microscopes - Simple, Compound, Confocal, Fluorescence, and Electron microscopes and their working principles; Flowcytometry and cell sorting.

Unit II

Separation techniques: Centrifugation - principles and types of centrifugation, Low and high speed centrifuges, density gradient centrifugation, ultracentrifuge; Applications of centrifugation - preparative techniques, analytical measurements; care of Centrifuges and rotors; Chromatography – principles and types (paper chromatography, thin layer chromatography, gas chromatography, gel permeation chromatography, ion-exchange

chromatography, high pressure liquid chromatography, affinity chromatography); Isolation of biomolecule using chromatography techniques, Separation of molecules using Soxhlet and Clevenger apparatus.

Unit III

Tools for biological assays and electrophoresis: Colorimeter and spectrophotometer; Concept of blank solution and reference; Standard curves; IC_{50} and LD_{50}; Electrophoresis: PAGE, SDS-PAGE, Agarose gel electrophoresis, Pore gradient, 1D and 2D electrophoresis, Isoelectric Focusing; Capillary Electrophoresis, Gel Staining and Visualization, Troubleshooting in gel running; Principles and types of PCR; PCR primer designing; Rolling cycle amplification; Blotting techniques: Southern, Northern, and Western; Basics of probes; Hybridization techniques: FISH, GISH, and Colony hybridization; DNA fingerprinting; Gel retardation assay; RNase protection assay.

Unit IV

Molecular techniques: Mutagenesis - types; Mutation detection techniques: SSCP, DGGE, RFLP, Oligo Ligation Assay, Mismatch Chemical Cleavage, Allele-Specific Amplification, Protein Truncation Test; Protein engineering – introduction of new amino acids, creation of disulfide bonds; DNA and protein microarrays genome editing technologies; ZFNs, TALEN, Cre-Lox and CRISPR/Cas9) system): Gene therapy; DNA sequencing – Enzymatic and Chemical basis, Automated DNA sequencing, RNA sequencing, Chemical Synthesis of oligonucleotide.

Suggested Readings

1. *Histology: A Text and Atlas*" by Michael H. Ross, Wojciech Pawlina, Indian Publisher: Wolters Kluwer India Pvt Ltd, 2010
2. *Chromatography: Concepts and Contrasts* by James M. Miller, Pearson India Education Services Pvt. Ltd., 2005.
3. *Spectrophotometry and Spectrofluorimetry: A Practical Approach* edited by Michael G. Gore, Taylor & Francis India Pvt. Ltd., 2000
4. *Electrophoresis: Theory, Methods, and Applications* edited by S. Shapiro, Oxford University Press India, 2010
5. *Principles and Techniques of Biochemistry and Molecular Biology* edited by Keith Wilson and John Walker, Cambridge University Press, 2010

SEMESTER IX
PRACTICAL: CMB 01
PAPER CODE: ZOOSPL25044
No. of Credits 4: {0(T) + 4(P)}
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

[1] Temporary slide preparation of buccal smear to study sex chromatin in humans
[2] Spectrophotometric analysis of nucleic acids (DNA and RNA).
[3] Perform restriction enzyme digestion of DNA samples.
[4] Create and screen DNA libraries, including cDNA libraries, genomic libraries, jumping libraries, and hopping libraries.
[5] Laddering of DNA samples in gel electrophoresis.
[6] Study of PCR amplification of a gene.
[7] Extraction of genomic DNA from animal tissue.
[8] Isolation of RNA from animal tissue.
[9] Agarose gel electrophoresis for DNA analysis.
[10] Agarose gel electrophoresis for RNA analysis.
[11] Extraction of DNA from mammalian tissue.
[12] Isolation of total RNA from cellular samples.
[13] Phylogenetic analysis using molecular data.
[14] Construction of phylogenetic trees for DNA and proteins.
[15] Extraction and detection of chromatin from mammalian tissue.
[16] Cell morphology and behavior study in response to signaling molecules by microscopy.
[17] Preparation of Mitotic chromosomes from onion root tip for Cell cycle study
[18] Single Cell Gel Electrophoresis (Comet Assay).
[19] Measuring of cell proliferation using colorimetric assay.

Suggested Readings

- Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.). Cold Spring Harbor Laboratory Press.
- Brown, T. A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). Wiley-Blackwell.
- Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., & Struhl, K. (2002). *Short Protocols in Molecular Biology* (5th ed.). Wiley.
- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular Biology of the Cell* (6th ed.). Garland Science

SEMESTER IX
PRACTICAL: CMB 02
PAPER CODE: ZOOSPL25054
No. of Credits 4: {0(T) + 4(P)}
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

[1] Spectrophotometry: Visible and UV spectrophotometry.
[2] Perform any chromatography techniques to separate biomolecules.
[3] Perform any electrophoresis technique to separate biomolecules.
[4] Perform any blotting technique to detect biomolecules.
[5] Demonstration of Microtome and its functioning.
[6] Demonstration of electron microscopes, confocal microscope.
[7] Identification of monosaccharide or amino acids in a given sample by TLC method. Calculate the Rf value.
[8] Demonstration of Column Chromatography.
[9] Demonstrate SDS-PAGE under reducing conditions for separation of Plasma/Proteins.
[10] Quantification of Nucleic acids through spectrophotometric analysis.
[11] Demonstration of Agarose gel electrophoresis.
[12] Educational tour to advance institute to study various equipment and advance facilities/ field study tour (vide Resolution No. 3 DAC/2020/06 dated 10 October 2020).
[13] Report on educational tour.

Suggested Readings

- Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.). Cold Spring Harbor Laboratory Press.
- Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4th ed.). Cold Spring Harbor Laboratory Press.
- Westermeier, R. (2005). *Electrophoresis in Practice: A Guide to Methods and Applications of DNA and Protein Separations* (4th ed.). Wiley-VCH.
- Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). *Principles of Instrumental Analysis* (7th ed.). Cengage Learning.

SEMESTER X

PROTEOMICS AND GENETIC ENGINEERING

Paper Code: ZOOSPL25064

No. of Credits 4: 4(T) + 0(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

These units aim to unravel the intricacies of protein structures and their stability, delve into the dynamic world of functional and quantitative proteomics, and unlock the transformative potential of genetic engineering. Together, they equip you with cutting-edge techniques and insights vital for pioneering advancements in biological research and medicine.

Course outcome

Upon completion, students will have

- Proficiency in understanding protein structures, including amino acid classification, peptide bonds, and higher-order structures.
- Mastery in interpreting Ramachandran plots, backbone conformations, and mechanisms of protein folding.
- Competence in analyzing post-translational modifications and deciphering protein complex interactions.
- Proficiency in quantitative proteomics methods, including comparing proteomes and utilizing quantitative techniques.

Course Contents

Theory **Credit: 04**

Unit I

Protein structure and stability: Classification and structural features of amino acids; Peptides and peptide bonds; primary and higher order structures of proteins; Ramachandran plot and backbone conformation; Protein denaturation and Folding; Chaperons and Heat shock proteins, misfolding and diseases (prion diseases, or amyloidosis)

Unit II

Functional proteomics: Post-translational modification (PTMs): Phosphorylation, glycosylation, ubiquitination, acetylation, PTMs regulation of protein function, stability and interactions; protein complex interactions: co-immunoprecipitation (Co-IP), Y2H, FRET/BRET, techniques for identifying disease markers, protein profiling, Single-Cell Proteomics: Techniques, challenges, and applications; Immunopeptidomics: Identifying peptides presented by MHC molecules; Chromatin Proteomics;

Unit III

Quantitative and comparative proteomics: Differential Expression Analysis: Techniques for comparing proteomes under different conditions; Quantitative Techniques: TMT, SILAC, label-free approaches; Proteo-genomics: Integration of proteomic and genomic data; advancements in mass spectrometry; Proteomics data analysis; Mutagenesis: Site specific mutagenesis

Unit IV

Genetic engineering: Molecular Cloning: cloning vectors, restriction enzymes, cloning libraries, transformation; expression cloning; Gene manipulation and sequencing techniques: Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knockout mice; Gene replacement; Gene targeting and disruption; siRNA and miRNA construction of shRNA vectors

Suggested Readings

1. Introduction to Proteomics: Principles and Applications by Nawin C. Mishra
2. Proteomics: From Protein Sequence to Function by Stephen R. Pennington and Michael J. Dunn
3. Mass Spectrometry for Proteomics by Tim S. Veenstra and John R. Yates
4. Molecular Cloning: A Laboratory Manual by Michael R. Green and Joseph Sambrook, Cold Spring Harbor Laboratory Press, 2012.
5. Gene Cloning and DNA Analysis: An Introduction by T.A. Brown, Wiley-Blackwell, 2016.
6. Recombinant DNA: Genes and Genomes - A Short Course by James D. Watson, Amy A. Caudy, Richard M. Myers, and Jan A. Witkowski, W.H. Freeman, 2007.
7. Genome Editing: Principles and Applications by Kursad Turksen, Humana Press, 2016.
8. CRISPR-Cas: A Laboratory Manual by Jennifer Doudna and Prashant Mali, Cold Spring Harbor Laboratory Press, 2016.

SEMESTER X
MOLECULAR GENETICS
Paper Code: ZOOSPL25074
No. of Credits 4: {4(T) + 0(P)}
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Objective
This course aims to delve into chromatin structure, chromosome organization, and organelle genome organization, including the origin and structure of mitochondria and chloroplasts, telomeres, centromeres, euchromatin, heterochromatin, karyotyping, chromosome banding, chromosomal aberrations, mutations, and their relevance to diseases.

Course Outcome
Upon completion, students will grasp
- the principles of Mendelism and its extensions
- the chromosomal theory of heredity, sex linkage, sex determination, crossing over, chromosome segregation, gene mapping, epigenetic inheritance, and
- the genetic basis of complex traits, population genetics, quantitative genetics, and their applications in conservation biology and speciation studies.

Course Content

Theory **Credit: 04**

Unit I
Chromosome and genome organization: Chromatin Structure: Histone modification and chromatin remodeling complexes; Chromosome organization and territories in the nucleus; Organelle genome organization: Origin and genome organization of mitochondria and chloroplast; Telomere: structure, maintenance and aging; Centromere: Structure, function and kinetochore assembly, Dynamic regulation of Euchromatin and Heterochromatin, Karyotyping, Chromosome Banding, Chromosomal aberration/ anomalies, mutation and cancer (Molecular mechanism: CML and Burkitt's Lymphoma).

Unit II
Classical and modern genetics: Mendelism and its extension (multiple alleles, incomplete dominance, co-dominance, gene interactions, epistasis, pleiotropy, essential and lethal genes, gene action from genotype to phenotype- penetrance and expressivity) and their applications in modern genetics, Chromosomal Theory of Heredity, Sex Linkage, Sex-limited, Sex-influenced Characters and their regulations, Sex Determination, Dosage compensation, Mechanism and types of crossing over, Chromosome segregation and gene mapping; Epigenetic and Epigenetic inheritance: mechanism of DNA methylation and histone modification, role of non-coding RNAs, transgenerational epigenetic.

Unit III

Population and quantitative genetics: Genotype and allele frequency, analysis of population genetics data, Hardy-Weinberg's law of equilibrium: extensions and applications; Factors affecting Hardy-Weinberg's law and modeling of population dynamics, Genetic Variation; Genetic hitchhiking; Role of genetics in conservational biology, Role of gene flow, Genetic basis of speciation.

Unit IV

Genetic analysis of complex traits: phylogenic inheritance and its implications, complex pattern of inheritance, Quantitative traits, Continuous traits, Threshold traits; Inbreeding, Heritability, Statistical method, Phylogeny: phylogenetic analysis and evolution, Response to Selection: Artificial selection and genetic improvement, genomic selection and breeding value prediction.

Suggested Readings

1. Watson et al. 2014. Molecular Biology of the Gene, 7th edition
2. T.A. Brown. 2007. Genome 3. 3rd edition
3. Robert F. Weaver. 2012. Molecular Biology. 5th Edition.
4. Jocelyn E. Krebs et al. 2014. Lewin's GENES XI. 11th edition
5. Peter J. Russell. 2010. iGenetics: A molecular Approach 3rd Edition
6. Robert H. Tamarin. 2001. Principles of Genetics 7th Edition.
7. T A Brown. 2006. Gene cloning and DNA analysis: An Introduction by.
8. Benjamin Lewin. 2004. Genes VIII.

SEMESTER X

BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

Paper Code: ZOOSPL25084

No. of Credits 4: 4(T) + 0(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

Bioinformatics and drug designing courses offer a deep understanding of principles, tools, and applications in both fields. Students learn to analyze biological data, develop computational methods for drug discovery, and understand the drug development pipeline. Emphasis is on interdisciplinary integration, critical thinking, and practical applications for careers in academia, industry, and healthcare.

