UNIVERSITY OF KALYANI

Curriculum Based On NEP-2020 Guidelines
for three/ four Years Under-graduate course
in
ZOOLOGY

– SYLLABUS OF COURSES –

MAJOR (MJ)
MINOR (MI)
Skill Enhancement Course (SEC)
and
Multi-Disciplinary Course (MDC)

COURSES EFFECTIVE FROM THE ACADEMIC SESSION 2023-24

*The **Under Graduate syllabus in Zoology (eight-semester course) under NEP system (2023-2024)** has been placed in the meeting of Board of Postgraduate Studies (UG-BoS) in Zoology held on 05.11.2024. The members of UG-BOS restructured and recommended the syllabus and the same was subsequently submitted to the Secretary, UG, University of Kalyani, for approval from the Faculty Council and Executive Council of the University.*

The Faculty Council of the University of Kalyani approved the syllabus on ……. The approved syllabus will be placed in the subsequent meeting of the Executive Council of the University for final approval.

PREAMBLE

The National Education Policy, 2020, envisages a broad-based multi-disciplinary holistic education at the undergraduate level for integrated, rigorous exposure to science, arts, humanities, mathematics and professional fields having imaginative and flexible curricular structures, creative combinations of study, integration of vocational education and multiple entry/exit points.

To this end, it is envisioned that the **undergraduate degree will be of either 3 or 4-year duration**, with multiple exit options within this period, with appropriate certifications - a certificate after completing 1 year in a discipline or field including vocational and professional areas, or a diploma after 2 years of study, or a Bachelor's degree after a 3-year programme. The 4-year multidisciplinary Bachelor's programme shall be the preferred option since it allows the opportunity to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per the choices of the student.

Curricula set out herein thus includes credit-based courses in the areas of classical and modern zoology, applications of the subject, and value-based education. Since improvement and enhancement of both capacity and quality of agri- and allied cultures is a prime necessity in order to achieve self-sufficiency in food production, the courses also cater to the industry needs of better skilled graduates and technicians, innovative research, and market-based extension linked to technologies and practices.

The main objective of this new syllabus is thus to give the students a thorough understanding of the subject giving adequate weightages to both the core content and techniques used in various branches of Zoology. Keeping in mind and in tune with the changing nature of the subject, adequate emphasis has been given to new techniques and understanding of the subject. The syllabus has also been framed so that the basic skills of the subject are taught to the students, thus making them employable. Further, this syllabus aims to exploit the available niches for self-employment and entrepreneurship development.

The undergraduate course in Zoology of this University is designed to impart knowledge about the subject in a phased manner. The course offers Core, Ability Enhancement Compulsory, Discipline Specific (Major), and Discipline Specific (Minor) papers including practical for Core and Discipline Specific papers for students of the disciplines. It is believed that with the advancement of knowledge in this branch of science, augmented with phenomenal discoveries directly associated with human welfare, the subject is gaining in participation from a wide range of students, and the course, as designed, will cater needfully to their future employability.

Programme Objectives

A curriculum is a holistic approach to establish a better teaching-learning platform in Zoology for the students, and the teachers, and to generate trained manpower to feed the industry requirements and fuel further entrepreneurship development.

To this end, the Undergraduate programme in Zoology aims to equip students with knowledge and techniques of recent advances in Zoology and ancillary disciplines. It also aims to empower students to understand the challenges of industrial requirements that fall within the scope of this vast science, from theory to practice to research and employment or entrepreneurship.

In consonance with the spirit of NEP, different courses are offered to the students, like Major (theory and practical), Minor, Multidisciplinary Courses, Value Added Courses, and Ability Enhancement Compulsory courses. The undergraduate course is designed to ignite inquisitive minds about learning the basics as well as the advances in Zoology. It is open for admission to students who have studied Biological science, along with Physics, Chemistry, and

allied subjects in the 10+2 stage.

Programme Specific Outcomes

After completing semesters of Undergraduate programme, it is hoped that students would be sufficiently skilled and empowered to apply acquired knowledge in Zoology and its allied areas. They would have many job opportunities in the agriculture, food production, aquaculture, pharmaceutical and allied sectors and entrepreneurship. The bright and ignited mind may also enter research in the contemporary areas of Zoology, where the broad skills and deeper knowledge in the field would make them highly successful and excellent researchers.

Syllabus of 3-Year Degree/4-Year Honors in Zoology as per guidelines of National Education Policy-2020
With effect from 2023-2024

Semester 1: Total Credits – 20; Total Class Hours – 25; Total Marks – 265.							
Course Code	**Course title**	**Nature of Course**	**Credit of course**	**Class hours/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-101	Taxonomy and Introduction to Non-chordates	Major (Theory)	4	4	40	15	75
ZOO-MJ-P-101	Taxonomy and Introduction to Non-chordates Lab	Major (Practical)	2	4	20		
ZOO-MI-T-101	Basic Idea of Animal diversity and taxonomy	Minor-1(Theory)	3	3	25	10	50
ZOO-MI-P-101	Basic Idea of Animal diversity and taxonomy Lab	Minor-1(Practical)	1	2	15		
ZOO-MDC-1	Biodiversity, Wildlife Conservation and Ecotourism	Multi disciplinary course	3	3	35	10 (Field Study)	45
ZOO-SEC-1	Introduction to Sericulture	Skill Enhancement course	3	3	35	10 (Field Study)	45
VAC-1 (Value Added Course)	Environmental Education	From University listed course	4	4	40	10	50
Total			**20**	**25**			**265**

Semester 2: Total Credits – 20; Total Class Hours – 23; Total Marks – 265.							
Course Code	**Course title**	**Nature of Course**	**Credit of course**	**Class hours/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-201	Introduction to Chordate Diversity & Its Zoogeographical Distribution	Major (Theory)	4	4	40	15	75
ZOO-MJ-P-201	Introduction to Chordate Diversity & Its Zoogeographical Distribution Lab	Major (Practical)	2	4	20		
ZOO-MI-T-101	Basic Idea of Animal diversity and taxonomy	Minor- 1 (Theory)	3	3	25	10	50
ZOO-MI-P-101	Basic Idea of Animal diversity and taxonomy Lab	Minor- 1 (Practical)	1	2	15		
ZOO-MDC-1	Biodiversity, Wildlife Conservation and Ecotourism	Multi disciplinary course	3	3	35	10 (Field Study)	45
ZOO-SEC-2	Basic concept of Aquaculture, Induced Breeding and Integrated Fish Farming	Skill Enhancement course	3	3	35	10 (Field Study)	45
AEC	Communicative English	Ability Enhancement course	4	4	40	10	50
ZOO-SI-201 (Summer Course)	Summer certificate course/ diploma course for 10 working days from any biological research laboratory, or from registered farm	(Additional for Certificate/ Diploma)	4	(Additional, from external agency/MOOC)			
Total			**20**	**23**			**265**

Syllabus of 3-Year Degree/4-Year Honors in Zoology as per guidelines of National Education Policy-2020
With effect from 2023-2024

Semester 3: Total Credits – 20; Total Class Hours – 23; Total Marks – 265.							
Course Code	**Course title**	**Nature of Course**	**Credit of course**	**Class hours/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-301	Ecology and Wildlife Biology	Major (Theory)	4	4	40	15	75
ZOO-MJ-P-301	Ecology and Wildlife Biology Lab	Major (Practical)	2	4	20		
ZOO-MI-T-201	Comparative anatomy and Development al Biology	Minor-2(Theory)	3	3	25	10	50
ZOO-MI-P-201	Comparative anatomy and Developmental Biology Lab	Minor-2 (Practical)	1	2	15		
ZOO-MDC-1	Biodiversity, Wildlife Conservation and Ecotourism	Multi-disciplinary course	3	3	35	10 (Field Study)	45
ZOO-SEC-3	Statistical and Computational Biology	Skill Enhancement course	3	3	35	10	45
VAC-2 (Value Added Course)	From University listed course		4	4	40	10	50
AEC	Communicative English	Ability Enhancement course	4	4	40	10	50
Total			**24**	**27**			**315**

Syllabus of 3-Year Degree/4-Year Honors in Zoology as per guidelines of National Education Policy-2020
With effect from 2023-2024

Semester 4: Total Credits – 20; Total Class Hours – 20; Total Marks – 250.							
Course Code	**Course title**	**Nature of Course**	**Credit of course**	**Class hours/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-401	Cell Biology	Major 1(Theory)	4	4	40	15	75
ZOO-MJ-P-401	Cell Biology Lab	Major1 (Practical)	2	4	20		
ZOO-MJ-T-401	Biochemistry	Major 2 (Theory)	4	4	40	15	75
ZOO-MJ-P-401	Biochemistry Lab	Major 2 (Practical)	2	4	20		
ZOO-MI-T-201	Comparative anatomy and Developmental Biology	Minor-2(Theory)	3	3	25	10	50
ZOO-MI-P-201	Comparative anatomy and Developmental Biology Lab	Minor-2 (Practical)	1	2	15		
AEC	Communicative English	Ability Enhancement course	4	4	40	10	50
ZOO-SI-401 (Summer Course)	Summer certificate course/ diploma course for 10 working days from any biological research laboratory, or from registered farm.	(Additional for Certificate / Diploma)	4	(Additional, from external agency/MOOC)			
Total			**20**	**20**			**250**

Syllabus of 3-Year Degree/4-Year Honors in Zoology as per guidelines of National Education Policy-2020
With effect from 2023-2024

Semester 5: Total Credits – 20; Total Class Hours – 20; Total Marks – 250.							
Course Code	**Course title**	**Nature of Course**	**Credit of course**	**Class hours/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-501	Animal Physiology	Major 1 (Theory)	4	4	40	15	75
ZOO-MJ-P-501	Animal Physiology Lab.	Major 1 (Practical)	2	2	20		
ZOO-MJ-T-502	Immunology	Major 2 (Theory)	4	4	40	15	75
ZOO-MJ-P-502	Immunology Lab.	Major 2 (Practical)	2	2	20		
ZOO-MI-T-301	Ecology, Evolutionary Biology and Immuno-parasitology	Minor-3 (Theory)	3	3	25	10	50
ZOO-MI-P-301	Ecology, Evolutionary Biology and Immuno-parasitology Lab.	Minor-3 (Practical)	1	2	15		
Total			**20**	**20**	**200**	**40**	**250**