Course Outcome

Upon completion of the topics,

- Students will gain proficiency in handling biological data, including database submission, retrieval, and sequence analysis.
- They will develop analytical skills to conduct molecular phylogenetic studies, analyze evolutionary relationships.
- Student will learn to apply bioinformatics approaches in drug design, including molecular docking, pharmacophore modeling, and compound library screening.
- Throughout the course, emphasis is placed on preparing the students for successful careers in bioinformatics research and application.

Course Contents

Theory **Credit 4**

Unit I

Introduction to Bioinformatics: Computational Biology and Bioinformatics; Basics of Genomics and Proteomics; Biological Databases: Protein and Nucleic Acid Databases, Protein interaction databases (e.g., STRING, BioGRID); Pathway databases (e.g., KEGG, Reactome); Correlation between Biological Databases; Importance of File Formats; Database Submission and Retrieval Techniques; Relationship between Sequences and Biological Functions; Significance of Biological Sequences; Sequence Searching using BLAST and FASTA; Sequence Alignments

Unit II

Sequence Analysis: Finding and Calculating Core Nucleotide Sequences; Predicting Open Reading Frames (ORFs); Locating Transcription Start and End Points; Extraction of Polypeptide Sequences from Nucleotide Sequences; Designing Primers for Specific Genes; Generating and Analyzing Restriction Maps; Application of Bioinformatics in Epigenomics;

Long-read Sequencing Data Analysis; Single-cell Sequencing Analysis; Metagenomics and Microbiome Analysis

Unit III

Structural Bioinformatics and Drug designing: Study of 2D and 3D protein structure using bioinformatic tools; Structural analysis of active pockets; Methods for 3D Structure Determination: X-ray Crystallography; NMR, Cryo-EM; Protein Folding and Function Studies; Homology Modeling and Protein Structure Prediction; Tools for Structure Prediction, Validation, and Visualization; Structural Analysis using Molecular Dynamics Simulations; Study of MD trajectories; Analysis of free energy in complexes

Unit IV

Drug Designing: Database for drugs and compounds; Computer-Assisted Drug Design; Molecular Docking, Drug Likeness Assessment, ADMET study, LigPlot Analysis, QSAR Modeling; Biomarker Discovery; Pharmacophore Modeling and Compound Library Screening; Drug Repurposing

Suggested Readings

1. *Bioinformatics Basics: Applications in Biological Science and Medicine* by Hooman H. Rashidi, Lukas K. Buehler, Publisher: CRC Press, 2017
2. *Introduction to Bioinformatics* by M.S. Udaya Prakash, Publisher: Himalaya Publishing House, 2010
3. *Bioinformatics Algorithms: An Active Learning Approach* by Phillip Compeau, Pavel Pevzner Publisher: Active Learning Publishers, 2014
4. *Essential Bioinformatics* by Jin Xiong, Cambridge University Press, 2006

SEMESTER X
PRACTICAL: CMB 03
PAPER CODE: ZOOSPL25094
No. of Credits 4: 0(T) + 4(P)
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

[1] Protein profiling using SDS-PAGE electrophoresis.
[2] Estimation of protein by Lowry's method.
[3] Culture media preparation for drosophila
[4] Monohybrid/ dihybrid cross setting
[5] Gene mapping using linkage analysis.
[6] Measuring of cell proliferation using colorimetric assay
[7] Cell morphology and behavior study in response to signaling molecules by microscopy
[8] ELISA
[9] Chromosome Banding techniques and anomalies study
[10] Karyotyping: Study of chromosome structures
[11] Study of Hardy-Weinberg equilibrium in human population by taking example of blood group system (ABO).
[12] Heritability estimation of quantitative traits
[13] Phylogenetic analysis using molecular data
[14] Analyze segregation ratios and perform chi-square tests to assess goodness of fit to expected Mendelian ratios.
[15] To perform Tissue Fixation and Microtomy of any biological sample.
[16] Perform any chromatography techniques to separate biomolecules.
[17] Perform any electrophoresis technique to separate biomolecules.
[18] Perform any blotting technique to detect biomolecules.
[19] Comparative study of colorimeter and spectrophotometer using a sample.

Suggested Readings

- Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). *Principles of Instrumental Analysis* (7th ed.). Cengage Learning.
- Westermeier, R. (2005). *Electrophoresis in Practice: A Guide to Methods and Applications of DNA and Protein Separations* (4th ed.). Wiley-VCH.
- Bancroft, J. D., & Gamble, M. (2008). *Theory and Practice of Histological Techniques* (6th ed.). Churchill Livingstone.
- Pierce, B. A. (2012). *Genetics: A Conceptual Approach* (4th ed.). W. H. Freeman.
- Nei, M., & Kumar, S. (2000). *Molecular Evolution and Phylogenetics*. Oxford University Press.

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular Biology of the Cell* (6th ed.). Garland Science.
- Hartl, D. L., & Jones, E. W. (2005). *Genetics: Analysis of Genes and Genomes* (6th ed.). Jones and Bartlett.
- Ashburner, M., Roote, J., & Thompson, J. N. (2005). *Drosophila: A Laboratory Handbook* (2nd ed.). Cold Spring Harbor Laboratory Press.
- Walker, J. M. (2009). *The Protein Protocols Handbook* (3rd ed.). Humana Press.
- Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Folin phenol reagent. *Journal of Biological Chemistry*, 193(1), 265-275.

SEMESTER X
PRACTICAL: CMB 04
PAPER CODE: ZOOSPL25104
No. of Credits 4: {0(T) + 4(P)}
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

[1] Perform a sequence alignment using FASTA and compare the results with those obtained from BLAST.
[2] Explore databases and predict the functional consequences of mutations using in silico tools
[3] Retrieval of protein sequences from the UniProt database and analyze their features.
[4] Explore the interaction network of a specific protein, such as TP53, and analyze the types of interactions and their confidence scores using STRING or BioGRID.
[5] To explore biological pathways using databases like KEGG and Reactome.
[6] Perform cross-reference data from UniProt and KEGG to link protein sequences with metabolic pathways.
[7] Analyze a gene sequence to predict its coding regions, potential protein products, and functional domains using tools like ORF Finder and Pfam.
[8] Use of protein modeling tools like SWISS-MODEL to predict protein structures based on homologous templates.
[9] Validation of the quality of the predicted structures using tools like PROCHECK or Verify3D.
[10] Perform molecular docking studies using tools like AutoDock to predict ligand binding sites.
[11] Perform molecular dynamics simulations using software like GROMACS.
[12] Analyze MD trajectories to study the stability and dynamics of the complexes (any two parameters)
[13] Assess drug-likeness and ADMET properties of a compound using bioinformatic tools.
[14] Build quantitative structure-activity relationship (QSAR) models using tools like QSAR Toolbox/Knime, etc.
[15] Screen compound libraries for potential drug candidates of a disease
[16] Perform pharmacophore model from existing compounds (Tools e.g., Phase, LigandScout).

Suggested Readings

- Mount, D. W. (2004). *Bioinformatics: Sequence and Genome Analysis* (2nd ed.). Cold Spring Harbor Laboratory Press.
- Baxevanis, A. D., & Ouellette, B. F. F. (Eds.). (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd ed.). Wiley-Interscience.

- Pevsner, J. (2015). *Bioinformatics and Functional Genomics* (3rd ed.). Wiley-Blackwell.
- Kitchen, D. B., Decornez, H., Furr, J. R., & Bajorath, J. (2004). *Molecular Docking and Structure-Based Drug Design* (1st ed.). Springer.
- Frenkel, D., & Smit, B. (2002). *Understanding Molecular Simulation: From Algorithms to Applications* (2nd ed.). Academic Press.
- Leach, A. R. (2001). *Molecular Modelling: Principles and Applications* (2nd ed.). Prentice Hall.

SEMESTER IX

SPECIALIZATION: ENTOMOLOGY

FUNDAMENTALS OF INSECT TAXONOMY AND CLASSIFICATION

Paper Code: ZOOSPL25014
No. of Credits –4: 4(T) + 0(P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Objective

The objective of this course is to provide students with a thorough understanding of the evolutionary history, phylogeny, and major classifications of insects within the Superclass Hexapoda. The course will cover the distinguishing characteristics, biology, habits, and habitats of various insect orders and economically important families.

Course Outcomes

1. Gain an understanding of the evolutionary history and phylogenetic relationships of insects within the Superclass Hexapoda, including the major classifications and orders.
2. Learn to identify and describe the distinguishing characteristics, general biology, and ecological roles of insect orders and economically important families within the classes Ellipura (Collembola, Protura), Diplura, and Insecta (Apterygota and Pterygota).
3. Understand the biology, habits, and habitats of Orthopteroid and Blattoid orders (Oligoneoptera) and Hemipteroid orders (Paraneoptera), including their distinguishing features and economic significance.
4. Comprehend the distinguishing characteristics, biology, habits, and habitats of insect orders within the subdivision Endopterygota, focusing on the Neuropteroid-Coleopteroid and Panorpoid orders, and their economic importance.
5. Develop knowledge of the distinguishing features, biology, habits, and habitats of the Hymenopteroid orders, with an emphasis on their ecological roles and economic significance

Course contents

Theory **Credit: 04**

Unit I
Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda; Classes; Ellipura (Collembola, Protura), Diplura and Insecta- Orders contained.

Unit II
Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera.

Unit III
Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

Unit IV

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera. Insect molecular taxonomy =DNA as a new tool for insect identification.

Suggested Readings

1. Blackwelder RE. 1967. *Taxonomy - A Text and Reference Book.* John Wiley & Sons, New York.
2. Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie, London.
3. CSIRO 1990. *The Insects of Australia: A Text Book for Students and*
4. *Researchers*. 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.
5. Freeman S & Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.
6. Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Chapman & Hall, London.
7. Ross HH.1974. *Biological Systematics.* Addison Wesley Publ. Co.
8. Triplehorn CA & Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects.* 7th Ed. Thomson/ Brooks/ Cole, USA/Australia.

SEMESTER IX
INSECT MORPHOLOGY

Paper Code: ZOOSPL25024
No. of Credits –4: 4(T) + 0(P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Course Objective

The objective of this course is to provide a comprehensive understanding of the principles, relevance, and utility of insect taxonomy and classification, focusing on insect morphology, development, and sensory systems.

Course Outcomes

1. Understand the structure of the insect body wall, tagmata, sclerites, and segmentation.
2. Describe the structure and modifications of the insect head, mouthparts, antennae, tentorium, and neck sclerites.
3. Learn the structure of the thorax, wings, and legs, including modifications, venation, and flight mechanisms.
4. Understand abdominal segmentation, genitalia modifications, and types of insect development and metamorphosis.
5. Identify and describe insect sense organs and their functions (mechano-, photo-, and chemoreceptors).

Course contents
Theory **Credit: 04**

Unit I
Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation; Head- Origin, **s**tructure and modification; types of mouthparts and antennae, tentorium and neck sclerites.
Unit II
Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications.
Unit III
Abdomen- Segmentation and appendages; Genitalia and their modifications; Embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs: sensilla types and function (mechano-, photo- and chemoreceptors).
Unit IV
Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemimetabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Suggested Readings

1. Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, ambridge.
2. David BV & Ananthkrishnan TN. 2004. *General and Applied Entomology*. Tata-McGraw Hill, New Delhi.
3. Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.
4. Vans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.

5. Richards OW & Davies RG. 1977. *Imm's General Text Book ofEntomology*. 10th Ed. Chapman & Hall, London.
6. Saxena RC & Srivastava RC. 2007. *Entomology: At a Glance*. Agrotech Publ. Academy, Jodhpur.

SEMESTER IX
INSECT PHYSIOLOGY

Paper Code: ZOOSPL25034
No. of Credits –4: 4(T) + 0(P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Course Objective

The objective of this course is to provide a comprehensive understanding of the endocrine, nervous, digestive, excretory, circulatory, and visual systems of insects, along with their physiological processes, including sound production, bioluminescence, thermodynamics, moulting, growth, metamorphosis, and diapause.

Course Outcomes

1. Understand the historical perspective, structure, and function of endocrine glands, neurosecretion, hormone biosynthesis, and the roles and mechanisms of juvenile hormones (JH) and ecdysteroids in insects.
2. Learn the basic components and functions of the insect nervous system, digestive processes, nutrient absorption, and the role of symbionts in nutrition.
3. Comprehend the organs and processes of excretion, urine production and its hormonal regulation, and the components and functions of the insect circulatory system, including haemocytes and haemopoietic organs.
4. Understand the structure and function of the compound eye, mechanisms of sound production and bioluminescence, and the physiological processes of light production and adaptation.
5. Gain insights into the physiology of the integument, thermodynamics, moulting, growth, metamorphosis, and diapause, and their significance in insect development and survival.

Course contents
Theory **Credit: 04**

Unit I
Endocrine organs and hormones: Historical perspective, Endocrine glands and concept of neurosecretion. Biosynthesis and degradation of hormones, Function of JH and ecdysteroids, Mechanism of action of JH and ecdysteroids, Vertebrate hormones in insects, Eicosanoids and their functions; Nervous system: basic components and their function

Unit II
Digestive system: Digestion. Absorption, Nutrition, Nutritional requirements, Ectosymbiotic fungi, Endosymbionts; general organisation of respiration system, respiratory system in aquatic and terrestrial insects, Excretory system: Organs of excretion, Excretory products, Production of urine and its hormonal regulation; Circulatory system: Circulation, Haemocytes, Type, Haemopoietic organs, Changes in haemocyte population

Unit III
Visual system: Compound eye, Image formation, Light and dark adaptation; Mechanism and significance of sound production; Bioluminescence: Light producing organs, Mechanism of light production, Control and significance of light production; Thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapause.

Unit IV

Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

Suggested Readings

1. Kerkut GA & Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, New York.
2. Patnaik BD. 2002. *Physiology of Insects*. Dominant, New Delhi. Richards OW & Davies RG. 1977. *Imm's General Text Book of*
3. *Entomology.* 10th Ed. Vol. 1. *Structure, Physiology and Development.* Chapman & Hall, New York.
4. Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.
5. Wigglesworth VB.1984. *Insect Physiology.* 8th Ed. Chapman & Hall, New, York

SEMESTER IX
PRACTICAL: ENT 01

PAPER CODE: ZOOSPL25044
No. of Credits –4: {0(T) + 4(P)}
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Study of Orders of insects and their identification using taxonomic keys.
2. Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera.
3. Different types of mouthparts
4. Different types of antenna
5. Different types of legs
6. Preparation of arolium, empodium and pollen busket.
7. Sense organs
8. Stages of metamorphosis stages in of model insects.
9. Collection and preservation of insects by Dry preservation methods (direct pinning, carding and pointing), Liquid preservation and processesed mounting methods
10. Study of key features of insects belonging to economically important insect orders (Orthoptera, Hemiptera, Lepidoptera, Hymenoptera, Diptera).
11. Types of immature stages in insects; their collection, rearing and preservation.
12. Identification of immature insects to orders and families, in endopterygote orders viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key.
13. Field visits to collect insects of different orders.

Suggested Readings

1. Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, ambridge.
2. David BV & Ananthkrishnan TN. 2004. *General and Applied Entomology*. Tata-McGraw Hill, New Delhi.
3. Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.
4. Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Chapman & Hall, London.

SEMESTER IX
PRACTICAL: ENT 02

PAPER CODE: ZOOSPL25054
No. of Credits –4: {0(T) + 4(P)}
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Dissection of different insects to study comparative anatomical details of different systems;
2. Alimentary canal of house fly with crop
3. Bacterial chamber of termite
4. Sting apparatus of honey bee
5. Chromatographic analysis of free amino acids of haemolymph
6. Examination of insect haemocytes
7. Dissection of CNS of *Dysdercus* and cockroach.
8. Whole mount stained preparation of Brain, Corpora cardiaca, Corpora allata, Prothoracic gland
9. Preparation of histological slides of brain, corpus cardiacum, corpus allatum and CNS ganglia
10. Demonstration of presence of chitin in the cuticle of cockroach
11. Dissection of lamina medulla lobula complex in live cockroach/cricket
12. Report on educational tour.

Suggested Readings

1. Kerkut GA & Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology.* Vols. I-XIII. Pergamon Press, New York.
2. Patnaik BD. 2002. *Physiology of Insects*. Dominant, New Delhi.
3. Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Vol. 1. *Structure, Physiology and Development.* Chapman & Hall, New York.
4. Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.
5. Wigglesworth VB.1984. *Insect Physiology.* 8th Ed. Chapman & Hall, New York.

SEMESTER X
INSECT ECOLOGY

Paper Code: ZOOSPL25064
No. of Credits –4: 4(T) + 0(P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Objective

The primary objective of this course is to provide a comprehensive understanding of the biological principles governing the abundance, diversity, and distribution of insects. It aims to equip students with knowledge about the interaction of biotic and abiotic factors in ecological systems, the population dynamics of insects, and the ecological relationships within communities. The course also seeks to highlight the importance of ecological concepts such as carrying capacity, life tables, survivorship curves, and seasonality in understanding insect biology and ecology.

Course Outcome

1. Understand the historical context and basic concepts related to the organization of the biological world and insect diversity.
2. Analyze the impact of abiotic factors on the abundance and distribution of insects using principles like the Law of the Minimum, Law of Tolerance, and biocoenosis.
3. Apply concepts such as carrying capacity and life tables to insect biology, and interpret survivorship curves through case studies.
4. Evaluate the factors affecting insect population dynamics, including environmental factors, dispersal, migration, and seasonality.
5. Recognize the role of biotic factors in the distribution and abundance of insects, including nutritional ecology, food chains, and interspecific interactions.
6. Understand community ecology concepts, assess diversity, and analyze the organization and distribution of organisms within communities.

Course contents

Theory **Credit: 04**

Unit I

History and Definition. Basic Concepts. Organisation of the Biological world. Abundance and diversity of insects. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis.

Unit II

Concepts of Carrying capacity, Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation.

Unit III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions: Prey-predator interactions, Basic model- Lotka-Volterra Model, Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

Unit IV

Community ecology- Concept of guild, Organisation of communities, Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity.

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Suggested Readings

Chapman JL & Reiss MJ. 2006. *Ecology: Principles & Applications*. 2nd Ed. Cambridge Univ. Press, Cambridge.

Gotelli NJ & Ellison AM. 2004. *A Primer of Ecological Statistics.* Sinauer Associates, Inc., Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology.* 3rd Ed. Sinauer Associates, Inc., Sunderland, MA

Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.

Krebs CJ. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.

Krebs CJ. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance.* 5th Ed. Benjamin-Cummings Publ. Co., New York.

Magurran AE. 1988. *Ecological Diversity and its Measurement.* Princeton

Univ. Press, Princeton.

Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.

Real LA & Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.

Southwood TRE & Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Methuen & Co. Ltd., London.

Speight MR, Hunta MD & Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.

Wilson EO & William H Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.

Wratten SD & Fry GLA.1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

SEMESTER X

FOREST AND AGRICULTURAL ENTOMOLOGY

Paper Code: ZOOSPL25074

No. of Credits –4: {4(T) + 0(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The objective of this course is to explore the diverse interactions between insects and plants, understand the role of ground-dwelling insects in ecosystems, and study major insect pests of crops, their life cycles, and pest management strategies.

Course Outcomes

1. Understand various types of insect herbivory, plant defenses, and the role of plant chemicals in insect behavior and host-plant selection. Learn about the impact of insects on plant reproductive biology, including pollination and host-plant resistance.
2. Recognize the ecological roles of ground-dwelling insects, including scavenging, fungivory, and fungus farming by ants and termites. Understand their importance as environmental indicators and in environmental monitoring.
3. Identify major insect pests of key crops, their life cycles, nature of damage, and pest management strategies. Study polyphagous insect pests and forest entomology, focusing on insects that damage forest trees and their control methods

Course contents

Theory **Credit: 04**

Unit I

Insect – plant interactions: Herbivory, Leaf chewing, Plant mining and boring, Sap sucking, Gall formation, Seed predation, Insect feeding preference and host-plant selection, Role of plant chemicals in stimulation of feeding and oviposition, Role of plant chemicals as feeding deterrents, Plant toxins and their effect on insects; Insects and plant reproductive biology: Pollination, Myrmecochory, Host-plant resistance

Unit II

Ground-dwelling insects: Insects as scavengers, Insect-fungal interactions, Fungivorous insect, Fungus farming by leaf-cutter ants, Fungus cultivation by termites, ground-dwelling insects as environmental indicators, insects as Environmental monitoring.

Unit III

Insect pests of crops: Major pests of the following crops, their life cycles, nature of damage caused and pest management: paddy, wheat, sugarcane, pulses, fiber crops, vegetables, fruits and stored grain; Polyphagous insect pest: locusts, termites, cutworms, gram pod borer, aphids; Forest entomology (insects damaging forest trees and their control).

Unit IV

Methods of collection, killing, preserving, pinning, setting and handling and rearing.

Suggested Readings

1. Advances in Insect Physiology (vols. 1-28), Academic Press, 1986-2001
2. Alford: A textbook of Agricultural Entomology, Blackwell 1999
3. Atwal: Agricultural pests of India and South-East Asia, Kalyani Publishers, 1986
4. Busvine: Insects and Hygiene (3rd ed.), Chapman and Hall, 1980
5. Byrd and Castner: Forensic Entomology, CRC Press, 2001

6. Chandler & Read: Introduction to Parasitology, Wiley International, 1970
7. Chapman: The Insects: Structure and Function (4th ed.), ELBS, 1998
8. Gullan & Cranston: The Insects: An Outline of Entomology (2nd ed.) Blackwell, 2000
9. Gupta: Insect Hemocytes, Cambridge University Press, 1979
10. Harborne: Introduction to Ecological Biochemistry (4th ed.), 1993
11. Hill: Pest of stored foodstuffs and their control, Springer, 2002
12. Imms: A General Text Book of Entomology (2 vols.), Asia Publishing House, 1997
13. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002
14. Pedigo: Entomology and Pest Management (4th ed.), Prentice Hall, 2002
15. Pruthi: A Text Book of Agricultural Entomology, ICAR, New Delhi, 1969
16. Srivastava: A Text Book of Applied Entomology (Vol. I & II, 2nd ed.) Kalyani Publ., 2001
17. Wigglesworth: Principles of Insect Physiology, ELBS, 1972

SEMESTER X
INSECT TOXICOLOGY AND PEST CONTROL

Paper Code: ZOOSPL25084
No. of Credits –4: {4(T) + 0(P)}
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Objective

To orient the students with various methods of pest management, structure and mode of action of insecticides, applications equipment, insecticide resistance, and introduce to them the alternative methods, new areas of control using targeted approaches. Since pesticides and agrichemicals have been implicated in causing stress and toxicity to non-target organisms including human, the trend is towards minimizing their use by adopting the integrated pest management (IPM) which will be discussed in-depth.

Course outcomes

1. After completing this course, students will have working knowledge of conventional methods of insect control.
2. The students will become familiar with non- conventional methods of insect pest management, also they will be able to appreciate the advantages of safer environmental technology.
3. After completion of this unit, the students will have in-depth idea of parasitoids that spend their larval life on various life stages of host insects, with emphasis on major pests. Furthermore, they will also have working knowledge of the predatory insect preying on pests. Another important outcome will be the knowledge of their mass production for commercial applications.
4. After careful consideration of available methods of pest control, weighing the pros and cons, the students will have sufficient understanding of designing the 1PM for the crops in question.

Course contents

Theory **Credit: 04**

Unit I

Definition and history of pest control. Methods of insect pest control: General methods (physical, mechanical, cultural) and special method (insecticides). Nomenclature and classification of insecticides. Types of formulations. Mode of action of conventional insecticides (organophosphates, carbamates and fumigants). Insecticide application appliances.

Unit II

Mechanism of insecticide resistance in insects. Non-conventional insecticides: definition, utilization and mode of action of chemosterilants, repellents. Hormones: juvenoids, ecdysteroids and anti-hormones. Pheromones: types and application.

Unit III

Biological control: definition, history. Biological control agents: parasitoids and predators. Mass production and release of commonly used parasitoids and predators. Advantages and disadvantages of biological control; Integrated Pest Management (IPM): Basic principles and evolutionary trends of IPM. Ecological basis of IPM. Legislative methods.

Unit IV

Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Suggested Readings

1. Wigglesworth,V.B.(1973) The Principles of Insect Physiology,7th Ed. Chapman and Hall, London.
2. Chatterjee K D (1980) Parasitology 12th Ed. Chatterjee Medical Pub., Calcutta.
3. Principles of Toxicology by Karen Stine, Thomas M. Brown.
4. Text Book of Pathology by Harsh Mohan, Jaypee Brothers.
5. Principles and Methods of Toxicology by A. Wallace Hayes.
6. Srivastava, R. 1989. Text Book of Insect Toxicology. Himanshu Publications.

SEMESTER X
PRACTICAL: ENT 03

PAPER CODE: ZOOSPL25094

No. of Credits –4: {0(T) + 4(P)}
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Methods of sampling insects
2. Estimation of densities and abundance of insects.
3. Assessment of prey-predator densities from natural systems and understanding the correlation between the two.
4. Calculation of some diversity indices- Shannon's, Simpson's, etc.
5. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Suggested Readings

Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.
Real LA & Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.