Semester 6: Total Credits – 20; Total Class Hours – 20; Total Marks – 225.							
Course Code	**Course title**	**Nature of Course**	**Credit of course**	**Class hours/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-601	Cytogenetics	Major 1 (Theory)	4	4	40	15	75
ZOO-MJ-P-601	Cytogenetics Lab.	Major 1 (Practical)	2	2	20		
ZOO-MJ-T-602	Parasitology and Vector Biology	Major 2 (Theory)	4	4	40	15	75
ZOO-MJ-P-602	Parasitology and Vector Biology Lab.	Major 2 (Practical)	2	2	20		
ZOO-MJ-T-603	Evolutionary Biology and Ethology	Major 3 (Theory)	4	4	40	15	75
ZOO-MJ-P-603	Evolutionary Biology and Ethology Lab.	Major 3 (Practical)	2	2	20		
ZOO-SI-601	Outreach or internship for 5 working days from any biological research laboratory, Sericulture center/ ICAR institute or from registered farm.		2				
Total			**20**	**20**	**180**	**45**	**225**

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Semester 7: Total Credits – 26; Total Class Hours – 26; Total Marks – 325.							
Course Code	**Course title**	**Nature of Course**	**Credit of Course**	**Class hour/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-701	Economic Zoology and Entrepreneurial Opportunities in Aquaculture	Major 1 (Theory)	4	4	40	15	75
ZOO-MJ-P-701	Economic Zoology and Entrepreneurial Opportunities in Aquaculture Lab.	Major 1 (Practical)	2	2	20		
ZOO-MJ-T-702	Environmental Toxicology	Major 2 (Theory)	4	4	40	15	75
ZOO-MJ-P-702	Environmental Toxicology Lab	Major 2 (Practical)	2	2	20		
ZOO-MJ-T-703	Genomics, Molecular Biology and Basic Methods in Animal Biology	Major 3 (Theory)	4	4	40		75
ZOO-MJ-P-703	Genomics, Molecular Biology and Basic Methods in Animal Biology Lab.	Major 3 (Practical)	2	2	20		
ZOO-MI-T-401	Basic Methods in Animal Biology	Minor-4 (Theory)	3	3	25	10	50
ZOO-MI-P-401	Basic Methods in Animal Biology Lab.	Minor-4 (Practical)	1	2	15		
			26	**26**	**65**	**260**	**325**

Semester 8: Total Credits – 24; Total Class Hours – 24; Total Marks – 300.							
Course Code	**Course title**	**Nature of Course**	**Credit of Course**	**Class hour/week**	**End-Term**	**Internal Assessment**	**Total Marks**
ZOO-MJ-T-801	Endocrinology and Developmental Biology	Major 1 (Theory)	3	3	25	10	50
ZOO-MJ-P-801	Endocrinology and Developmental Biology Lab.	Major 1 (Practical)	1	2	15		
ZOO-MJ-T-802	Fish Biology	Major 2 (Theory)	3	3	25	10	50
ZOO-MJ-P-802	Fish Biology Lab	Major 2 (Practical)	1	2	15		
ZOO-MJ-T-803	Research Methodology	Major 3 (Theory)	3	3	25	10	50
ZOO-MJ-P-803	Research Methodology Lab	Major 3 (Practical)	1	2	15		
ZOO-MJ-T-804	Human Genetics and Medical Diagnostic Techniques	Major 4 (Theory)	4	4	40	15	75
ZOO-MJ-P-804	Human Genetics and Medical Diagnostic Techniques Lab	Major 4 (Practical)	2	2	20		
ZOO-MJ-T-805	Animal Biotechnology	Major 5 (Theory)	4	4	40	15	75
ZOO-MJ-P-805	Animal Biotechnology Lab	Major 5 (Practical)	2	2	20		
ZOO-MJ-T-804, ZOO-MJ-P-804, ZOO-MJ-T-805 and ZOO-MJ-P-805 are f**or Students who opt for Honors without Research**							
ZOO-RW - 801	Research work from any biological research laboratory, National Research Institute or from registered farm (Four to Six weeks)		**12**	**12**			
ZOO-RW-801 are f**or Students who opt for Honors with Research**							
			24	**24**			**300**

Marks Distribution vis-à-vis credits and question patterns

A) Full marks of a course, having 6 /4 /3 credits, along with distribution of marks

Full marks of each course of B.Sc. (Major), carrying **6 credits**, be **75.**
Full marks of each course B.Sc. (Minor/ VAC/AEC), carrying **4 credits**, be **50.**
Full marks of each course B.Sc. (SEC/MDC), carrying **3 credits**, be **45.**

Class **Attendance cum Internal Assessment: 20% of 75 marks = 15 marks** of which 5 marks be reserved for theoretical class attendance in the following manner:

Attendance **50%**& above but **below 60% - 2** marks
Attendance **60%** & above but **below 75% - 3** marks
Attendance **75%** & above but **below 90% - 4** marks
Attendance **90% & above - 5** marks

And **10 marks** be reserved for **class test/ assignment/ seminar** (Theoretical-5 & Practical-5).

B) i) Distribution of 6 credits/75 marks (for Major) be as follows

Internal Assessment: 20% of 75 marks = **15 marks** (distribution as given above)
Semester-end-Theoretical Examination of each course = **40 marks**
Semester-end-Practical (Major) Examination of each course = **20 marks**

Distribution of 40 marks of Semester-end-Theoretical Examination (Major)

a) Answer 05 questions out of 08 carrying 02 marks each = 05x02 = 10
b) Answer 02 questions out of 04 carrying 05 marks each = 02x05 = 10
c) Answer 02 questions out of 04 carrying 10 marks each = 02x10 = 20
However, questions, carrying 5 or 10 marks, need not necessarily to be a single question.

Distribution of 20 marks of Semester-end-Practical Examination (Major)

a) Lab. Note Book = 05
b) Viva- voce = 05
c) Experiment = 10

ii) Distribution of 4 credits/50 marks (for Minor) be as follows

Internal Assessment: 20% of 50 marks = **10 marks** be reserved for **class test/ assignment/ seminar**.

Distribution of 25 marks of Semester-end-Theoretical Examination (Minor)

a) Answer 05 questions out of 08 carrying 02 marks each = 05x01 = 05
b) Answer 02 questions out of 04 carrying 05 marks each = 02x05 = 10
c) Answer 01 questions out of 02 carrying 10 marks each = 01x10 = 10
However, questions, carrying 5 or 10 marks, need not necessarily to be a single question.

Distribution of 15 marks of Semester-end-Practical Examination (Minor)

a) Lab. Note Book = 03
b) Viva- voce = 05
c) Experiment = 7

iii) Distribution of 45 marks (for each SEC/MDC) be as follows:

Internal Assessment: 10 marks (reserved for **class test/ assignment/ seminar/field-study)**
Semester-end-Theoretical Examination of each course = **35 marks**

Distribution of 35 marks of Semester-end-Practical Examination (SEC)

35 marks be allotted for Semester-end-Theoretical Examination of each SEC course, distribution of which may be as under:
a) Answer 05 questions out of 08 carrying 01 marks each = 05 x 01 = 5
b) Answer 02 questions out of 04 carrying 05 marks each = 02 x 05 = 10
c) Answer 02 questions out of 04 carrying 10 marks each = 02 x 10 = 20
However, questions, carrying 5 or 10 marks, need not necessarily to be a single question.
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iv) Distribution of 35 marks (MDC)

a) Answer 35 questions ((MCQ) out of 40 carrying 01 marks each = 35 x 01 = 35

Summer Course/ Internship:

Summer Course/internship is necessary for exit after either one-year or two-year study. Student should complete an internship of 4 credits for a duration of at least 1week. Hands-on training in any reputed Institute/ Laboratory or any Govt. / Regd. Farm is ideal but equivalence may be granted to completion certificates of online/offline Add-On course/ MOOC/SWAYAM/FOSS.

Ability Enhancement Course (AEC):

Two AEC Courses of 4 credits each need to be completed by the student. Course structure, examination and evaluation will be as communicated by the University.

There may also be a PROJECT PAPER instead of CLASS TEST in any one of the semesters and the college authority shall take the final decision regarding the evaluation of the project paper.

ZOO-MJ-T-101: 13 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
I	ZOO-MJ-T-101	Taxonomy and Introduction to Non-chordates	4	40+20+15 = 75
	ZOO-MJ-P-101	Taxonomy and Introduction to Non-chordates Lab	2	

OBJECTIVES OF THE STUDY: The main objective of this syllabus is to acquaint the students about the taxonomy of animals and diversity and special features of invertebrates.

Module 1: Basics of Animal Classification

Classification, Systematics and Taxonomy; Hierarchy, Types, Nomenclature; Priority; Synonymy, Homonymy. Biological species concept. Basic principles of differentiating among animal phyla – body plan, symmetry, coelom, germ layers, metamerism, body temperature, mode of nutrition.

Module 2: Protozoa

Protozoa: General characteristics and schematic classification at phylum level; Locomotion in *Amoeba*, Conjugation in *Paramoecium.*

Module 3: Porifera

General characteristics and schematic classification; Canal system and spicules of sponges.

Module 4: Cnidaria

General characteristics and schematic classification; Metagenesis of *Obelia*, Coral reef types and formation.

Module 5: Ctenophora

General characteristics and schematic classification.

Module 6: Platyhelminthes

General characteristics and schematic classification.Parasitic adaptations.

Module 7: Nematoda

General characteristics and schematic classification.Life history of *Ascaris*.

Module 8: Annelida

General characteristics and schematic classification; Metamerism in Annelida; Nephridia: Structure and function.

Module 9: Arthropoda

General characteristics and schematic classification; Vision in insects, Metamorphosis in Lepidopteran insect.

Module 10: Onychophora

Evolutionary Significance.

Module 11: Mollusca

General characteristics and schematic classification; Modification of foot; Nervous system in Mollusca and torsion in Gastropoda.

Module 12: Echinodermata

General characteristics and schematic classification; Water vascular system of *Asteroidea;* Structure of tubefeet.

Module 13: Hemichordata

General characteristics and schematic classification; Relationship with nonchordates and chordates.

Classification of Protozoa upto Phylum rank; Classification of Arthropoda upto Class rank; classification of all others upto Subclass rank wherever possible; all classification schemes as per Ruppert and Barnes, 1994.

COURSE OUTCOME: Knowledge of Taxonomic principles and special features of non-chordates.

ZOO-MJ-P-101: 4 Class Hours/week

1. Identification (rank and scheme as per theoretical syllabus)
2. Protozoa: *Amoeba*, *Euglena*, *Entamoeba*, *Opalina, Paramecium*, *Plasmodium vivax* and/or *Plasmodium falciparum* (from the prepared slides);
3. Pseudocoelomata: *Sycon*, Neptune's Cup, *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora;*
4. Coelomata*:* Annelids - *Nereis, Pheretima, Hirudinaria.* Arthropods – *Limulus, Palaemon, Eupagurus, Scolopendra, Bombyx, Periplaneta, termites and honey bees.* Onychophora– *Peripatus.*
5. Molluscs-*Chiton, Unio Pila, Sepia.*Echinodermata - *Asterias, Echinus, Antedon* Hemichordata: *Balanoglossus*
6. Compilation of Dichotomous key with arthropods.
7. Adaptations: parasitic adaptations of adult *Fasciola hepatica*, *Taenia solium* and *Ascaris lumbricoides.*

Study of digestive system and nervous system of Earthworm/*Periplaneta*.
Staining/mounting of any protozoa/helminth from gut of cockroach.
Lab notebook, with labelled diagrams and identifications, with reason. *Viva-voce.*

References and Suggested Texts

1. Anderson, D.T. (Ed.) (2001). Invertebrate Zoology. 2nd Ed. Oxford University Press.
2. Barnes, R.D. and Ruppert, E.E., (1994). Invertebrate Zoology. 6th Ed. Brooks Cole.
3. Barrington, E.J.W. (1981). Invertebrate Structure and function. 2nd Ed. ELBS and Nelson.
4. Blackwelder, R.E., (1967). Taxonomy- A text and reference book. John Wiley and Sons.
5. Brusca, R.C. and Brusca, G.J. (2002). Invertebrates. 4th Ed. Sinauer Associates.
6. Dhami P.S and J.K. Dhami – Invertebrate Zoology – S. Chand and Co.
7. Hickman, C.P. Jr., F.M. Hickman and L.S. Roberts, 1984. Integrated Principles of Zoology, 7th Edition, Times Mirror/Mosby College Publication. St. Louis. 1065pp.
8. Hyman, L. H. (1951). The Invertebrates (Vol-I). McGraw-Hill Book Company.
9. Jordan, E. L. and Verma, P. S. (2006). Invertebrate Zoology. S. Chand and Company Ltd. New Delhi.
10. Kapoor, V. C. (2008). Theory and practice of animal taxonomy. 6th Ed. Oxford and IBH Pub
11. Kotpal, R.L., 1988 – 1992. (All Series) Protozoa, Porifera, Coelenterata, Annelida, Arthropoda, Mollusca, Echinodermata, – Rastogi Publications, Meerut – 250 002.
12. Mayr, E. (1969). Principles of Systematic Zoology. Tata McGraw-Hill.
13. Mayr, E. and Ashlock, P. D. (1991). Principles of Systematic Zoology. 2nd Ed., McGraw-Hill.
14. Meglitsch, P. A. and Schram, F. R. (1991). Invertebrate Zoology. Oxford University Press.
15. Chaki, Kundu, Sarkar. Introduction to General Zoology. Vol 1. New Central Book Agency (P) LTD.
16. Parker, T.J. and Haswell, W. (1972). Text Book of Zoology, Volume I. Macmillan Press, London.
17. Pechenik, J. A. (1998). Biology of the Invertebrates, 4th Ed. McGraw Hill.
18. Ruppert E. E., Fox, R. and Barnes R. D. (2003). Invertebrate Zoology: a Functional Evolutionary Approach. 7th Ed. Brooks Cole.
19. Sinha, K. S., Adhikari, S., and Ganguly, B. B. Biology of Animals. Vol. I. New Central Book Agency. Kolkata.

ZOO-MI-T-101: 16 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
I	ZOO-MI-T-101	Basic Idea of Animal Diversity and Taxonomy	3	25+15+10 = 50
	ZOO-MI-P-101	Basic Idea of Animal Diversity and Taxonomy Lab	1	

OBJECTIVES OF THE STUDY: The main objective of this syllabus is to acquaint the students about the taxonomy of animals and diversity and special features of non-chordates and chordates.

Module 1: Basics of Animal Classification

Systematics, taxonomy, classification; Codes of Zoological Nomenclature; Principle of priority; Synonymy and Homonymy.

Module 2: Protista

Protozoa. Outline of classification (salient features and classification scheme upto phylum only); Locomotion in *Amoeba*; Conjugation in *Paramoecium*; Life cycle and pathogenicity of *Entamoeba histolytica.*

Module 3: Porifera

Outline of classification (salient features and classification scheme upto class only). Canal system in sponges.

Module 4: Cnidaria

Outline of classification (salient features and classification scheme upto class only). Metagenesis in *Obelia.*

Module 5: Platyhelminthes

Outline of classification (salient features and classification scheme upto class only). Life cycle and pathogenicity and control measures of *Fasciola hepatica.*

Module 6: Nematoda

Outline of classification (salient features and classification scheme upto class only). Life cycle and pathogenicity and control measures of *Ascaris lumbricoides.*

Module 7: Annelida

Outline of classification (salient features and classification scheme upto class only). Excretion in Annelida through nephridia.

Module 8: Arthropoda

Outline of classification (salient features and classification scheme upto class only). Social life in termite.

Module 9: Mollusca

Outline of classification (salient features and classification scheme upto class only). Respiration in *Pila.*

Module10: Echinodermata

Outline of classification (salient features and classification scheme upto class only). Water-vascular system in Asteroidea.

Module 11: Protochordata

Retrogressive metamorphosis in *Ascidia*.

Module 12: Pisces

Outline of classification (salient features and classification scheme upto subclass only). Swim-bladder in fishes.

Module 13: Amphibia

Outline of classification (salient features and classification scheme upto order only). Parental care in Amphibia.

Module 14: Reptilia

Outline of classification (salient features and classification scheme upto order only). Poison apparatus and Biting mechanism in Snake.

Module 15: Aves

Outline of classification (salient features and classification scheme upto subclass only). Exoskeleton and MigrationinBirds.

Module 16: Mammalia

Outline of classification (salient features and classification scheme upto infraclass only). Exoskeletal derivatives of mammals.

COURSE OUTCOME: Knowledge of the kinds and diversity of living organisms.

Classification scheme to be followed from Ruppert and Barnes for Invertebrates and Young for Vertebrates.

References and Suggested Texts

1. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, 8th. Edition. Holt Saunders International Edition
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3. Young, J.Z. (2004).The Life of Vertebrates. 3rd. Edition. Oxford University Press.
4. Parker, T.J. & Haswell, W.(1972). Text Book of Zoology, VolumeII: Marshall and Willam(Eds.) 7thEd. Macmillan Press, London.
5. Jordan,E.L.&Verma,P.S.(2003).ChordateZoology.S.Chand&CompanyLtd.NewDelhi.
6. Sinha, K.S., Adhikari, S., Ganguly, B.B. & BharatiGoswami, B.D. (2001). Biology of Animals. Vol.II. New Central Book Agency (P)Ltd.

ZOO-MI-P-101: 2 Class Hours/week

1. Identification of:
    a. Porifera - *Sycon*, *Obelia*, *Physalia*, *Corallium*, *Metridium*, *Pennatula*.
    b. Annelids- *Nereis, Pheretima, Hirudinaria.*
    c. Arthropods–*Limulus, Palaemon, Eupagurus, Scolopendra, Bombyx, Periplaneta*, termites and honeybees.
    d. Onychophora–*Peripatus.*
    e. Molluscs-*Pila, Sepia.*
    f. Echinodermata- *Asterias, Echinus.*
    g. Protochordata – *Balanoglossus.*
    h. Fishes - *Sphyrna*, *Torpedo*, *Labeo*, *Exocoetus*, *Echeneis*, *Hippocampus.*
    i. Amphibia - *Hyla, Tylototriton.*
    j. Reptilia - *Trionyx*, *Hemidactylus, Chamaeleon, Draco, Naja.*
    k. Mammalia: Bat
2. Pecten from Fowl head
3. Demonstration of brain and pituitary of Rohu/Catla/Mrigal
4. Identification and significance of adult *Fasciola hepatica* and *Ascaris lumbricoides.*

Lab note book, with labelled diagrams and identifications, with reason. *Viva-voce.*
Identification (rank and scheme as per theoretical syllabus), with labeled diagrams, systematic position and characters, in Lab Notebook.

ZOO-MDC-1: 9 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
I	ZOO-MDC-1	Biodiversity, Wildlife Conservation and Ecotourism	3	35+10 (Field Study) = 45

OBJECTIVES OF THE STUDY: The main objective of this syllabus is to acquaint the students about the importance of biodiversity and conservation and the need to promote sustainable ecotourism.

Module 1: Introduction to Biodiversity and Conservation

Biodiversity – definition, types and importance; Biodiversity hotspots – Global and Indian; Megabiodiversity countries; Biodiversity Act, Biopiracy and Bioprospecting; IPR; Convention on Biological Diversity; National Biodiversity Authority; Brief introduction to Conservation: Importance of conservation – *in-situ* and *ex-situ*; Causes of depletion.

Module 2: Evaluation and management of wild life

Habitat analysis: Physical parameters – Topography, soil and water; Biological Parameters – food and cover estimation; Brief idea on remote sensing and GIS in wildlife status estimation.

Module 3: Management of habitats

Setting back succession; Advancing the successional process; Cover construction; Restoration of degraded habitats.

Module 4: Population estimation

Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores; Pug marks and census method.

Module 5: Management planning of wild life in protected areas

Estimation of carrying capacity; Eco tourism / wild life tourism in forests.

Module 6: Man and Wildlife

Causes and consequences of human-wildlife conflicts.

Module 7: Protected areas

National parks & sanctuaries. Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve.

Module 8: Experiencing Wildlife

Visiting any National Park/Sanctuary/Reserve Forest/Zoo/Biodiversity Park.

COURSE OUTCOME: Idea of the biodiversity resources of our country.

References and Suggested Texts

1. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
2. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co- existence? Cambridge University.
3. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5 th edition. The Wildlife Society, Allen Press.
4. Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
5. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

ZOO-SEC-1: 5 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
I	ZOO-SEC-1	Introduction to Sericulture	3	35+10 (Field Study) = 45

OBJECTIVES OF THE STUDY: The main objective of framing this new syllabus is to give the students a proper understanding of Sericulture. Students will get knowledge about mulberry plant cultivation, different silkworms, culture techniques, silk production, and the knowledge of diseases and enemies of silkworms. Students can utilize the knowledge in starting their own enterprise after completion of the course.

Module 1: Introduction

Types of silkworms, Distribution and Races; Exotic and indigenous races; Mulberry and non-mulberry Sericulture.Mulberry plant cultivation.

Module 2: Biology of Silkworm

Life cycle of *Bombyxmori;* Structure of silk gland and secretion of silk.