SEMESTER X
PRACTICAL: ENT 04

PAPER CODE: ZOOSPL250104
No. of Credits –4: {0(T) + 4(P)}
Mark: 70 +30 (Internal)
Total hours: 90 (Practical) (6 h/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Study the role of insects in forest litter decomposition.
2. Pathogens and parasitoids in controlling forest insect populations.
3. Identify and study wood-boring insects
4. Identification of ground dwelling insects
5. Study of different parasites using permanent slides.
6. Toxicity studies in insects and rodents.
7. Insecticide formulations and mixtures
8. quality control of pesticide formulations
9. laboratory and field evaluation of bioefficacy of insecticides
10. bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides; visit to toxicology laboratories.
11. Good laboratory practices.

Suggested Readings

1. Principles and Methods of Toxicology by A. Wallace Hayes.
2. Srivastava, R. 1989. Text Book of Insect Toxicology. Himanshu Publications.

SEMESTER IX
SPECIALIZATION: FISH AND FISHERY SCIENCE

FISH TAXONOMY, DIVERSITY AND ADAPTATION

Paper Code: ZOOSPL25014

No. of Credits 4: 4(T) + 0(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The objectives include understanding fish taxonomy, diversity, and classification principles; exploring Indian fisheries resources, behavior, and distribution; and analyzing fish adaptations to diverse environments. They also encompass learning about aquatic ecology, wetland conservation, and pollution remediation; gaining practical skills in fish specimen collection and analysis; studying applied fisheries science, including reproduction and genetics; and understanding the economics and management of fisheries.

Course Outcome

- Mastery in fish taxonomy, classification, and identification.
- Understanding of Indian fisheries, behavior, and distribution.
- Insight into fish adaptations to diverse environments.
- Competence in aquatic ecosystem management and pollution control.
- Proficiency in fish specimen collection, preservation, and analysis.
- Knowledge of applied fisheries science, including reproduction and conservation.
- Understanding of fisheries economics and management practices

Course contents

Theory **Credit 4**

Unit I

Principles and Practices in fish identification: History of taxonomy; Fish diagnostics. Collection, preservation and care; identification: measurements, counts; Classification: hierarchy. Rules of nomenclature: Law of priority, Synonyms and homonyms, validity of subspecific names. Type concept: For genera; type by original designation, indication and monotypy, tautonomy, subsequent selection. Type concept for order: primary categories (Holotype,paratype, Allotype, syntype, lectotype; Suplementary or secondary categories: Neotype. Some defintions regarding selection of types, description of a taxa.

Unit II

Fish Diversity, Behavior, and Fisheries Resources in India: Diversity and Biogeographical distribution of major groups of fishes (Fresh and marine water fishes). Shoaling, courtship and parental care in fish, Migration: types, methods and patterns of migration. Causes and advantages, factors, orientation of migration, Role of hormones. General principles of locomotion in fish. Fresh water, Cold water, Estuarine and Marine fisheries of India. Biology of Sardine, Mackerel, Hilsa, Mahseer. Plankton diversity and productivity: Classification, sampling and preservation. Beneficial and harmful effects on aquatic life, Biological control of algal blooms.

Unit III

Fishes: Jawless agnathans to bony Teleostomes: Classification, Merits and demerits of Berg's classification. Ostracoderms and placoderms: Euphanerida, Pteraspida, Anaspida, Cephalaspida. Origin and Interrelationship: Palaeozoic fishes, Acanthodii, Coccostei. Cyclostomes: Lampreys and Hagfishes, specialised characters of cyclostomes. Chondrichthyes: Distinguishing features, earliest elasmobranchs, sharks and rays. Holocephali, salient features, characters showing affinity with elasmobranch. Teleostomes: Osteichthyes, Crossopterygii, Salient features of Latimeria (Coelacanth), Significance and Phylogeny.

Unit IV

Adaptations of hill stream and deep-ssea fishes: Conditions in the hill streams, modifications in the fish fauna, histological structure, mechanism of adhesion, origin of the hill stream fishes. Conditions in the deep sea, adaptations shown by mesopelagic fishes, adaptations in bathypelagic fishes, adaptations in benthic fishes, food and feeding habits, eyes and other sense organs, bioluminescence, methods for maintaining buoyancy, adaptations for reproduction and spawning.

Suggested Readings

1. Jayaram, K.C. 2009. Fundamentals of Fish Taxonomy. Narendra Publishing House,; 1st edition (1 January 2009).
2. Khanna, S.S and Singh, H.R. (2009) A text book of fish biology and fisheries. NPH,New Delhi110006. Jhingran, V.G. (1997). Fish and Fisheries of India. Hindustan Publications, Delhi, India.
3. Srivastava, C. B. L. (1985). A Textbook of Fishery Science and Indian Fisheries. Kitab Mahal.
4. Gene., et al. (2009). The diversity of fishes: Biology, Evolution, And Ecology (2nd Edn). Wiley-Blackwell. A John Wiley & Sons, Ltd.
5. Priede, I. G. (2017). Deep-sea fishes: biology, diversity, ecology and fisheries. Cambridge University Press.
6. Moyle, P.B. and Cech, J.J.(2014) Fishes: An Introduction to Ichthyology. (5th edn). Pearson Prentice Hall.
7. Dholakia , A.D. (2013). Fisheries and Aquatic resources of India. Daya publishing house.
8. Sardet C. 2015. Plankton: wonders of the drifting world. University

SEMESTER IX

AQUATIC ECOLOGY AND ENVIRONMENTAL MANAGEMENT IN FISHERIES

Paper Code: ZOOSPL25024

No. of Credits –4: {4(T) + 0(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objectives

The objectives include understanding brood fish ponds, hatcheries, nursery, and grow-out ponds; learning about care, stocking rates, and water quality management in aquaculture systems; and identifying abiotic and biotic components of aquaculture environments. They also cover understanding trophic classifications and ecological functions of wetlands, learning about bioindicators, biosensors, and nano-sensors, and identifying the causes and effects of water pollution.

Course Outcome

- Manage brood fish ponds, hatcheries, nursery, and grow out ponds.
- Maintain stocking rates and water quality in aquaculture.
- Understand abiotic and biotic interactions in aquaculture.
- Comprehend wetland ecological roles and trophic classifications.
- Use bioindicators, biosensors, and nano-sensors for environmental monitoring.
- Identify and understand sources and impacts of aquatic pollutants.

Course content

Theory **Credits 4**

Unit I

Ecology of Pond, reservoirs and RAS: Concept of brood fish pond, hatchery, nursery and grow out ponds. Care and stocking rate, water quality management; Abiotic and biotic components; Food chain; productivity and its measurement. Race ways, recirculating system, Types of culture systems; cage, pen. Development of reservoir fisheries in India, commercial Exploitation, conservation and management of Reservoirs. Setting of an Aquarium, Plants of the Aquarium, Common Aquarium Fishes, Food and Feeding of Prawns; Types of Prawn Fishery. Ecology and fisheries of beels.

Unit II

Wetlands and its role in biodiversity conservation: Trophic classifications, Functions, Degradation of wetlands (Causes, consequences; Constructed wetlands; Restoration, Conservation and management of wetlands, Ecological services and livelihood from wetland. Conservation of Genetic Diversity and ecological diversity, IUCN red list categories, Present status of Fisheries, Threatened Freshwater Fishes, Characteristics of an Endangered Fish, Measures for Fish Conservation, In-Situ Conservation, Ex-Situ Conservation, Cryopreservation of Gametes, Technique of Cryopreservation, Other Applications of Cryopreserved Sperms.

Unit III

Environmental monitoring and Remediation: Cellular and molecular markers of environmental pollution monitoring; Bioindicators; Biosensors and nano-sensors.

Bioremediation; Genetically-improved/engineered organisms - Basic concepts; Applications in remediation of metals, Pesticides and hydrocarbons.

Unit IV

Water pollution and Sewage fed fisheries: Causes of water pollution, domestic sewage, industrial wastes and effluents, soil erosion and sedimentation, fertilizers, pesticides and insecticides, radioactive waste, thermal waste, oil pollution, acidification, mining wastes, effect of pollutants on fish fauna and flora, precautions, types of water pollution on the basis of fisheries. Definition of sewage; general account; quality of sewage; treatment of sewage; principal cultivated fishes; production in sewage fish culture; quality of fish harvested from sewage irrigated ponds.

Suggested Readings

1. Jhingran, V.G. (1997). Fish and Fisheries of India. (Corrected reprint 2007) Hindustan Publications, Delhi, India.
2. Alderton, D. (2019). Encyclopedia of aquarium and pond fish. Dorling Kindersley Ltd.
3. Srivastava and Srivastava (2023). A text book of fishery science and indian fisheries. Kitab Mahal.
4. Kumar, A. (2019). Fisheries development and management in India 1785-2018.
5. Krishnan, M. (2006). Fisheries extension, development, and policy in India. Daya Publishing House.
6. Pandey and Shukla (2010) Fish and fisheries (2nd edn), Rastogi publication.
7. Sangeetha., et al (2016). Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. CRC Press.
8. Sayler., et al (1997). Biotechnology in Sustainable Environment. Plenum Press, New York.

SEMESTER IX
APPLIED FISHERY SCIENCE AND MANAGEMENT
Paper code: ZOOSPL25034
No. of Credits –4: {4(T) + 0(P)}
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Objective
The objectives include understanding fish population dynamics and abundance estimation, mastering the handling, storage, and labeling of freshwater fish products, and learning fish reproductive anatomy and hatchery management. They also encompass applying strategic genetics for fish conservation, advancing fisheries education and extension methods, and analyzing fisheries development plans, laws, and economic aspects.

Course Outcome
- Understand fish population dynamics and abundance estimation.
- Master handling, storage, and labeling of freshwater fish products.
- Learn fish reproductive anatomy and hatchery management.
- Apply strategic genetics for fish conservation.
- Advance skills in fisheries education and extension methods.
- Analyze fisheries development plans, laws, and economics.

Course contents
Theory **Credits: 4**

Unit I
Fish population dynamics: Processing and packaging: Definition of fish population density and dynamics; significance of abundance; estimation of population; population dynamics: fluctuation in population abundance; relationship between fish catch, mortality and population. introduction, handling, chilled storage, types of ice, chilled sea water (CSW) storage, the role of packaging, labelling requirements for freshwater fish products, retail packaging for freshwater fish products.

Unit II
Fish Reproduction and Hatchery Management: Eco-hatchery-circular spawning pool, eco-hatchery incubation pool, supplementary feed, chinese fish hatchery. Maturation and spawning, seasonal changes and GSI, process of follicular atresia, regulation of oocyte maturation by hormones, migration for spawning. Water quality management in hatcheries; Strategies to control diseases, Diagnosis, quarantine procedure, Prebiotics, Probiotics use in hatcheries, Seed quality testing methods and seed certification, Use of Immunostimulants in hatcheries, Advances in seed production of commercially important finfishes, Recent technologies for enhancing survival and growth, Nursery technology for different finfishes, Legal issues in seed quality and marketing.

Unit III
Strategic genetics for wild fish conservation: Fish stock improvement through selective hybridization natural hybridization; in bundhs; in natural habitat, artificial hybridization; intraspecific/interspecific and intergeneric hybridization, hybridization of chinese carp, hybridization of Indian carp with chinese carp, selective breeding, gynogenesis, androgenesis,

polyploidy. Production of monosex population, sex reversal, sterile fish. Biotechnology in fish conservation. Fish quarantine.

Unit IV

Advancing fisheries: education & extension in India: Fisheries extension methods and education in India; Extension service for fisheries development, Important fisheries development schemes and organizations: training follow up programmes – entrepreneurship development. Fishery as a tool for rural development and employment potentiality. Different fisheries development plan/schemes in India. Role of Government, NGOs, fisheries co-operatives and other agencies engaged in fisheries sector. Different fishery related laws in India. Planning and design of different projects related to aquaculture and their economic analysis.

Suggested Readings

1. Pandey and Shukla (2010) Fish and fisheries. Rastogi publications.
2. Chattopadhyay, N.R. (2017). Induced fish breeding A Practical Guide for Hatcheries. Academic Press is an imprint of Elsevier.
3. Pillay, T. V. R. (1990). Aquaculture: principles and practices. Fishing news books.
4. JB, P. (Ed.). (2002). Handbook of Fish Biology and Fisheries: volume 1-Fish biology. Blackwell science.
5. Allan, G. and Burnell, G. (2013). Advances in Aquaculture Hatchery Technology. Woodhead Publishing Limited.
6. Betsy, C.J. and Kumar, J.S.S., 2017. Biotechnological Applications in Fish Seed Production. Narendra Publishing House.
7. Iain M. Suthers and David Rissik (2009) Plankton: A guide to their ecology and monitoring for water quality. CSIRO Publishing Oxford Street.
8. Van Vuuren, J. (2006). Easy identification of the most common freshwater algae.
9. Marshall, B. (Ed.). (2017). Aquaculture and fish farming. Larsen and Keller Education.
10. Khanna, S.S and Singh, H.R. (2009) A text book of fish biology and fisheries. NPH,New Delhi110006.