Module 3: Rearing of Silkworms

Rearing house and rearing appliances; Disinfectants: Formalin, bleaching powder; Silkworm rearing technology: Early age and Late age rearing; Types of mountages; Spinning, harvesting and storage of cocoons.

Module 4: Pests and Diseases

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial; Control and prevention of pests and diseases.

Module 5: Entrepreneurship in Sericulture

Sericulture as a source of employment and livelihood; The role of Central Silk Board in supporting and guiding entrepreneurship; Visit to a sericulture farm and submission of report.

COURSE OUTCOME: Knowledge of sericulture as a livelihood.

ZOO-MJ-T-201: 10 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
II	ZOO-MJ-T-201	Introduction to Chordate Diversity and its Zoogeographical Distribution	4	40+20+15 = 75
	ZOO-MJ-P-201	Introduction to Chordate Diversity and its Zoogeographical Distribution Lab	2	

OBJECTIVES OF THE STUDY: This course is carefully drafted and tailor made to give a comprehensive knowledge of diversity of chordates along with their origin, key features, classification, distribution and functioning.

Module 1: Introduction to Chordates

General characteristics and outline classification of Phylum Chordataupto living subclasses.

Module 2: Origin of Chordata

Dipleurula concept and the Echinoderm theory of origin of chordates.

Module 3: Origin of Chordata

General characteristics and classification of sub-phylum Urochordata and Cephalochordata up to Classes; Retrogressive metamorphosis in *Ascidia*; Feeding mechanism in *Branchiostoma*.

Module 4: Agnatha

General characteristics and classification of cyclostomes up to subclass.

Module 5: Pisces

General characteristics and classification of Chondrichthyes and Osteichthyes up to Subclasses; Accessory respiratory organ and swim bladder in fishes; Migration and parental care in fishes.

Module 6: Amphibia

General characteristics and classification up to living Orders; Metamorphosis and parental care in Amphibia..

Module 7: Reptilia

General characteristics and classification up to living Orders; Poison apparatus and Biting mechanism in Snake.

Module 8: Aves

General characteristics and classification up to Sub-Classes; Migration in Birds; Principles and aerodynamics of flight.

Module 9: Mammals

General characters and classification up to living infra-class; Affinities of Prototheria; Echolocation in Micro chiropterans.

Module 10: Zoogeography

Zoogeographical realms; Plate tectonic and Continental drift theory;Distribution of birds and mammals in different realms

COURSE OUTCOME: With this course students will have idea about diversity, organization, adaptation and taxonomic status of chordates. The course will give the understanding of the affinities of chordates with other groups.

References and Suggested Texts

1. Young J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.
2. Pough H. Vertebrate life, VIII Edition, Pearson International.
3. Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub Co.
4. Hall B.K. and Hallgrimsson B. (2008). Strickberger'sEvolution. IV Edition. Jones and Bartlett Publishers Inc.
5. Parker, T. J. & Haswell, W. (1972). Text Book of Zoology, Volume II: Marshall and William (Eds.) 7th Ed. Macmillan Press, London.
6. Kardong, K. V. (2002). Vertebrates: Comparative anatomy, function evolution. Tata McGraw Hill.
7. Kent, G. C. & Carr, R. K. (2001). Comparative anatomy of the Vertebrates. 9th ed., McGraw Hill.
8. Nelson, J.S., (2006) : Fishes of the World, 4th edn., Wiley.
9. Romer, A. S. & Parsons, T. S. (1986). The vertebrate body. 6th Ed. Saunders College Publishing.
10. Jordan, E.L. and Verma, P.S. (2003). Chordate Zoology. S. Chand & Company Ltd. New Delhi.
11. Sinha, K. S., Adhikari, S., Ganguly, B. B. &BharatiGoswami, B. C. (2001). Biology of Animals. Vol. II. New Central Book Agency (P) Ltd.
12. Futuyma, D. (1997). Evolutionary Biology. 3rd ed. Sinauer Associates, INC.

Note: Classifications to be followed from Young (1981).

ZOO-MJ-P-201: 4 Class Hours/week

Identification of

1. Protochordata: *Balanoglossus*, *Branchiostoma*
2. Agnatha: *Petromyzon* or *Myxine*
3. Fishes: *Scoliodon*, *Sphyrna*, *Torpedo*, *Mystus*, *Heteropneustes*, *Labeo*, *Exocoetus*, *Echeneis*, *Anguilla*, *Hippocampus*, *Tetrodon*/ *Diodon*, *Anabas*, Flatfish
4. Amphibia: *Bufo, Hyla, Axolotl,Tylototriton*
5. Reptilia: *Chelone*, *Trionyx*, *Hemidactylus, Varanus, Chamaeleon, Ophiosaurus, Draco, Vipera, Naja, Crocodylus*; preparation of dichotomous key for identification of poisonous and non-poisonous snakes.
6. Mammalia: Bat (Insectivorous and Frugivorous).
7. Demonstration of brain and pituitary of Rohu/Catla/Mrigal.
8. Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission).

Lab note book, with labelled diagrams and identifications, with reason. *Viva-voce.*

ZOO-MI-T-201: 16 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
II	ZOO-MI-T-101	Basic Idea of Animal Diversity and Taxonomy	3	25+15+10 = 50
	ZOO-MI-P-101	Basic Idea of Animal Diversity and Taxonomy Lab	1	

OBJECTIVES OF THE STUDY: The main objective of this syllabus is to acquaint the students about the taxonomy of animals and diversity and special features of non-chordates and chordates.

Module1: Basics of Animal Classification

Systematics, taxonomy, classification; Codes of Zoological Nomenclature; Principle of priority; Synonymy and Homonymy.

Module 2: Protista

Protozoa. Outline of classification (salient features and classification scheme upto phylum only); Locomotion in *Amoeba*; Conjugation in *Paramoecium*; Life cycle and pathogenicity of *Entamoeba histolytica.*

Module 3: Porifera

Outline of classification (salient features and classification scheme upto class only). Canal system in sponges.

Module 4: Cnidaria

Outline of classification (salient features and classification scheme upto class only). Metagenesis in *Obelia.*

Module 5: Platyhelminthes

Outline of classification (salient features and classification scheme upto class only). Life cycle and pathogenicity and control measures of *Fasciola hepatica.*

Module 6: Nematoda

Outline of classification (salient features and classification scheme upto class only). Lifecycle and pathogenicity and control measures of *Ascaris lumbricoides.*

Module 7: Annelida

Outline of classification (salient features and classification scheme upto class only). Excretion in Annelida through nephridia.

Module 8: Arthropoda

Outline of classification (salient features and classification scheme upto class only). Social life in termite.

Module 9: Mollusca

Outline of classification (salient features and classification scheme upto class only). Respiration in *Pila.*

Module 10: Echinodermata

Outline of classification (salient features and classification scheme upto class only). Water-vascular system in Asteroidea.

Module 11: Protochordata

Retrogressive metamorphosis in *Ascidia*.

Module 12: Pisces

Outline of classification (salient features and classification scheme upto subclass only). Swim bladde in fishes.

Module 13: Amphibia

Outline of classification (salient features and classification scheme upto order only). Parental care in Amphibia.

Module 14: Reptilia

Outline of classification (salient features and classification scheme upto order only). Poison apparatus and Biting mechanism in Snake.

Module 15: Aves

Outline of classification (salient features and classification scheme upto subclass only). Exoskeleton and Migration in Birds.

Module 16: Mammalia

Outline of classification (salient features and classification scheme upto infraclass only). Exoskeletal derivatives of mammals.

COURSE OUTCOME: Knowledge of the kinds and diversity of living organisms.

Classification scheme to be followed from Levine for Protozoa, Ruppert and Barnes for other Invertebrates and Young for Vertebrates.

References and Suggested Texts

1. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, 8th Edition. Holt Saunders International Edition.
2. The Invertebrates: A New Synthesis, 3rd Edition, Blackwell Science.
3. Young, J.Z .(2004).The Life of Vertebrates. 3rd Edition. Oxford University Press.
4. Parker, T.J.& Haswell, W. (1972). Textbook of Zoology. (1972). Volume II: Marshall and Willam (Eds.) 7thEd. Macmillan Press, London.
5. Jordan, E.L. & Verma, P.S.(2003).Chordate Zoology. S. Chand & Company Ltd. New Delhi.
6. Sinha, K.S., Adhikari, S., Ganguly, B.B. & BharatiGoswami, B.D.(2001). Biology of Animals. Vol. II. New Central Book Agency (P)Ltd.

ZOO-MI-P-101: 2 Class Hours/week

1. Identification of:
    a. Porifera - *Sycon*, *Obelia*, *Physalia*, *Corallium*, *Metridium*, *Pennatula*.
    b. Annelids- *Nereis, Pheretima, Hirudinaria.*
    c. Arthropods–*Limulus, Palaemon, Eupagurus, Scolopendra, Bombyx, Periplaneta*, termites and honeybees.
    d. Onychophora– *Peripatus.*
    e. Molluscs-*Pila,Sepia.*
    f. Echinodermata- *Asterias, Echinus.*
    g. Protochordata – *Balanoglossus.*
    h. Fishes - *Sphyrna*, *Torpedo*, *Labeo*, *Exocoetus*, *Echeneis*, *Hippocampus.*
    i. Amphibia - *Hyla, Tylototriton.*
    j. Reptilia - *Trionyx*, *Hemidactylus, Chamaeleon, Draco, Naja.*
    k. Mammalia: Bat
2. Pecten from Fowl head
3. Dissection of brain and pituitary of Rohu/Catla/Mrigal
4. Identification and significance of adult *Fasciola hepatica* and *Ascaris lumbricoides*
   Lab note book, with labelled diagrams and identifications, with reason. *Viva-voce.*

Identification upto Subclass in invertebrates and upto Order in vertebrates, with labeled diagrams, systematic position and characters, in Lab Notebook.

ZOO-MDC-1: 9 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
II	ZOO-MDC-1	Biodiversity, Wildlife Conservation and Ecotourism	3	35+10 (Field Study) = 45

OBJECTIVES OF THE STUDY: The main objective of this syllabus is to acquaint the students about the importance of biodiversity and conservation and the need to promote sustainable ecotourism.

Module 1: Introduction to Biodiversity and Conservation

Biodiversity – definition, types and importance; Biodiversity hotspots – Global and Indian; Mega biodiversity countries; Biodiversity Act, Biopiracy and Bioprospecting; IPR; Convention on Biological Diversity; National Biodiversity Authority; Brief introduction to Conservation: Importance of conservation – *in-situ* and *ex-situ*; Causes of depletion.

Module 2: Evaluation and management of wild life

Habitat analysis: Physical parameters – Topography, soil and water; Biological Parameters – food and cover estimation; Brief idea on remote sensing and GIS in wildlife status estimation.