SEMESTER IX

PRACTICAL: FFSc 01

Paper Code: ZOOSPL25044

No. of Credits 4: 0(T) + 4(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Practical **Credits: 4**

1. Fish specimen collection, preservation, and care demonstration.
2. Fish identification through morphological features.
3. Measurement and counting practice.
4. Collection and preservation phytoplankton and zooplankton.
5. Identification of various phytoplankton and zooplankton.
6. Study of selected marine fishes with the help of picture/image from text books.
7. Collection, preservation and analysis of flora and fauna (macrophytes and benthos) of wetland/degraded aquatic ecosystem.
8. Field visits to selected lakes/wetlands/degraded/restored ecosystem.
9. Wetland Livelihood Assessment.
10. Bioindicator Species Identification.
11. Identification and study of some important Indian common fish faunal resources (cold, warm, ornamental).
12. Estimation of species diversity, richness and evenness.
13. Study of hill stream fish morphology.
14. Field visits and IUCN redlist status assessment.

Suggested Readings

1. Nelson, J. S., Grande, T. C., & Wilson, M. V. H. (2016). Fishes of the World (5th ed.). John Wiley & Sons.
2. Froese, R., & Pauly, D. (Eds.). (2009). FishBase. World Wide Web electronic publication. Retrieved from http://www.fishbase.org
3. Mitsch, W. J., & Gosselink, J. G. (2015). Wetlands (5th ed.). John Wiley & Sons.
4. Jayaram, K. C. (2010). The freshwater fishes of the Indian region (2nd ed.). Narendra Publishing House.
5. Bohlen, J., & Šlechtová, V. (2009). Pangasius: Hypophthalmidae. In R. Froese & D. Pauly (Eds.), FishBase (pp. 57-64). World Wide Web electronic publication. Retrieved from http://www.fishbase.org
6. IUCN. (2021). The IUCN Red List of Threatened Species. Version 2021-3. Retrieved from https://www.iucnredlist.org

SEMESTER IX
PRACTICAL: FFSc 02
Paper code: ZOOSPL25054
No. of Credits –4: {0(T) + 4(P)}
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credits: 4**

1. Identification of locally available prawn/indigenous ornamental fishes
2. Fabrication of all-glass aquarium, setting-up and maintenance, Aquarium accessories and equipment
3. Morphometric study and identification of locally available hill stream fishes
4. Estimation of Gonadosomatic index (GSI) and fecundity.
5. Examine fresh/preserved specimens or images, note adaptations such as body shape, fin structure, and adhesive apparatus.
6. Study models/images or visit a hatchery, learn about spawning and incubation systems.
7. Designing of model of brood, hatchery, and nursery ponds.
8. Collecting data of the Fishermen in the nearby fishing villages.
9. Collecting the particulars of Farming practices and its economics.
10. Field report/ visit to a local fish market and survey of indigenous fish and shellfish species.
11. Observation of the annuli (growth rings) on scales and determine the age of the fish.
12. Collect scales from various fish and prepare them for examination by cleaning and mounting them.
13. Consumer Preference Survey
14. Population Estimation Field Study
15. Quality Control Assessment

Suggested Readings

1. Moyle, P. B., & Cech, J. J. (2004). Fishes: An Introduction to Ichthyology (5th ed.). Pearson/Prentice Hall.
2. Urquhart, A. E., & Smith, M. (2016). Ornamental Fish Farming. Blackwell Science Ltd.
3. Balon, E. K. (1975). Reproductive Guilds of Fishes: A Proposal and Definition. Canadian Journal of Fisheries and Aquatic Sciences.
4. Parker, R. (2012). Aquaculture Science (3rd ed.). Delmar Cengage Learning.
5. Jobling, M. (1995). Environmental Biology of Fishes. Chapman and Hall.
6. Pillay, T. V. R., & Kutty, M. N. (2005). Aquaculture: Principles and Practices (2nd ed.). Wiley-Blackwell.
7. Helfman, G. S., Collette, B. B., Facey, D. E., & Bowen, B. W. (2009). The Diversity of Fishes: Biology, Evolution, and Ecology (2nd ed.). Wiley-Blackwell.

SEMESTER X

ANATOMY AND PHYSIOLOGY OF FISH

Paper code: ZOOSPL25064

No. of Credits 4: 4(T) + 0(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The objectives include understanding fish feeding, digestion, and absorption regulation, describing respiratory and circulatory systems, gas transport, and osmoregulation, and explaining coloration, luminescence, and sensory systems. They also cover reproductive and endocrine systems, immune responses, nutrition, stress indicators, advanced aquaculture techniques, toxicology, nutritional biochemistry, energy utilization, and recognizing fishery by-products and preservation methods.

Course Outcomes

- Understanding feeding and physiological mechanisms.
- Proficiency in circulatory and excretory systems.
- Analysis of coloration, luminescence, and sensory systems.
- Knowledge of reproductive and endocrine functions.
- Mastery of immunity, nutrition, and preservation.
- Competence in advanced aquaculture and toxicology.
- Integration of aquaculture practices for effective management.

Course content

Theory **Credits 4**

Unit I

Feeding habits and physiology of digestion and respiration: Categories of food, Feeding habits and intensity. Modifications of Digestive system in fish. Regulation of digestion and absorption: Role of enzymes and hormones. Air breathing organs, Structure and function of gills in fin fishes; Structure and function of swim bladder (Dipnoi, teleostei), mechanism of gas secretion, origin of the swim bladder, weberian ossicle: structure, arrangement and functions; origin and homologies. Strategies of bouyancy in fish.

Unit II

Fish Circulatory and Excretory System: Hematology of fin fishes, Cardiovascular physiology of fin fishes, Gas transport, Acid-base balance. Comparative anatomy of Kidney in different fishes, rectal gland, chloride cell; Nitrogen excretion and metabolism, osmoregulation of fin fishes: Strategies, regulation in freshwater and marine teleosts.

Unit III

Colouration and luminescence in fish: Sources of colour: chromatophores; iridiocytes; control of chomatophores; effect of diet and water quality on colouration, structure of luminous

organs or photophore; types of luminescence and control of luminescence; mechanism of light production from luminous organs; biological significance of luminescence; Families of light producing fishes. Electric organ. Lateral line system: structure and function.

Unit IV

Reproductive and Endocrine System: Structure and physiology of reproductive system of fin fishes, physiological adaptation for reproduction, modes of reproduction: Sex determination and differentiation; Sexual dimorphism; Primary and secondary sex characters; Hermaphroditism. Endocrine glands of fin fishes and their hormonal regulation, Neuroendocrine system of fin fishes. Physiological role of different types of fish hormones, role of pheromones in fish.

Suggested Readings

1. Pandey and Shukla (2010) Fish and fisheries. Rastogi publications.
2. Khanna and Singh (2022). A text Book of fish biology and fisheries (3rd edn). Narendra publishing house. Delhi-06
3. David H. Evans, James B. Claiborne. (2006). The physiology of fishes. CRC press.
4. Quentin Bone, Richard Moore (2008). Biology of fishes. Taylor & Francis.
5. Gene Helfman, Bruce B. Collette, Douglas E. Facey. (2009) The diversity of fishes: biology, evolution, and ecology. Wiley-Blackwell.
6. Kumar and Tembhre (2011). Fish and fisheries (2nd edn). New central book agency.
7. Farrell, A. (2011). Encyclopedia of fish physiology: from genome to environment. Academic Press.
8. Roberts, R.J et al. (2012) Fish Pathology (4thed). A John Wiley & Sons, Ltd., Publication.

SEMESTER X

IMMUNE RESPONSES AND PRESERVATION TECHNIQUES

Paper code: ZOOSPL25074

No. of Credits –4: {4(T) + 0(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objectives

The objectives include understanding fish immune systems, nutrition, and stress responses; evaluating feed resources, formulating diets, and managing nutrition in aquaculture; and identifying and mitigating toxins and hazards in aquaculture. They also encompass recognizing principles of fish toxicology, analyzing fish bioenergetics and metabolic waste output, understanding preservation techniques like canning and curing, and recognizing common fish diseases and prevention methods.

Course Outcome

- Understanding fish immune systems, nutrition, and stress responses.
- Evaluating feed resources, formulating diets, and managing nutrition in aquaculture.
- Identifying and mitigating toxins and hazards in aquaculture.
- Applying principles of fish toxicology to aquaculture settings.
- Analyzing fish bioenergetics and metabolic waste output.
- Understanding fish preservation techniques, such as canning and curing.
- Recognizing common fish diseases and methods for prevention

Course contents

Theory **Credits 4**

Unit I

Immunity, nutrition and stress response in Fish: Lymphoid organs and cellular components of immune system; Phagocytic systems; Antigen processing and MHC; Immunostimulants; Fish antibodies, antibody responses, complement system, Cytokines of fish. Role of fatty acids and vitamins (Vitamin C, E and A) in immune response. Basic principles of immune system in fishes; Principles of stress resistance; stress indicators in fish. Common microbial diseases in fishes.

Unit II

Advanced Aquaculture: Nutrition and Toxicology: Types of feed resources. Nutritional value of feed ingredients. Non-conventional feed resources. Artificial diet and its formulation. Feed additives (attractants, growth stimulants, probiotics, prebiotics and binders). Antinutritional factors and antimetabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms. Definition and principles. Bioaccumulation and biomagnifications. Factors influencing toxicity, key target organs systems, Metabolism of toxic substances by aquatic organisms, toxicokinetics and biotransformation. Toxicity Testing - Microcosm and Mesocosm Tests, genotoxicity assay, Biomarkers.

Unit III

Nutritional biochemistry and Bioenergetics: Classification, nutrient quality, requirement and evaluation of proteins, lipids and carbohydrates in fish nutrition. Protein to energy ratio, nitrogen balance index, protein sparing effect. Bioenergetics of fish, Energy utilization and requirements. Concept of gross energy, digestible energy, Urinary, Branchial and metabolizable energy. Factors affecting metabolic waste utput.

Unit IV

Fishery by-products and fish preservation: Fish and fisheries products, status and significance. Useful products from fish and its processing wastes. Causes of fish spoilage: biochemical changes during fish spoilage; Principle and practice of fish preservation. Canning: Principles of canning; canning materials; handling and preparation of fish and shellfish for canning; spoilage of canned fish; chemical and microbiological spoilage and their prevention. Curing: Salting of fish-principles and practices; pickling; smoked fish; spoilage of cured fish.

Suggested Readings

1. Swain, P.K. and Sahoo Ayyappam, S. (2023). Fish and shellfish Immunology: An introduction. NPH, Delhi-110006.
2. Schreck, C.B. (2016) Biology of stress in fish: Fish Physiology (Academic Press (Elsevier).
3. Pillay, T.V.R. 2005. Aquaculture Principles and Practices. Second edition, Blackwell Publishing, USA.
4. Dunham, R.A. 2011. Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI Publishing, USA.
5. Lim, C., & Webster, C. D. (2001). Nutrition and fish health (pp. 163-175). New York: Food Products Press.
6. De Silva, S.S., Anderson, T.A. (1995). Fish Nutrition in Aquaculture. Chapman and Hall Aquaculture Series, London.
7. Lovell, T. (1989). Nutrition and feeding of fish (Vol. 260). New York: Van Nostrand Reinhold.
8. Halver, J.E. and Hardy, R. W. 2002. Fish Nutrition. Academic Press, London.
9. Nikinmaa, M. 2014. An Introduction to Aquatic Toxicology. Academic Press; 1st edn.
10. Di Giulio, R.T. Hinton, D.E. (2008). The Toxicology of Fishes. CRC Press Taylor & Francis Group.

SEMESTER X

INTEGRATED AQUACULTURE: BREEDING, NUTRITION, AND BIOTECHNOLOGY

Paper code: ZOOSPL25084

No. of Credits 4: 4(T) + 0(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The objectives include learning criteria for selecting aquaculture sites and species, managing optimal water conditions, and understanding fish nutrition principles and feed types. They also involve conducting morphometric studies to determine fish age and growth, familiarizing with fishing technologies in India, and studying genetic biotechnology and breeding techniques in aquaculture.

Course Outcomes

- Ability to select suitable sites and species for aquaculture.
- Skills in managing optimal water conditions for aquaculture.
- Understanding of fish nutrition and the use of various feeds.
- Proficiency in conducting morphometric studies and assessing fish growth.
- Knowledge of modern and traditional fishing technologies.
- Competence in applying genetic biotechnology and breeding techniques in aquaculture.

Course contents

Theory **Credits: 4**

Unit I

Introduction to Aquaculture: Scopes of aquaculture, importance and different types, Present status, problems/constraints and prospects for fish and prawn farming Indian perspective. Extensive, semi-intensive and intensive culture. Site and species selection. Important aquaculture species. Water-quality criteria for Aquaculture: Role of temperature, pH, salinity, dissolved oxygen, ammonia, nitrite, nitrate, phosphate. Aquatic weed management: biological and chemical control, predatory and weed fish, aquatic insects and their controls. Recent developments in aquaculture research and technology.

Unit II

Nutrition in Aquaculture: Concept of feeding the fish, Principles of fish nutrition and terminologies. Nutritional requirements of commercially important fish. Bioavailability of nutrients. Nutritional Physiology of food digestion in fish, Digestibility: significance and estimation. Broodstock and Larval nutrition. Types and components of artificial feed. Natural food and its importance. Biofloc and its significance.

Unit III

Morphometry and sustainable fishing techniques: Morphometric study of fish and its significance, types of scales and their roles. Determination of age in fishes; growth curve, length-weight relationship, condition factor and their significance, Fecundity estimation.

Fishing Techniques: Remote sensing, sonar, radar. Marking, Tagging and Population enumeration. Fishing technology in India: Scope and present status. Types of fishing crafts and gears in marine and inland waters.

Unit IV

Applied biotechnology, Breeding and Culture of fish: Biochemical, molecular markers: Applications of Allozymes, mtDNA markers, RFLP, RAPD, AFLP, Minisatellites, Microsatellites and SNPs. Regulation of transgenic fish by government, Constraints and limitations of genetic biotechnology. Fish Seed: natural collection, Bundh breeding, Induced breeding. Breeding and culture of carps. Ecology of swamps and their use for culture of air breathing fishes (*Heteropneustus, Clarius, Channa and Anabas*). Integrated fish farming: Fish-cum-livestock farming, paddy-cum-fish farming. Impact of exotic fish species and GMOs on aquatic biodiversity. Larvivorous fishes.

Suggested readings

1. Arumugam, N. (2014). Saras Aquaculture and fisheries. Saras publication.
2. Khanna and Singh (2022). A text Book of fish biology and fisheries (3rd edn). Narendra publishing house. Delhi-06
3. Gene Helfman, Bruce B. Collette, Douglas E. Facey. (2009) The diversity of fishes: biology, evolution, and ecology. Wiley-blackwell.
4. Pillay, T.V.R. 2005. Aquaculture Principles and Practices. Second edition, Blackwell Publishing, USA.
5. Srivastava, C. B. L. (1985). A Textbook of Fishery Science and Indian Fisheries. Kitab Mahal.
6. Dunham, R.A. 2011. Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI Publishing, USA.
7. Chattopadhyay, N. R. (2016). Induced fish breeding: a practical guide for hatcheries. Academic Press.

SEMESTER X

PRACTICAL: FFSc 03

Paper code: ZOOSPL25094

No. of Credits 4: 0(T) + 4(P)

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Practical **Credits: 4**

1. Dissection, display and study of the selected fish: a) Weberian ossicles and their association with internal ear and air bladder b) cranial nerves of selected fishes
2. Comparative study of feeding habits of different fish by gut content analysis.
3. Comparative study of digestive enzymes of herbivore, carnivore and omnivore fishes.
4. Accessory respiratory organ of some air breathing fish (*Clarias, Heteropneustes, Anabas, Channa*).
5. Analysis of hemoglobin percentage concentration.
6. Dissection and examination of gill structure.
7. Estimation of fecundity.
8. Identification of lymphoid organs
9. Dissection and display of endocrine glands – Fish thyroid, adrenals, gonads.
10. Toxicity assessment of pesticides and other contaminants on selected organisms
11. Preparation of formulated diets for fish larvae and adult.
12. Collection, identification and estimation of nutrient content of traditionally used fish diets in unmanaged fish culture.
13. Collection and identification of important live feeds
14. Determination of protein and carbohydrate from fish exposed to piscicidal compounds.
15. Analysis of vitamin C content of feed.

Suggested Readings

1. Pandey and Shukla (2010) Fish and fisheries (2nd edn), Rastogi publication.
2. Helfman, G. S., Collette, B. B., Facey, D. E., & Bowen, B. W. (2009). The diversity of fishes: Biology, evolution, and ecology (2nd ed.). Wiley-Blackwell.
3. Kuz'mina, V. V. (2013). Digestive enzymes of fish and their significance in fisheries practice. Journal of Ichthyology, 53(8), 597-612. https://doi.org/10.1134/S0032945213070035
4. Farrell, A. P. (2009). Encyclopedia of fish physiology: From genome to environment (Vol. 1). Academic Press.
5. Bagenal, T. B. (1978). Methods for assessment of fish production in fresh waters (3rd ed.). Blackwell Scientific Publications.
6. Di Giulio, R. T., & Hinton, D. E. (2008). The toxicology of fishes. CRC Press.

SEMESTER X
PRACTICAL: FFSc 04
Paper code: ZOOSPL25104
No. of Credits 4: 0(T) + 4(P)
Total hours: 45 (Theory) (3 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credits: 4**

1. Identification and study of various types of fishing gears and nets.
2. Determination of age and growth by scale methods.
3. Length-weight relationship and condition factor determination.
4. Study of different Types of scales, fins and otoliths
5. Physico-chemical parameters (temperature, pH, conductivity, turbidity, transparency, dissolved oxygen, Free CO2, alkalinity, hardness, phosphate) of freshwater/pond water.
6. Demonstration of Induced breeding of Indian major carps/catfishes.
7. Preparation of check list/ survey report / identification of indigenous ornamental/exotic fishes.
8. Collection and identification of feeding habit of indigenous larvivorous fishes
9. Visit to freshwater fish farm/breeding ponds/biofloc facility.
10. Design of various integrated farming models
11. Case study reports submission by the students on fish culture related issues /methods of fish culture.
12. Visit to integrated fish farms
13. Presentation and submission of excursion report.

Suggested readings

1. Pandey and Shukla (2010) Fish and fisheries (2nd edn), Rastogi publication.
2. Froese, R., & Pauly, D. (Eds.). (2012). FishBase. World Wide Web electronic publication. Retrieved from http://www.fishbase.org
3. Helfman, G. S., Collette, B. B., Facey, D. E., & Bowen, B. W. (2009). The diversity of fishes: Biology, evolution, and ecology (2nd ed.). Wiley-Blackwell.
4. APHA, AWWA, WEF. (2017). Standard methods for the examination of water and wastewater (23rd ed.). American Public Health Association.
5. Pillay, T. V. R. (1990). Aquaculture principles and practices: Fishing news books. Blackwell Science Ltd.
6. Tietze, U., & Villareal, L. V. (2003). Microfinance in fisheries and aquaculture-guidelines and case studies.

Specialization: WILDLIFE ECOLOGY

Semester IX

FUNDAMENTALS OF WILDLIFE ECOLOGY

Paper Code: ZOOSPL25014

No. of Credits: 4

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objectives

To build the foundation of knowledge about the basics of wildlife ecology.

Course Outcome

Theory **Credits: 4**

Unit I

Biodiversity and Wildlife: Concept of biodiversity: Species diversity, Genetic diversity and Ecosystem biodiversity; biodiversity hotspots, measurement of biodiversity: species richness, evenness; Factors governing species diversity; Threats to biodiversity, causes and consequences of biodiversity loss and decline. Definition, concept, importance and values of wildlife.

Unit II

Population Ecology: monitoring of wildlife population, different population estimation techniques; Population dynamics: population regulation, natality, fecundity, density, mortality; carrying capacity; Occupancy Modelling. Animal dispersion: immigration, emigration, migration in different taxa with examples. Commonly observed population growth models.

Unit III

Community Ecology: Community structure, organization and its stability; Social organization in vertebrates: birds and mammals; Group living: costs, benefits and optimal group size. Predator-prey dynamics; functional diversity and food webs; plant and animal interactions. Ecological guilds: spatial and foraging guilds in different communities.

Unit IV

Behavioural Ecology: Concept of Ethology; Pattern of behaviour: Innate behaviour, learned behaviour; Adaptation; Altruism; Communication in animals and their methods (acoustics and semiochemicals); Sexual selection; mating systems: polygyny, polyandry, promiscuity and lekking; Foraging ecology of animals: optimal foraging theory; home range, territory; Parental care in birds and mammals.

Suggested Readings

1. Alcock, J. (2005) Animal Behaviour: An Evolutionary Approach (8th edn.). Sinauer Associates, Inc.
2. Atkins, M.D. (1980). Introduction to Insect Behaviour. Mc Millan Publishing Company.
3. Begon, M., Harper, J.L. and Townsend, C.R. (2006). Ecology: Individuals, Populations and Communities. Blackwell Scientific Publications.
4. Chapman, J.L.K. and Reiss, M.J. (1997). Ecology: Principles and Applications. Cambridge University Press.
5. Colin, J., Bibby, Burgess, N.D. and Hill, D.A. (2011) Bird Census Techniques. Academic Press.
6. Dash, M.C. and Dash, S.P. (2009). Fundamentals of Ecology (3rdeds.). Tata Mc Graw-Hill Publishing Co., New Delhi.
7. Davis, B., Krebs, J.R. and West, S.A. (2012). An Introduction to Behavioural Ecology (4thedn.). Wiley-Blackwell.
8. Gaston, K.G. (2004). Biodiversity: An Introduction (2nd edn.). Blackwell Science Ltd.
9. Kaur, S., Batish, D.R., Singh, H.P., Kohli, R. (2022). Biodiversity in India: Status, Issues and Challenges. Springer Singapore, 665pp. ISBN: 978-981-16-9777-7
10. Kormondy, E.J. (1996). Concepts of Ecology (4th eds.). Prentice-Hall of India Pvt. Ltd.
11. Krebs, C.J. (1985). Ecology: The Experimental Analysis of Distribution and Abundance. Harper and Row, New York.
12. Putman, R.J. (1993). Community Ecology. Chapman and Hall, New York.

Semester IX

APPLIED RESEARCH METHODOLOGY

Paper Code: ZOOSPL25024

No. of Credits: 4

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

To establish the foundational principles for the application of research methodology and modern techniques in the field of wildlife research.

Course outcome

- Studying research methodology, biostatistics and the use of modern technology in wildlife research enable effective design and analysis.
- Conservation genetics will enhance the understanding of molecular ecology and its application for conservation strategies.

Course Contents

Theory **Credits: 4**

Unit I

Research methods and design: defining the Research problem, generating research questions and research hypotheses, research design, workplan; random sampling design and stratified random sampling design, sample size and its determination. Collection of Primary and Secondary Data; overview of various field research techniques: questionnaires and schedule survey, Participatory Rural Appraisal (PRA); distance sampling, Geospatial Approach for Predicting habitat suitability, Maximum Entropy (MaxEnt).

Unit II

Concept of Biostatistics and its applications: descriptive and inferential statistics; data transformation: Log transformations, Square-Root Transformation, Arcsine transformation; Normality tests: Shapiro-Wilk Test, Kolmogorov-Smirnov Test, Anderson-Darling Test; Chi-Square Analysis of Contingency Tables, multiple regression, Factor analysis: Principal Component Analysis, Canonical Correspondence Analysis; Generalized Linear Models. Model selection and model criticism using Akaike Information Criterion (AIC).

Unit III

Modern technology in wildlife research: Introduction to Remote Sensing: definitions, concepts and types of remote sensing and advantages of remote sensing; Principles of GIS and GPS: Basic concepts of GIS, Components of GIS and GPS, Spatial data models; Mark-release-recapture technique, Camera trapping; Bird Ringing, Use of Transmitters: PTT, Radio telemetry, Micro Chips, Radio collar; Satellite tracking.

Unit IV

Conservation Genetics: Application of genetics for wildlife conservation; PCR, DNA Sequencing, DNA Fingerprinting, Loss of genetic diversity, Genetic Depression, Demographic bottlenecks. Wildlife forensics: Overview, various forensic protocols for species identification, Molecular markers used in wildlife forensics; Wildlife forensics based on DNA analysis and morphometry; Scat/dung analysis techniques, hair and feather analysis techniques.

Suggested Readings

1) Bhatta Basudeb. (2021). Remote Sensing and GIS, (2nd edn.) Oxford University Press India.
2) Burrough, P. A. and Mc. Donnell, R. A. (1998). Principles of Geographical Information Systems. (2nd eds.). Oxford University Press.
3) Demers, M.N. (2005). Fundamentals of Geographic Information System. Wiley and Sons.
4) Dobzhansky, T. (1973). Genetics and the Origin of Species. Oxford and IBH Publishing Co.
5) Joseph G., and Jeganathan C.(2018). Fundamentals of Remote Sensing (3rd edn.). University Press.
6) Rastogi, V.B. (2015). Biostatistics. Third edition. Med Tec, Scientific International Pvt. Ltd. (New Delhi).
7) Richards, J.A. and Jia, X. (1999). Remote Sensing and Digital Image Processing. Springer.
8) Zar, J. H. (2004). Biostatistical Analyses (Fourth Edition). Pearson Education (Singapore) Pvt. Ltd., Indian Branch, Patparganj, Delhi. 663pp.