Module 3: Management of habitats

Setting back succession; Advancing the successional process; Cover construction; Restoration of degraded habitats.

Module 4: Population estimation

Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores; Pug marks and census method.

Module 5: Management planning of wild life in protected areas

Estimation of carrying capacity; Eco tourism / wild life tourism in forests.

Module 6: Man and Wildlife

Causes and consequences of human-wildlife conflicts.

Module 7: Protected areas

National parks & sanctuaries. Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve.

Module 8: Experiencing Wildlife

Visiting any National Park/Sanctuary/Reserve Forest/Zoo/Biodiversity Park.

COURSE OUTCOME: Idea of the biodiversity resources of our country.

References and Suggested Texts

1. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
2. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co-existence? Cambridge University.
3. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5 th edition. The Wildlife Society, Allen Press.
4. Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
5. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

ZOO-SEC-2: 6 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
II	ZOO-SEC-2	Basic Concept of Aquaculture, Induced Breeding and Integrated Fish Farming	3	35+10 (Field Study) = 45

OBJECTIVES OF THE STUDY: To acquaint the students with the aquaculture methods, different systems, non-conventional aquaculture technology, induced breeding and fish pathology.

Module 1: Aquaculture methods

Concept and significance, Different systems of aquaculture for carps and shrimps: Extensive, Semi-intensive, Intensive.

Module 2: Different systems of aquaculture

Monoculture, polyculture; Definition, importance and types of Integrated fish farming.

Module 3: Non-conventional aquaculture technology

Raceways and recirculatory system, Cages and pen culture, Wastewater aquaculture Organic aquaculture, Aquaponics and hydroponics, Biofloc culture.

Module 4: Induced breeding

Induced breeding care of brood fish, secondary sex characters, hypophysation, HCG, pheromones, GnRH, LH-RH and their analogues, new generation drugs, induced breeding and multiple breeding, environmental factors, limitations-inbreeding depressions.

Module 5: Fish pathology

Environment and fish health; fin-fish diseases and their control. Control and prevention of pests and diseases.

Module 6: Entrepreneurship in Aquaculture

Aquaculture as a sourc e of employment and livelihood - visit to an aquaculture farm/lab and submission of report.

COURSE OUTCOME

1. Students will be exposed to the aquaculture methods, different systems, non-conventional and aquaculture technology.
2. They will get idea about induced breeding and fish pathology.

References and Suggested Texts

1. Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons.
2. Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed. Hindusthan Pub.Corp.
3. Lowe, H. (2005). *Beginner's Guide to Aquarium Fish and Fish Care*. Abhishek Press, New Delhi.
4. Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd.
5. De Silva, S. S. and Anderson, T. A. (1995). *Fish Nutrition in Aquaculture*. Chapman and Hall, London.
6. Merrifield, D. L. and Ringø, E. (2014). *Aquaculture Nutrition: Gut Health, Probiotics and Prebiotics*. Wiley-Blackwell.
7. Srivastava, C. B. L. (1999). *Fish Biology*.Narendra Publishing House. New Delhi.

ZOO-MJ-T-301: 5 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
III	ZOO-MJ-T-301	Ecology and Wildlife Biology	4	40+20+15 = 75
	ZOO-MJ-P-301	Ecology and Wildlife Biology Lab	2	

OBJECTIVES OF THE STUDY: This course is aimed at introducing the student to the basic principles that govern interrelationships among living organisms and their environment.

Module 1: Introduction to Ecology

Levels of organization, Laws of limiting factors, Scope of ecology.

Module 2: Ecosystem

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.

Module 3: Community

1. Community characteristics: species diversity, abundance, dominance, richness,Vertical stratification, Ecotone and edge effect,
2. Community interactions: Gause's Principle with laboratory and field examples; Lotka-Volterra equation for competition.
3. Ecological succession and Habitat management: Nudation, Pioneer, Seral stages, Climax concept, Modes of succession (in Hydrosere). Setting back succession.

Module 4: Population

1. Unique and group attributes of population: Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Demographic factors, life tables, fecundity tables, survivorship curves.
2. Geometric, exponential and logistic growth, equation, r and K strategies Population regulation - density-dependent and independent factors.

Module 5: Conservation biology

1. Wildlife Conservation; *in-situ* and *ex-situ* conservation. Faecal analysis of ungulates and carnivores; Pug mark census method.
2. Management strategies and challenges for tiger and elephant conservation; Wild life protection acts and amendments (upto 2024) of India.
3. Brief idea on remote sensing and GIS in wildlife status estimation.
4. Causes and consequences of human-wildlife conflicts (emphasis on tiger and elephant related issues in India).
5. Protected areas: National parks & sanctuaries, Hotspots & Biosphere reserves.

COURSE OUTCOME: This course offers students an understanding of the intricacies of how the environmental changes govern the lifestyles of organisms, and how organisms interact within themselves as groups and individuals, to maximize their chances of survival and reproduction. Students are also introduced to the idea of protection and sustainable exploitation of natural resources like wildlife.

Reference Books

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. Sharma, P. D., Ecology and Environment. Rastogi Publications
5. Caughley, G., Fryxell, J.M., and Sinclair, A.R.E. (2006). Wildlife Ecology, Conservation and Management. Willey-Blackwell Science.
6. Singh, S.K., (2020). Textbook of Wildlife Management. CBS Publishers
7. Reena Mathur, Wildlife Conservation and Management. Rastogi Publications
8. Gautam Kr. Saha & Subhendu Mazumdar, Wildlife Biology-an Indian Perspective. PHI

ZOO-MJ-P-301: 4 Class Hours/week

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
2. Setting quadrate, pitfall/light traps and recording results from collections therein: determination of population density, faunal abundance, species richness, importance value index, and calculation of Shannon-Weiner diversity index from the results.
3. Study of aquatic ecosystem: Zooplankton, determination of pH, Dissolved Oxygen content (Winkler's method), and Free CO_2.
4. Observation and description (Original photograph, systematic position, character and habitat description in LNB) of local wild flora, birds, butterflies, mammals (any 2 groups; 5 examples from both).
5. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary OR Study visit to a marine ecosystem.

6: Major excursion.

Lab note book, with labelled diagrams and identifications, with reason. *Viva-voce.*

N.B. Animals collected from traps should be released back into their own habitat as far as possible; only pictures/sketches and descriptions should be retained and submitted. Nests/eggs should not be disturbed/collected unless abandoned. In no case should wildlife be harmed – only noninvasive recording and data collection is permitted.

ZOO-MI-T-301: 9 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
III	ZOO-MI-T-201	Comparative Anatomy and Developmental Biology	3	25+15+10 = 50
	ZOO-MI-P-201	Comparative Anatomy and Developmental Biology Lab	1	

OBJECTIVES OF THE STUDY: This course is carefully drafted and tailor made to give a comprehensive knowledge of comparative anatomy, Developmental Biology and Ecology.

Module 1: Integumentary System

Structure, function and derivatives of integument in amphibian, birds and mammals.

Module 3: Digestive System

Comparative anatomy of stomach; dentition in mammals.

Module 4: Circulatory System

Comparative account of heart and aortic arches.

Module 5: Respiratory System

Respiratory organs in Pisces, Aves and Mammalia.

Module 6: Urinogenital System

Succession of kidney, Types of mammalian uteri.

Module 7: Nervous System and sense organs

Cranial nerves in mammals and Classification of receptors

Module 8: Sense Organs

Classification of different types of sensory receptors.

Module 9: Early embryonic development

Spermatogenesis in detail; Oogenesis in detail; egg types; Fertilization.

Module 10: Late embryonic development

Organizer concept; regeneration in amphibia.

COURSE OUTCOME: Idea of the basic tenets of relationships among animals.

References and Suggested Texts

1. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. 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 Sons Saxena, R.K. &Saxena, S.C.(2008) : Comparative Anatomy of Vertebrates, Viva Books Pvt. Ltd.
4. Gilbert, S.F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
5. Slack J.M.W, Essential Developmental Biology.
6. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
7. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies
8. Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons Saxena, R.K. &Saxena, S.C.(2008) : Comparative Anatomy of Vertebrates, Viva Books Pvt. Ltd.
9. Krebs,C.J.(2001).Ecology. VI Edition. Benjamin Cummings.
10. Odum,E.P.,(2008).Fundamentals of Ecology. Indian Edition. Brooks/Cole
11. Robert Leo Smith Ecology and field biology Harper and Row Publisher

ZOO-MI-P-201: 2 Class Hours/week

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Study of disarticulated skeleton of Toad/Pigeon/Guineapig.
3. Demonstration of Carapace and plastron of turtle OR Identification of mammalian skulls: One herbivorous (Guineapig) and one carnivorous (Dog) animal.
4. Dissection of Tilapia/carp: Circulatory system/urinogenital system; brain/pituitary.
5. Study of whole mounts of developmental stages of chick through permanent slides: 24, 48, 72, and 96 hours of incubation.
6. Lab note book, with labelled diagrams and identifications, with reason. *Viva-voce.*

Separate Lab Notebooks for Identification and Ecology.
Separate Field Notebook.

ZOO-MDC-1: 9 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
III	ZOO-MDC-1	Biodiversity, Wildlife Conservation and Ecotourism	3	35+10 (Field Study) = 45

OBJECTIVES OF THE STUDY: The main objective of this syllabus is to acquaint the students about the importance of biodiversity and conservation and the need to promote sustainable ecotourism.

Module 1: Introduction to Biodiversity and Conservation

Biodiversity – definition, types and importance; Biodiversity hotspots – Global and Indian; Mega biodiversity countries; Biodiversity Act, Biopiracy and Bioprospecting; IPR; Convention on Biological Diversity; National Biodiversity Authority; Brief introduction to Conservation: Importance of conservation – *in-situ* and *ex-situ*; Causes of depletion.

Module 2: Evaluation and management of wild life

Habitat analysis: Physical parameters – Topography, soil and water; Biological Parameters – food and cover estimation; Brief idea on remote sensing and GIS in wildlife status estimation.

Module 3: Management of habitats

Setting back succession; Advancing the successional process; Cover construction; Restoration of degraded habitats.

Module 4: Population estimation

Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores; Pug marks and census method.

Module 5: Management planning of wild life in protected areas

Estimation of carrying capacity; Eco tourism / wild life tourism in forests.

Module 6: Man and Wildlife

Causes and consequences of human-wildlife conflicts.

Module 7: Protected areas

National parks & sanctuaries. Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve.

Module 8: Experiencing Wildlife

Visiting any National Park/Sanctuary/Reserve Forest/Zoo/Biodiversity Park.

COURSE OUTCOME: Idea of the biodiversity resources of our country.

References and Suggested Texts

1. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
2. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co- existence? Cambridge University.
3. Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5 th edition. The Wildlife Society, Allen Press.
4. Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
5. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

ZOO-SEC-3: 5 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
III	ZOO-SEC-3	Statistical and Computational Biology	3	35+10 (Internal Assessment) = 45

OBJECTIVES OF THE STUDY: This course is to provide a basic idea and understanding of the elementary concepts of statistics. This is designed to acquaint the students with the preliminary knowledge of descriptive and inferential statistics. It will also make students equipped with the basic knowledge of bioinformatics such biological database, data retrieval and sequence alignment.

Module 1: Introduction to Biostatistics

Data, population, sample and sampling, frequency distribution, measures of central tendency, frequency distribution curve, measures of dispersion. Mean, median, mode, mean deviation, standard deviation, data visualization by bar chart.

Module 2: Testing of Hypotheses

Concepts of Null Hypothesis, Level of significance, Degrees of freedom; Determination of Chi-square for goodness of fit, and determination of Student's t.

Module 3: Correlations and Regression

Basic concept of correlation and regression; Determination of correlation coefficient (Pearson's *r*).

Module 4: Introduction to Bioinformatics

Aims and scope of bioinformatics, Introduction to biological data bases (nucleic acid, protein databases).

Module 5: Basic concept of data retrieval and sequence alignment

Sequence submission tools, sequence file format, data retrieval system (Entrez, SRS), Types of sequence alignment, method of sequence alignment (BLAST).

Course outcome: By the end of the course students will be able to work with sample data. They will be able to analyses and make inference about the data. The basic knowledge of biological databases, sequence submission tools, sequence alignment will help them to pursue their future study and research work as well.

References and Suggested Texts

1. Essential Biostatistics: A concise and applied digest with computer applications- Dr. Maharaj Biswas, 1st Ed. ISBN: 9789359112626
2. Fundamentals of biostatistics. 7thed./Bernard Rosner
3. Principles of Biostatistics – Marcello Pagano/DuxburyPress1993
4. Basic Biostatistics and its application, Animesh kumar Dutta, New Central Book Agency (P)Ltd.
5. Basic bioinformatics,2nded, S Ignacimuthu Sj. Narosa
6. Introduction To Bioinformatics. 1st Edition 2007 by Attwood TK etal, Pearson India.

ZOO-MJ-T-401: 8 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
IV	ZOO-MJ-T-401	Cell Biology	4	40+20+15 = 75
	ZOO-MJ-P-401	Cell Biology Lab	2	

OBJECTIVES OF THE STUDY: Students will gain knowledge and insights into fundamental cellular processes and their implications in biological systems.

Module 1: Overview of Cells

Basic structure of prokaryotic and eukaryotic cells, viruses.

Module 2: Plasma Membrane

Ultra structure and composition of plasma membrane, fluid mosaic model. Transport across membrane: Active and passive transport, facilitated transport. Cell junctions: Tight junctions, Gap junctions, Desmosomes.

Module 3: Cytoplasmic organelles I

Structure and Functions: Endoplasmic Reticulum, Golgi apparatus, lysosome. Protein sorting.

Module 4: Cytoplasmic organelles II

Mitochondria: Structure, semi-autonomous nature endosymbiotic hypothesis, mitochondrial respiratory chain, chemiosmotic hypothesis.

Module 5: Cytoskeleton

Type, structure and functions of cytoskeleton.

Module 6: Nucleus

Chromatin: Euchromatin and heterochromatin and packaging (nucleosome).

Module 7: Cell cycle and Cancer biology

Cell cycle and its regulation, Cancer (Concept of oncogenes and tumor suppressor genes with special reference top53, Retinoblastoma and Ras and APC.

Module 8: Cell Signaling

Cell signaling transduction pathways (GPCR, RTK and JAK-STAT); Types of signaling molecules and receptors. GPCR and Role of second messenger (cAMP). Apoptosis and Necrosis.

COURSE OUTCOME: to provide students a comprehensive understanding of the principles and concepts basic structure of cells. They gain a knowledge about various components of cells, including organelles, cytoskeletons, and cell membranes, and to explore their roles in cell biology. Additionally, the course aims to familiarize students with key processes such as the cell cycle, cell adhesion, extracellular matrix, and the development and progression of cancer.

References and Suggested Texts

- Lewin's Cells–Cassimeris/Lingappa/Plopper–Johns & Bartlett Publishers.
- Biology of Cancer by Robert. A. Weinberg. 2ndedition.
- 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.
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James. Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

ZOO-MJ-P-401: 2 Class Hours/week

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
2. Preparation of various stages of meiosis from temporary stained squash of grasshopper testes.
3. Temporary preparation to demonstrate:
   a) DNA by Feulgen reaction.
   b) Cell viability by Trypan Blue staining.

Either 3a or 3b.

4. Lab note book, withdrawing and labelling; methods where applicable. *Viva-voce.*

ZOO-MJ-T-402: 8 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
IV	ZOO-MJ-T-402	Biochemistry	4	40+20+15 = 75
	ZOO-MJ-P-402	Biochemistry Lab	2	

OBJECTIVES OF THE STUDY: To comprehensively study cellular metabolism and biomolecular interactions, focusing on key biochemical pathways and enzymatic processes essential for understanding biological systems.

Module 1: Carbohydrates

Molecular structure and classification of Carbohydrates. Carbohydrate metabolism: Glycolysis, Citric acid cycle, Pentose phosphate pathway, Gluconeogenesis.

Module 2: Lipids

Molecular structure and classification of Lipids. Lipid metabolism: β-oxidation of fatty acids; Fatty acid biosynthesis.

Module 3: Amino acids and Proteins

Amino acids: Structure, Classification, General and Electro chemical properties of α-amino acids; Physiological importance of essential and non-essential amino acids. Proteins: Bonds stabilizing protein structure; Levels of organization; Protein metabolism: Transamination, Deamination, Urea cycle, Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

Module 4: Nucleic acids

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids. Types of DNA and RNA, complementarity of DNA, Hypo- and Hyper-chromaticity of DNA.

Module 5: Enzymes

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

Module 6: Oxidative Phosphorylation

Redox systems; Review of mitochondrial respiratory chain, Inhibitors and un-couplers of Electron Transport System.

COURSE OUTCOME: Students will acquire in-depth knowledge of metabolic pathways, biomolecular structures, and enzyme kinetics, alongside practical skills in biochemical techniques. They will be prepared to analyze and apply biochemical principles to zoological contexts, enhancing their ability to contribute to research and practical applications in the field of zoology.

References and Suggested Texts

- Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H.Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L.(2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- 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.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
- 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.

ZOO-MJ-P-402: 2 Class Hours/week

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Quantitative estimation of proteins by Lowry Method.
3. Demonstration/Virtuallab/Drylabofpaperchromatographyofaminoacids.
4. Demonstration/Virtual lab/Dry lab of proteins separation by SDS-PAGE.
5. Wet lab: to study the enzymatic activity of Trypsinor Lipase.
6. Wetlab: Toper form the Acid or Alkaline phosphatase assay from serum/tissue/soil.

   Either 3 or 4; either 5 or 6.
7. Lab note book, with methods where applicable. *Viva-voce.*

ZOO-MI-T-401: 9 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
IV	ZOO-MI-T-201	Comparative Anatomy and Developmental Biology	3	25+15+10 = 50
	ZOO-MI-P-201	Comparative Anatomy and Developmental Biology Lab	1	

OBJECTIVES OF THE STUDY: This course is carefully drafted and tailor made to give a comprehensive knowledge of comparative anatomy and developmental biology.

Module 1: Integumentary System

Structure, function and derivatives of integument in amphibian, birds and mammals.

Module 3: Digestive System

Comparative anatomy of stomach; dentition in mammals.

Module 4: Circulatory System

Comparative account of heart and aortic arches.

Module 5: Respiratory System

Respiratory organs in Pisces, Aves and Mammalia.

Module 6: Urinogenital System

Succession of kidney, Types of mammalian uteri.

Module 7: Nervous System and sense organs

Cranial nerves in mammals and Classification of receptors

Module 8: Sense Organs

Classification of different types of sensory receptors.

Module 9: Early embryonic development

Spermatogenesis in detail; Oogenesis in detail; egg types; Fertilization.

Module 10: Late embryonic development

Organizer concept; regeneration in amphibia.

COURSE OUTCOME: Idea of the basic tenets of relationships among animals.

References and Suggested Texts

1. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. 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 Sons Saxena, R.K. &Saxena, S.C.(2008) : Comparative Anatomy of Vertebrates, Viva Books Pvt. Ltd.
4. Gilbert, S.F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
5. Slack J.M.W, Essential Developmental Biology.
6. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
7. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies
8. Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons Saxena, R.K. &Saxena, S.C.(2008) : Comparative Anatomy of Vertebrates, Viva Books Pvt. Ltd.
9. Krebs,C.J.(2001).Ecology. VI Edition. Benjamin Cummings.
10. Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
11. Robert Leo Smith. Ecology and field biology. Harper and Row.

ZOO-MI-P-201: 2 Class Hours/week

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Study of disarticulated skeleton of Toad/Pigeon/Guineapig.
3. Demonstration of Carapace and plastron of turtle OR Identification of mammalian skulls: One herbivorous (Guineapig) and one carnivorous (Dog) animal.
4. Dissection of Tilapia/carp: Circulatory system/urinogenital system; brain/pituitary.
5. Study of whole mounts of developmental stages of chick through permanent slides: 24, 48, 72, and 96 hours of incubation.

Lab note book, with labelled diagrams and identifications, with reason. *Viva-voce.*
Separate Lab Notebooks for Identification and Ecology.
Separate Field Notebook.

ZOO-MJ-T-501: 10 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
V	ZOO-MJ-T-501	Animal Physiology	4	40+20+15 = 75
	ZOO-MJ-P-501	Animal Physiology Lab	2	

OBJECTIVES OF THE STUDY: The objective of this course is to provide a comprehensive understanding of the physiological processes in animals, focusing on major systems such as digestion, respiration, circulation, thermoregulation, osmoregulation, renal, nervous, muscular, reproductive, sensory, and endocrine systems. Students will gain knowledge of the mechanisms and functions underlying these physiological systems, enabling them to appreciate how animals maintain homeostasis, respond to environmental changes, and support vital activities.

Module 1: Physiology of Digestion

Structural organization and functions of Gastrointestinal tract and Associated glands; Importance of GI tract hormones. Digestion and absorption of Carbohydrates, Lipids, Proteins.