Semester IX

WILDLIFE IN HUMAN PERSPECTIVE

Paper Code: ZOOSPL25034

No. of Credits: 4

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The study will establish the groundwork for comprehending the fundamental principles of wildlife ecology and the human dimensions involved in wildlife crime and management.

Course outcome

The study of Wildlife in Human Perspective aims to provide students with a comprehensive understanding of wildlife biology and human dimensions in wildlife management, allowing them to apply this knowledge in various contexts, including research, and conservation.

Course Contents

Theory **Credits: 4**

Unit I

Wildlife Biology: Importance of wildlife biology in wildlife conservation. Biology of major Indian amphibians and reptiles; biology of important bird species of India (Bengal Florican and Greater Adjutant); biology of important mammal species of India (Golden langur and Indian One-horned Rhinoceros).

Unit II

Urban Wildlife Ecology: Urban wildlife research─ past, present and future; multidisciplinary approach; Effects of urbanization on wildlife with emphasis on birds; synanthrope species; Human and urban wildlife interface: perception towards urban wildlife, conflict, food provisioning; Garbage dump─ habitat of scavenging urban wildlife. Case studies of urban birds: House Crow, Sparrows and Common Myna.

Unit III

Human dimensions in Wildlife Management: Human-wildlife conflict, case studies in India with special reference to northeast India; Sustainable Biodiversity Conservation: Ecosystem people; sacred groves, home garden; Citizen science: e-bird, Bird count India; Ecotourism: definition and scope, wildlife tourism; Environment Impact Assessment (EIA): Basic concepts & objectives of EIA, Relationship between EIA and wildlife conservation.

Unit IV

Wildlife Crime: Overview of wildlife trade in India; Various case studies of wildlife species in trade; aviculture; bushmeat hunting, poaching; Wildlife Crime Scenarios in global, national and local perspectives, CITES, TRAFFIC; Policies and law related to wildlife crime

in India: Wildlife (Protection) Amendment Act 2022; Wildlife Crime Control Bureau; Control measures of wildlife trade in India.

Suggested Readings

1) Alberti, M. (2008). Advances in urban ecology: integrating humans and ecological processes in urban ecosystems. Springer, Boston, 366pp. ISBN:978-0-387-75510-6
2) Chetry, D., Chetry, R. and Bhattacharjee, P. C. (2007) Hoolock: the Ape of India. A Publication of Gibbon Conservation Centre, Moriani, Jorhat, Assam.
3) Conover, M. (2001). Resolving Human wildlife conflicts, CRC press.
4) Fundamentals of Ecology and Environment, Pranav Kumar and Usha Mina 4th Edition. Pearson Education.
5) Mallya,A. (2006).Wildlife Tourism and Conservation. Eastern Book Corporation, New Delhi.
6) Marzluff, J.M., Shulenberger, E., Endlicher, W., Alberti, M., Bradley, G., Ryan, C.,Simon, U., ZumBrunnen, C. (2008). Urban Ecology: An International Perspective on the Interaction Between Humans and Nature. Springer New York, NY, 808 Pp. ISBN:978-0-387-73412-5
7) Shackleton, C.M., Cilliers, S.S., Davoren, E., duToit, M.J. (2021). Urban ecology in the Global South.Springer, Cham, 461pp. ISBN: 978-3-030-67650-6
8) Verdade L.M., Lyra-Jorge, M. C., Piña, C.I. (2014). Applied ecology and human dimensions in biological conservation. Springer, Berlin, 228 Pp. ISBN: 978-3-642-54751-5
9) Verma, P., Singh, P., Singh, R., Raghubanshi, A. (2020). Urban Ecology: Emerging Patterns and Social-Ecological Systems, Elsevier. ISBN: 9780128207307
10) Wildlife Ecology, Conservation, and Management, Anthony R.E. Sinclair and John M. Fryxell, 3rd Edition. Wiley-Blackwell.

Semester IX

PRACTICAL: WE 01

Paper Code: ZOOSPL25044

No. of Credits: 1

Total hours: 15 (1 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Analysis of species diversity: Shannon-Wiener Index, Simpson's Index; Similarity Index. Species-area curve.
2. Wildlife population estimation by: Line transect method, point count method, belt transect method, McKinnon's method, encounter rate, marked-recaptured technique.
3. Methods of behavioural observation: focal animal, all-occurrence and one-zero sampling, scan animal sampling; collection and analysis of behavioural data on some common availability species; time-activity budgets and preparation of ethograms of studied animal species.
4. Research methodology exercise: Research questions and research hypotheses designing. Concept of data collection, datasheet preparation, work plan designing. Research proposal preparation.
5. Questionnaire and Schedule survey datasheet preparation and application in various studies.
6. Visit to an urban garbage dump and study on urban wildlife therein. Time-activity budgeting of urban bird species.
7. Sign survey: identification of foot print, pug mark, pellet, dung, antler, dropping etc.
8. Identification of feather and hair of wild animals.

Suggested Readings

1. Daniel, JC. (2002). The book of Indian reptiles and amphibians. BNHS & Oxford University Press. 238pp. ISBN 9780195660999
2. Haccou, P., Meelis, E. (1992). Statistical analysis of behavioural data: an approach based on time structured models. Oxford university press. 416pp. ISBN 0198546637
3. Hasell, M. (2005). Bird nests and construction behaviour. Cambridge University Press. 400pp. ISBN 9780521017640
4. Henderson, P. A. (2021). Southwood's Ecological Methods. Oxford University Press. 528pp. ISBN 9780198862277
5. Kerbs, C.J. (1999). Ecological Methodology. Pearson Higher Education, Harlow, UK. 620pp. ISBN 9780321021731
6. Khandeshwar, S.R., Raman, N.S., Gajbhiye, A.R. (2019). Environmental Impact Assessment. Dreamtech Press and Wiley. 232pp. ISBN 9789389307702
7. Magurran, A.E. (2012). Ecological diversity and its measurement. Springer Dordrecht.179pp. ISBN 9789401573603
8. Manly, B.F.J., Amstrup, S.C., Mcdonald T.L. (2006). Handbook of capture-recapture analysis. Princeton University Press. 336pp. ISBN 9780691089683

9. Peirce, J.J., Vesilind P.A., Weiner, R.F. (1997). Environmental Pollution and Control. Elsevier Science and Technology books. 379pp. ISBN 0750698993
10. Singh, L. A. K. (2000). Tracking Tigers: Guidelines for estimating wild tiger populations using the Pugmark Technique. (Revised Edition). WWF Tiger Conservation Programme, India. 36pp.

Semester IX
PRACTICAL: WE 02
Paper Code: ZOOSPL25054
No. of Credits: 1
Total hours: 15 (1 hour/ Week)
Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Undertake rapid assessment of impacts of existing or upcoming developments related to wildlife habitats.
2. Collection of location data by hand-held GPS; False colour composition (FCC) interpretation; manual landscape mapping; georeferencing.
3. Field excursion to national parks/wildlife sanctuary.
4. Study of biodiversity in sacred grove/homegarden.
5. Market survey of bioresources including bushmeat.
6. Uploading of bird data in e-bird platform.
7. Statistical analyses of data collected during field exercises.
8. Interpretation of species ecology using: GLM, PCA, SDM, Niche modeling and Occupancy models.

Suggested readings

1. Abdi, H., & Williams, L. J. (2010). Principal component analysis. Wiley interdisciplinary reviews: computational statistics, 2(4), 433-459.
2. Bhagwat, S. A., & Rutte, C. (2006). Sacred groves: potential for biodiversity management. Frontiers in Ecology and the Environment, 4(10), 519-524.
3. Dobson, A. J., & Barnett, A. G. (2018). An introduction to generalized linear models. Chapman and Hall/CRC.
4. Featherstone, S. (2004). Outdoor guide to using your GPS. Creative Publishing international.
5. Hijmans, R. J., & Elith, J. (2013). Species distribution modeling with R. R Cran Project.
6. MacKenzie, D. I., Nichols, J. D., Royle, J. A., Pollock, K. H., Bailey, L., & Hines, J. E. (2017). Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier.
7. Malhotra, K. C., Gokhale, Y., Chatterjee, S., & Srivastava, S. (2001). Cultural and ecological dimensions of sacred groves in India. INSA, New Delhi, 1-30.
8. Miller, J. (2010). Species distribution modeling. Geography Compass, 4(6), 490-509.
9. Sillero, N. (2011). What does ecological modelling model? A proposed classification of ecological niche models based on their underlying methods. Ecological Modelling, 222(8), 1343-1346.
10. Stroup, W. W. (2012). Generalized linear mixed models: modern concepts, methods and applications. CRC press.

Semester X

BIOGEOGRAPHY AND HABITAT ECOLOGY

Paper Code: ZOOSPL25064

No. of Credits: 4

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The study aims of exploring biological concepts and theories of evolution to understand habitat ecology and the principles that guide forest management.

Course outcomes

- The aim of examining concepts and theories concerning evolution, the mechanisms of evolutionary change and flora and fauna in the Indian context.
- The study of habitat ecology and forest management will allow the students to understand the relationships between species and their environment.

Course Contents

Theory **Credits: 4**

Unit I

Biogeographical concepts: ecology of dispersal and faunal exchange; continental drift; endemism; continuous vs disjunct distributions; biogeographical realms. India's biogeographic classification. The biogeographic affinities of the fauna and flora of the Indian subcontinent. Island biogeography; metapopulation concept.

Unit II

Basic concepts in evolution: natural selection and genetic drift; macroevolution and coevolution; speciation and hybridization. Taxonomy and Systematics of Animals: classification and nomenclature issues of vertebrates; Taxonomy as a basic tool in wildlife research; biological, phylogenetic, evolutionary and ecological species concepts.

Unit III

Habitat Ecology: concept of habitats, major habitats of animals; habitat fragmentations and gap formation; Landscape Ecology: fundamentals of landscape ecology, ecological and spatial scales, drivers of Landscape Change. Habitat suitability indices and measurements. Ecology of major wildlife habitats: forests, grasslands, and wetlands.

Unit IV

Vegetation Ecology: Major vegetation types of India (Champion & Seth's classification). Vegetation surveys and sampling techniques. Introduction to forestry: structure of forest ecosystem, principles of forest management. Phenology of trees; Regeneration ecology of forest trees: forest seed bank, dormancy and germination.

Suggested Readings:

1) Ambasht R.S. and Ambasht, N.K. (2008). Text Book of Plant Ecology (15theds.). CBS Publishers and Distributers, New Delhi.
2) Champion, H.G. and Seth, S.K. (1968) A Revised Survey of the Forest Types of India (Reprinted 2004). Natraj Publishers, Dehradun.
3) Closs, G., Downes, B. and Boulton, A. (2004) Freshwater Ecology. Blackwell Science Limited, USA.
4) Colbert,E.M. (1996). Evolution of the Vertebrates: A History of Backboned Animals through Times. Wiley Eastern Ltd., New Delhi.
5) Gopal, B. (1995) Handbook of Wetland Management. WWF, India, New Delhi.
6) Grandcolas, P., Maurel, M.C. (2018). Biodiversity and Evolution. Elsevier, 270pp. ISBN 9781785482779.
7) Michael,P. (1984).Ecological Methods for Field and Laboratory Investigation. Tata McGraw-Hill, New Delhi.
8) Newton, A.C. (2007) Forest Ecology and Conservation: A Handbook of Techniques. Oxford University Press.
9) Raymond, Y.A. and Ronald G.L. (2003) Introduction to Forest Ecosystem: Science and Management (3rd edn.). John Wiley and sons.
10) Spellerberg, I.F. (2005) Monitoring Ecological Change (2nd). Cambridge University Press.
11) Turner, I.M. (2001) The Ecology of Trees in the Forest. Cambridge University Press.

Semester X

ECOLOGY OF MAJOR WILDLIFE TAXA

Paper Code: ZOOSPL25074

No. of Credits: 4

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The study will provide students an overview of distribution, status, their social organization, behavioural and ecological role in the Indian context.

Course outcomes

- Exploring entomology will help understand the significance of insects as bioindicators and pollinators, providing insights into their ecological role.
- Studying herpetology will enhance the understanding of reptiles and amphibians, crucial for conservation efforts and ecological balance.
- Ornithology would provide insights into avian behaviour aiding in habitat preservation. Studying bird migration will contribute to scientific understanding of navigation, and ecology, which would help in safeguarding bird populations and maintaining the balance of ecosystems.
- Studying mammalogy will offer crucial insights into mammalian biology, behaviour, and ecology, which are pivotal for both conservation efforts and the management of wildlife populations.

Course Contents

Theory **Credits: 4**

Unit I

Entomology: insects as key indicator taxa in forest ecosystems; role of insects in pollination, ecosystem functioning and other services. Diversity and distribution of butterflies in northeast India; seasonal and altitudinal migration. Socio-biology of insects: biology of butterflies and moths, host plants and nectar plants; mud puddling.

Unit II

Herpetology: diversity and distribution of amphibians and reptiles in India; factors affecting distribution and abundance of amphibian and reptilian fauna of India; biology of major Indian amphibians; population surveys and census techniques for reptiles and amphibians. Eco-physiological adaptations: aestivation, hibernation; role of temperature in sex determination in reptiles.

Unit III

Ornithology**:** Biogeographic patterns in Indian avifauna and their affinities; adaptive radiation and speciation in birds; kin selection & altruism; colonial breeding systems in birds─

heronries; brood parasitism. Migratory ecology of birds: local, latitudinal, longitudinal and altitudinal migrations. Proximate and ultimate factors. Major migratory flyways. Impacts of global climate change on migration phenology.

Unit IV

Mammalogy: diversity, distribution and status of Indian mammals; threatened mammals of India and their conservation; adaptations in mammals; foraging and nutrition ecology; behaviour and social organization in mammals; ecology of herbivores (ungulates), carnivores (cats) and omnivores (primates).

Suggested Readings

1. Ahmed, M.F., Das, and Dutta, S. K. (2009) Amphibians and Reptiles of Northeast India. Aaranyak Publication, Guwahati, Assam.
2. Ali, S. and Ripley, S.D. (1987) Compact Handbook of the Birds of India and Pakistan (2nd edn.).Oxford University Press.
3. Chetry, D., Chetry, R. and Bhattacharjee, P. C. (2007) Hoolock: the Ape of India. A Publication of Gibbon Conservation Centre, Moriani, Jorhat, Assam.
4. Choudhury, A. (2000) The Birds of Assam. WWF – India, N. E. regional office & Gibbon Books.
5. Choudhury, A. (2000) The Mammals of North East India. Gibbon Books and Rhino Foundation.
6. Daniel, JC. (2002). The book of Indian reptiles and amphibians. BNHS & Oxford University Press. 238pp. ISBN 9780195660999
7. Grimmett, R.; Inskipp, T. and Inskipp, C. (2002) Pocket Guide to Birds of the Indian Subcontinent. Oxford University Press.
8. Handbook of Bird Biology, 3rd Edition. 2016. Edited by Irby J. Lovette and John W. Fitzpatrick. John Wiley & Sons, Inc.
9. Islam, Zafar-ul. M and Rahmani, Asad, R. (2004) Important Bird Areas in India: Priority Sites for Conservation. BNHS Publication.
10. Johnsing, A. J. T. and Manjrekar, N. (Eds.) (2015)Mammals of South Asia. Vol.1. Universities Press of India Pvt. Ltd., Hyderabad.
11. Menon, V. (2013) Indian Mammals: A Field Guide. Hachette India, New Delhi.
12. Prater, S.H. (1971) The Book of Indian Animals. Bombay Natural History Society. Mumbai.
13. Rahmani, A.R. and Choudhury, A.U. (2012) Threatened Birds of Assam. Oxford University Press.
14. Rasmussen, P. C.and Anderton, J.C. (2012) Birds of South Asia: The Ripley Guide (2nd edn.). Lynx Editions.
15. Darby, M. (2023). The British Foundation of Indian Entomology. Cambridge Scholars Publishing.
16. Kunte, K., Basu, D. N., & Kumar, G. G. (2019). Taxonomy, systematics, and biology of Indian butterflies in the 21st century. In Indian insects (pp. 275-304). CRC Press.

Semester X

CONSERVATION ECOLOGY AND WILDLIFE MANAGEMENT

Paper Code: ZOOSPL25084

No. of Credits: 4

Total hours: 45 (Theory) (3 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Objective

The course offers an introduction to conservation ecology and explores a range of management techniques.

Course outcomes

- The study will equip students with the knowledge needed to develop effective strategies and mitigating threats to wildlife.
- It will explore conservation efforts and success of NGOs and local communities outside Protected Areas in India.

Course Contents

Theory **Credits: 4**

Unit I

Conservation Ecology: Viable population, Population and Habitat Viability Assessment (PHVA); Biological Invasion: exotic, invasive and introduced species of plants and animals; bioindicator species of plants and animals; animal corridor; wildlife Health: emerging wildlife and zoonotic diseases, wildlife-livestock interface and conservation; climate change: effects of climate change on wildlife.

Unit II

Wildlife management: Forest Conservation Act 1980; Wildlife Management Plan; conservation practices in NE Region of India: In-situ and Ex-situ conservation; Introduction, reintroduction and translocation of wild animals; wildlife rescue and rehabilitation; concept of Keystone, Flagship and Umbrella species; IUCN Criteria of Threatened Wildlife; Conservation Breeding Programme with few successful case studies in India; controlled burning practice in protected areas.

Unit III

Conservation efforts: wildlife sanctuary, national park, Biosphere Reserve, Tiger Reserve, Elephant Reserve, Important bird and Biodiversity Areas (IBA) in India. Conservation Assessment and Management Plan (CAMP). Convention on Biological Diversity (CBD), Central Zoo Authority (CZA); Convention on Wetlands of International Importance: Ramsar Convention.

Unit IV

Wildlife conservation outside PAs: reserve forest, Conservation and Community Reserves, Community Conserved Areas (CCA), eco-sensitive zones; Eco-development projects; Conservation with local community; Major International and National Organizations in Wildlife Conservation: IUCN, UNDP, FAO, WWF, BNHS, SACON, National Biodiversity Authority (NBA), WTI, NCF, Aaranyak.

Suggested Readings

1) Anonymous (1997). The Indian Forest Act, 1927 along with forest conservation act, 1980. Natraj Publisher's Dehradun
2) Baldauf, C. (2020). Participatory Biodiversity Conservation: Concepts, Experiences, and Perspectives. Springer Cham, 237pp. ISBN: 978-3-030-41686-7
3) Bond, S. (2002) Ecological footprints. A guide for local authorities. WWF-UK, Surrey.
4) Dash, S. K. (2007) Climate Change: An Indian Perspective. Cambridge University Press India Pvt. Ltd., New Delhi.
5) Filho, W.L., Barbir, J., Preziosi, R. (2019). Handbook of Climate Change and Biodiversity. Springer Cham, 408pp. ISBN: 978-3-319-98681-4
6) Gopal, R. (2011) Fundamentals of Wildlife Management. Natraj Publishers.
7) Steiner F. (2016). Human Ecology: How Nature and Culture Shape Our World. Island Press Washington, DC., 237pp. ISBN: 978-1-61091-778-0

Semester X

PRACTICAL: WL 03

Paper Code: ZOOSPL25094

No. of Credits: 1

Total hours: 15 (1 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Techniques of vegetation surveys and quantification: point-centred quarter method, line intercept method, quadrat sampling and nested quadrat method, crown-canopy estimation method, estimation of canopy cover using ocular method. Species-area curve.
2. Estimation of quantitative and qualitative characteristics of plant community: frequency, density, abundance, basal area, Important Value Index (IVI).
3. Study of phenology of some plant species.
4. Estimation of Systematic study of common plants: Field and Herbarium techniques, Rapid assessment of wetland vegetation.
5. Study of germination and regeneration of trees.
6. Study of tree structure analysis
7. Measuring and mapping habitat variables in the study area.
8. Field techniques for herpetofaunal surveys and population estimation.
9. Life cycle of insect species, morphometric studies; preservation techniques of insects.
10. Bird nest survey outside the protected area
11. Bird nest material analysis

Suggested Readings

1) Ambasht R.S. and Ambasht, N.K. (2008). Text Book of Plant Ecology (15theds.). CBS Publishers and Distributers, New Delhi.
2) Daniel, JC. (2002). The book of Indian reptiles and amphibians. BNHS & Oxford University Press. 238pp. ISBN 9780195660999
3) Darby, M. (2023). The British Foundation of Indian Entomology. Cambridge Scholars Publishing.
4) Kunte, K., Basu, D. N., & Kumar, G. G. (2019). Taxonomy, systematics, and biology of Indian butterflies in the 21st century. In Indian insects (pp. 275-304). CRC Press.
5) Michael,P. (1984).Ecological Methods for Field and Laboratory Investigation. Tata McGraw-Hill, New Delhi.
6) The Book of Indian Butterflies. Isaac Kehimkar. 2008. Bombay Natural History Society. ISBN13: 978-0195696202
7) Turner, I.M. (2001) The Ecology of Trees in the Forest. Cambridge University Press.

Semester X

PRACTICAL: WL 04

Paper Code: ZOOSPL25104

No. of Credits: 1

Total hours: 15 (1 hour/ Week)

Total Marks: 100 (70 External + 30 Internal)

Practical **Credit: 04**

1. Field visits to forests, grasslands and wetlands under various management regimes; Field report preparation.
2. Field visit to Wildlife Animal Health Centre and understand their management practices.
3. Visit to conservation breeding centre and learn the technique of rearing.
4. Visit to Animal Rescue Centre and study rearing, soft release and hard release techniques.
5. Field visit to community conserved areas and discuss with the local community.
6. Field visit to a bat colony: study population estimation, roosting behaviour, roosting ecology.
7. Study of exotic, invasive and introduced species of plants.
8. Short term placement with NGOs and other Wildlife based communities.
9. Group discussion regarding wildlife conservation issues.

Suggested Readings

1) Altringham, J. D., Senior, P., Ruckstuhl, K. E., & Neuhaus, P. (2005). Social systems and ecology of bats. Sexual segregation in vertebrates, 280-302.
2) Jose, S., Singh, H. P., Batish, D. R., & Kohli, R. K. (Eds.). (2013). *Invasive plant ecology*. CRC Press.
3) Kothari, A. (2012). Community conserved areas. In Managing Protected Areas (pp. 579-603). Routledge.
4) Kunz, T. H., & Fenton, M. B. (Eds.). (2003). Bat ecology. University of Chicago Press.
5) Mallinson, J. J. (1995). Conservation breeding programmes: an important ingredient for species survival. Biodiversity & Conservation, 4, 617-635.
6) Shankar, U., Yadav, A. S., Rai, J. P. N., & Tripathi, R. S. (2012). 14 Status of Alien Plant Invasions in the North-eastern Region of India. Invasive alien plants: An ecological appraisal for the Indian subcontinent, 1, 174.

2-Year PG/1-Year PG

General Guidelines for Syllabus Option 2: Coursework + Only Research

Research thesis/ Project with minimum 1 conferences paper. Peer-reviewed research publication should be encouraged.

- Research Thesis/Project: Choose relevant topics, conduct thorough literature reviews, and formulate research questions.
- Conference Papers: Produce a minimum of one papers for reputable conferences.
- Peer-Reviewed Publication: Peer-reviewed research publication should be encouraged.
- Research Methodology: Provide guidance on methodologies, data collection, and analysis.
- Supervision and Support: Assign dedicated supervisors, facilitate regular meetings, and offer additional support.
- Presentation and Defense: Prepare presentations and defend research findings before faculty and peers.
- Evaluation Criteria: Establish clear criteria for assessing originality, depth, clarity, and contribution.
- Ethical Considerations: Educate on research ethics and ensure adherence to ethical guidelines.
- Resources and Support Services: Provide access to research facilities, training, and funding opportunities.
- Timeline and Milestones: Set clear milestones and monitor progress to meet deadlines.

General Guidelines for Syllabus Option 3: Only Research

Research thesis/ Project with minimum 2 conferences papers. Peer reviewed research publication should be encouraged

- Overview: Emphasize research focus and academic contribution.
- Research Thesis/Project: Choose relevant topics, conduct thorough literature reviews, and formulate research questions.
- Conference Papers: Produce a minimum of two papers for reputable conferences.
- Peer-Reviewed Publication: Aim for publication in reputable journals; emphasize rigor and ethical standards.
- Research Methodology: Provide guidance on methodologies, data collection, and analysis.
- Supervision and Support: Assign dedicated supervisors, facilitate regular meetings, and offer additional support.
- Presentation and Defense: Prepare presentations and defend research findings before faculty and peers.

- Evaluation Criteria: Establish clear criteria for assessing originality, depth, clarity, and contribution.
- Ethical Considerations: Educate on research ethics and ensure adherence to ethical guidelines.
- Resources and Support Services: Provide access to research facilities, training, and funding opportunities.
- Timeline and Milestones: Set clear milestones and monitor progress to meet deadlines.