Module 2: Physiology of Respiration

Physiological Mechanism of Respiration; Respiratory volumes and capacities; Transport of Oxygen and Carbon-dioxide in blood; Dissociation curves and the factors influencing it; Respiratory pigments; Carbon monoxide poisoning.

Module 3: Physiology of Circulation

Structure of mammalian heart; Cardiac Cycle, cardiac output, blood pressure. Components of Blood; Structure and functions of hemoglobin; Homeostasis; Blood clotting system; Hematopoiesis and its regulation.

Module 4: Physiology of Thermoregulation & Osmoregulation

Physiological classification of animals based on thermal biology and mechanism of thermoregulation; Osmoregulation in aquatic vertebrates and invertebrates.

Module 5: Renal Physiology

Structure of nephron; Juxta-glomerular apparatus, Mechanism of countercurrent exchange and urine formation. Regulation of acid-base balance.

Module 6: Physiology of Nervous System

Structure of neuron; Resting membrane potential; Origin of action potential and its propagation across the myelinated and non-myelinated nerve fibers; Types of synapses, Synaptic transmission and Neuro-muscular junction.

Module 7: Physiology of Muscular System

Different types of muscle; Ultrastructure of skeletal muscle; Molecular and chemical basis of muscle contraction. Origin and conduction of cardiac impulses.

COURSE OUTCOME: The study of Animal Physiology provides insights into how organisms function at cellular, organ, and systemic levels, including processes like respiration, circulation, and metabolism. It reveals mechanisms of homeostasis, adaptation to environments, and responses to stressors like temperature or disease. This knowledge aids in advancing veterinary medicine, conservation, and biomedical research. It also deepens understanding of evolutionary traits and ecological interactions, linking form and function across species.

References and suggested texts

1. Guyton, A.C & Hall, J.E. Textbook of Medical Physiology, Xl Ed. W.B. Saunders Co. (2006).
2. Tortora, G.J. & Grabowski, S. Principles of Anatomy & Physiology. XI Ed. John Wiley & sons (2006).
3. Christopher D. Moyes, Patricia M. Schulte. Principles of Animal Physiology. 3rd Ed. Pearson Education(2016).
4. Hill, Richard W., et al. Animal physiology. Vol. 2. Sunderland, MA: Sinauer Associates, (2004).
5. Chatterjee CC Human Physiology Volume l & 2, 11th edition, CBS Publishers (20 I6).
6. Ganong's Review of Medical Physiology (2019).
7. Eckert. ANIMAL PHYSIOLOGY. Sinauer.

ZOO-MJ-P-501: Animal Physiology Lab **: 2 Class Hours/week**

1. Estimation of Hemoglobin in human blood using Sahli 's haemoglobinometer
2. Differential staining of human blood corpuscles using Leishman stain
3. Determination of Bleeding Time & Clotting Time using suitable methods.
4. Determination of Blood Group.
5. Recording of blood pressure using a sphygmomanometer
6. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
7. Microtomy: Preparation of permanent slide of any five mammalian (Goat (from commercial sources)/white rat) tissues
8. Lab notebook with labelled drawings and results. Methods to be mentioned where applicable. *Viva-voce.*

ZOO-MJ-T-501: 10 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
V	ZOO-MJ-T-502	Immunology	4	40+20+15 = 75
	ZOO-MJ-P-502	Immunology Lab	2	

OBJECTIVES OF THE STUDY: To provide knowledge on essential features of antigens and antibodies and their types and different theories of Antibody formation. To acquire knowledge on types of immune cells, phagocytosis, interferons and complement system. To explain the concept of hypersensitivity, auto immunity and transplantation. To provide knowledge on immune deficiencies and several immunological techniques. Student will learn immunization techniques and importance thereof.

Module 1: Overview of Immune System

Cells and organs of the Immune system.

Module 2: Innate and Adaptive Immunology

Innate immunology: Anatomical barriers, Inflammation. Adaptive immunology: Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals); Structure of T cell Receptor and its signaling. Killing Mechanisms by CTL and NK cells, Humoral Immune Response (Plasma and Memory cells).

Module 3: Antigens

Antigenicity and immunogenicity, Factors influencing immunogenicity, T-dependent and T-independent antigens, Adjuvants and haptens.

Module 4: Immunoglobulins

Structure and functions of different classes of immunoglobulins.

Module 5: Major Histocompatibility Complex

Organization of MHC locus (Human With brief comparison to mice); Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways) with role of APC.

Module 6: Cytokines

Types, properties and functions of cytokines

Module 7: Complement system

Components and pathways of complement activation.

Module 8: Hypersensitivity

Gell and Coombs' classification and brief description of various types of hypersensitivities..

Module 9: Vaccines

Various types of vaccines. Active & passive immunization (Artificial and natural).

References and suggested texts

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne, Immunology, 6th Edition, Freeman, 2002. 2.Brostoff J, Seaddin JK, Male D,
2. Roitt IM, Immunology, 6th Edition, Gower Medical Publishing, 2002. 3. Paul, Fundamentals of Immunology, 4th Edition, Lippencott Raven, 1999.

ZOO-MJ-P-502: Immunology Lab **: 2 Class Hours/week**

1. Demonstration/virtual lab/dry lab of lymphoid organs.
2. Determination of ABO Blood group.
3. Histological study of spleen, thymus and lymph nodes through permanent slides/ photographs.
4. Separate serum from the blood sample (demonstration)..
5. Demonstration/virtual lab/dry lab of ELISA.
6. Lab notebook with labelled drawings and results. Methods to be mentioned where applicable. *Viva-voce.*

COURSE OUTCOME: The study of Immunology reveals how the immune system defends against pathogens, detects abnormalities like cancer, and maintains tolerance to self-tissues. It underpins advancements in vaccines, allergy treatments, autoimmune therapies, and understanding diseases.

ZOO-MI-T-301: 9 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
V	ZOO-MI-T-301	Ecology, Evolutionary Biology and Immuno-parasitology	3	25+15+10 = 50
	ZOO-MI-P-301	Ecology, Evolutionary Biology and Immuno-parasitology Lab	1	

OBJECTIVES OF THE STUDY: Ecology deals with concept of ecosystem. The goal of this course to understand the basics of ecology. It includes population growth models, population genetics, community characteristics ecological succession etc. In evolutionary study it aims to acquire knowledge about the evolutionary history of earth - living and non-living, to acquire basic understanding about evolutionary concepts and theories. It also includes the distribution of animals on earth, its pattern, evolution and causative factors which impart basic knowledge on animal behavioral patterns and their role.

The aim of Immuno-parasitology is to introduce the students to various pathogens causing diseases and the reactions of the body against them. The objective of this course to increase awareness among the young students about the surrounding environment, the impact of climate change and its mitigation, and biodiversity, and educate the students about the basic environmental phenomena like pollution, ecosystem, etc. and to educate the students about the importance of wild life conservation.

Module 1: Population

Unique and group attributes of population: Demographic factors, life tables, survivorship curves. Exponential and logistic growth equation, r and K strategies. Population regulation - density-dependent and independent factors.

Module 2: Community and ecosystem

Community characteristics: species diversity, dominance, richness. Ecotone and edge effect. Ecological succession with one example. Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids.

Module 3: Evolution basics

Geological time scale; evolution of human. Natural selection (concept of fitness, types of selection). Genetic Drift mechanism (founder's effect, bottleneck phenomenon). Isolating mechanisms, Species concept.

Module 4: Immuno-parasitology

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). Different aspects of host-parasite interaction.

References and Suggested Texts

1. Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
2. Robert Leo Smith. Ecology and field biology. Harper and Row.
3. Organic Evolution. V.B. Rastogi. MedTech Science Press.
4. Parasitoses and zoonoses. Mala Bose. New Central Book Agency.

ZOO-MI-P-401: Ecology, Evolutionary Biology and Immuno-parasitology Lab**: 2 Class Hours/week**

1. Demonstration/virtual lab/dry lab of lymphoid organs.
2. Determination of ABO Blood group.
3. Histological study of spleen, thymus and lymph nodes through permanent slides/ photographs.
4. Study of fossils from models/photographs.
5. Study of aquatic ecosystem: Determination of pH, CO_2, and D.O. Observation and description of zooplankton (at least any three locally available species)

Lab note book, with labelled diagrams and identifications, with reason. *Viva-voce.*
Separate Lab Notebooks for Identification and Ecology.
Separate Field Notebook.

COURSE OUTCOME: The study of **Ecology** reveals species-environment interactions and ecosystem dynamics, guiding conservation and sustainable practices. **Evolutionary Biology** uncovers genetic adaptations, speciation, and evolutionary mechanisms driving biodiversity. **Immuno-parasitology** examines host-parasite immune interactions and understanding co-evolution.

ZOO-MJ-T-601: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VI	ZOO-MJ-T-601	Cytogenetics	4	40+20+15 = 75
	ZOO-MJ-P-601	Cytogenetics Lab	2	

OBJECTIVES OF THE STUDY: This course is to acquaint the students with Mendelian genetics, mechanism of linkage and sex determination, type of mutations. This curriculum is designed to provide knowledge about extrachromosomal inheritance, recombination in bacteria and viruses and transposable genetic elements.

Module 1: Mendelian Genetics and its Extension

Principles of inheritance, Incomplete dominance and co-dominance, Epistasis; Multiple alleles, Lethal alleles, Pleiotropy. Sex-linked, sex- influenced and sex-limited inheritance, Polygenic Inheritance.

Module 2: Linkage, Crossing-over and Chromosomal mapping

Linkage and Crossing Over, molecular basis of crossing over, measuring recombination frequency and linkage intensity using three factor crosses, Interference and coincidence.

Module 3: Mutations

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification with one suitable example of each), non-disjunction and variation in chromosome number; Molecular basis of mutations in relation to UV light and chemical mutagens.

Module 4: Sex-determination

Mechanisms of sex determination in *Drosophila.* Sex determination in human. Dosage compensation in *Drosophila* and man.

Module 5: Extra-chromosomal Inheritance

Criteria for extra chromosomal inheritance. Kappa particle in *Paramoecium*.

Module 6: Recombination in Bacteria and Viruses

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage.

Module 7: Transposable Genetic Elements

Transposons in bacteria, P elements in *Drosophila,* LINE, SINE, Alu elements in humans.

References and suggested texts

1. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc,
2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings.
3. Russell, P. J. (2009). Genetics- A Molecular Approach. 3d. ed. Benjamin Cumming.

ZOO-MJ-P-601: Cytogenetics Lab**: 2 Class Hours/week**

1. Chi-square analyses (goodness-of-fit with Mendelian ratio).
2. Preparation of linkage maps.
3. Identification of chromosomal aberration in *Drosophila* and man from photograph.
4. Pedigree analysis of some human inherited traits.
5. Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

COURSE OUTCOME: The study of **Cytogenetics** identifies chromosomal abnormalities (e.g., deletions, translocations) linked to genetic disorders, cancers, and developmental defects. It enables diagnostic tools like karyotyping and FISH, guiding personalized medicine, prenatal screening, and cancer research.

ZOO-MJ-T-602: 6 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VI	ZOO-MJ-T-602	Parasitology and Vector Biology	4	40+20+15 = 75
	ZOO-MJ-P-602	Parasitology and Vector Biology Lab	2	

OBJECTIVES OF THE STUDY: The course aims to provide a comprehensive understanding of parasitism, host-parasite interactions, and vector biology. It focuses on the study of parasitic organisms, their life cycles, modes of transmission, and impact on human and animal health. The course covers the identification of major parasites and vectors, including insects and vertebrates, their roles in disease transmission, and strategies for controlling vector-borne diseases through integrated management systems.

Module 1: Introduction to Parasitology and Vector Biology

Brief introduction of Parasitism, Parasite and Parasitoid. Host parasite relationship. Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host Specificity. Zoonotic diseases.

Module 2: Parasitic Protists

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Giardia intestinalis*, *Trypanosoma gambiense.*

Module 3: Parasitic Platyhelminthes

Study of *Morphology*, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Schistosoma haematobium*.

Module 4: Parasitic Nematodes

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostoma duodenale, Wuchereria bancrofti*. Nematode plant interaction; Gall formation.

Module 5: Insect Vectors and Diseases

Dipterans (Mosquitoes, Sand fly and Houseflies) as important insect vectors of diseases–Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Visceral Leishmaniasis, Cutaneous Leishmaniasis. Siphonaptera as *Disease* Vectors. Study of Flea-borne diseases – Plague, Typhus fever. Human louse (Head, Body and Pubic louse) as important insect vectors.

Module 6: Vertebrate Vectors and Diseases

Role of rats in transmission of diseases. Control of vector borne diseases by integrated vector management systems.

References and suggested texts

1. Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors
2. Atkinson, P. W. (2014) Vector Biology, Ecology and Control. Springer.
3. E.R. Noble and G.A. Noble (1982) Parasitology: The biology of animal parasites. V Edition, Lea &Febiger
4. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group
5. Mathews, G. (2011). Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases. Wiley-Blackwel
6. Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi
7. Rattan LalIchhpujani and Rajesh Bhatia. Medical Parasitology, III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi
8. Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers
9. K. D. Chatterjee (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd.
10. Bose, M. (2008) Parasitoses and Zoonoses. 1st Edition. NCBA.
11. Tyagi, B.K., (2022) Medical Entomology. 2nd edition, Scientific Publishers.

ZOO-MJ-P-601: 2 Parasitology and Vector Biology Lab**: Class Hours/week**

1. Study of life stages of any one: *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani* through permanent slides/micro photographs.
2. Study of adult and life stages of any one: *Schistosoma haematobium*, *Taenia saginata* through permanent slides/micro photographs.
3. Study of adult and life stages of any one: *Ancylostoma duodenale*, *Brugiamalayi* and *Trichinella spiralis* through permanent slides/micro photographs.
4. Study of any one: *Aedes sp.*, *Culex sp.*, *Anopheles sp.*, *Pediculus humanus*, *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.
5. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry].
6. Study of parasites from the intestines of Cockroach/ Poultry bird [Intestine can be procured from poultry/market as a by-product].

Lab notebook with labelled drawings and results. Methods to be mentioned where applicable. *Viva-voce.*

COURSE OUTCOME: The study of Parasitology and Vector Biology equips students to understand parasite life cycles, host-pathogen interactions, and vector-borne disease transmission (e.g., malaria, dengue). It develops skills in identifying parasites, designing control strategies, and addressing public health challenges linked to vectors like mosquitoes and ticks.

ZOO-MJ-T-603: 9 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VI	ZOO-MJ-T-603	Evolutionary Biology and Ethology	4	40+20+15 = 75
	ZOO-MJ-P-603	Evolutionary Biology and Ethology Lab	2	

OBJECTIVES OF THE STUDY: Since nothing in biology makes sense except in the light of evolution, learners need to be exposed to the basic concepts and mechanisms that shape naturally occurring variations into beneficial adaptations. Also, students will gain knowledge of the basic characteristic of learning and behavior by which an animal meets its daily needs and ensures its survival.

Module 1: Evolution basics

Darwinism and Neo Darwinism; neutral theory of molecular evolution.

Module 2: Fossils and their stories

Type of fossil, fossilization process, Geological timescale, fossil records of human Hominids (from *Australopithecus* to *Homo* sapiens); unique Hominid characteristics contrasted with primate characteristics.

Module 3: Ecology and evolution 1: populations and how they evolve

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to biallelic Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, types of selection, selection coefficient, mode of selection heterozygous superiority); Genetic Drift mechanism (founder's effect, bottleneck phenomenon).

Module 4: Ecology and evolution 2: the formation and diversification of species

Species concept, Isolating mechanisms, modes of speciation; Adaptive radiation/macroevolution(exemplified by Galapagos finches).

Module 5: Visualizing evolution: trees

Phylogenetic trees, Construction & interpretation of Phylogenetic trees by parsimony, Convergent and Divergent evolution.

Module 6: Patterns of Behaviour

Stereo typed Behaviors (Orientation, Reflexes); Individual Behavioral patterns; Instinct vs. Learnt Behavior; Associative learning, classical and operant conditioning, Habituation, Imprinting.

Module 7: Social and Sexual Behavior

Social Behavior, Altruism; Insects' society with Honeybee as example; Foraging and communication in honey bee (bee dance); Sexual Behavior: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice).

Module 8: Chronobiology and Biological Rhythms

Chronobiology: biological oscillation – the concept of average, amplitude, phase and period; adaptive significance of biological clocks. Biological rhythms: types and characteristics of biological rhythms: short- and long- term rhythms; circadian rhythms; tidal rhythms and lunar rhythms.

References and suggested texts

1. Barton ,N.H.,Birggs,D.E.G.,Elsen,J.A.Goldstein,D.B.andPatel,N.H.(2007).Evolution.CSHL Press
2. Bergstorm, C.T. and Dugatkin, L.A.(2012).Evolution.1stEdn.W.W.NortonandCo.
3. Dobzhansky, T. Ayala, F.J., Stebbins, J.L.& Valentine, J.W.(1977).Evolution. Surajeet Pub.,N. Delhi
4. Freeman, S .,Herron, J.C.(2016).Evolutionary Analysis. Pearson Education Limited, Noida, India.
5. Futuyma, D.J.(1997).EvolutionaryBiology.3rdEdn.SinauerAssociates.
6. Gillespie,J.H.(1998).PopulationGenetics:aConciseGuide.JohnHopkinsUnivPress.

7. Hall, B.K. and Hallgrimson, B.(2008).Stirckberger'sEvolution.4thEdn.Jones and Barlett.
8. Kardong, K.(2004).An Introduction to Biological Evolution. McGraw Hill.
9. Ridley, M.(1996).Evolution.2ndEdn.BlackwellScience.
10. Alcock, J.(2001).AnimalBehaviour:AnEvolutionaryApproach.,SinauerAssociateInc.,USA.
11. Chattopadhyay,S.(2012).Life:Evolution,Adaptation,Ethology.3rdEdn.BooksandAllied, Kolkata.
12. Dugatkin, L.A. (2014). Principles of Animal Behaviour.3rdEdn.W.W.NortonandCo.
13. Dunlap, J.C., Loros, J.J. and De Coursey, J.P. (2004). Chronobiology: Bioloigcal Time keeping. Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
14. Kumar, V. (2002) Biological Rhythms. Narosa Publishing House, New Delhi.
15. Mandal, F. (2010) A TextBook of Animal Behaviour. Prentice Hall India.
16. Mathur, R. (2005) Animal Behaviour. Rastogi Pub. Meerut.

ZOO-MJ-P-601: Evolutionary Biology and Ethology Lab**: 2 Class Hours/week**

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. Study of nests and nesting habits of the birds and social insects.
5. Study of geotaxis behavior in earthworm.
6. Study of phototaxis behavior in insect larvae.
7. Visit to Forest/Wildlife Sanctuary/ Biodiversity Park/ Zoological Parkto study behavioral activities of animals and prepare a short report.
8. Study of circadian functions in humans (daily eating, sleep and temperature patterns).

Lab notebook with labelled drawings and results. Methods to be mentioned where applicable. *Viva-voce*.

COURSE OUTCOME: The study of Evolutionary Biology enables understanding of genetic variation, adaptation, and speciation processes, fostering insights into biodiversity and species responses to environmental change. Ethology equips learners to analyze animal behavior patterns, communication, and social dynamics, linking evolutionary principles to ecological and conservation strategies. Together, they integrate mechanistic and evolutionary perspectives in behavioral and ecological research.

ZOO-MJ-T-701: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VII	ZOO-MJ-T-701	Economic Zoology and Entrepreneurial Opportunities in Aquaculture	4	40+20+15 = 75
	ZOO-MJ-P-701	Economic Zoology and Entrepreneurial Opportunities in Aquaculture Lab	2	

OBJECTIVES OF THE STUDY: Arthropods, the largest group of animals with approximately 1.3 million species on earth, play significant role in maintaining ecosystem balance. Together, they constitute the most important animal group in the form pests, pollinators, nutrient recyclers and vectors of many diseases.

1. To explore the various entrepreneurial opportunities available in the field of animal biology, focusing on areas such as biotechnology, aquaculture, animal breeding, and nutrition.
2. To understand the application of biological concepts in the development of sustainable animal-based industries.
3. To provide students with the skills and knowledge to identify market needs, develop business strategies, and manage enterprises related to animal biology.
4. To promote innovation and ethical practices in animal production, conservation, and biotechnological ventures.

This course is designed to provide students with the knowledge and skills necessary to develop, manage, and sustain entrepreneurial ventures in the aquaculture industry. It covers the principles of entrepreneurship, business planning, innovation, and the application of these concepts to aquaculture enterprises. Students will learn how to identify opportunities, assess risks, and create viable business models in the aquaculture sector.

Module -1: Economic Zoology

1. **Insect pests**: Morphology, bionomics and control of --

   i) Stored grains: Stored rice grain moth (*Corcyra cephalonica*) and stored pulse beetle (*Callosobruchus chinensis*)

   ii) Field insect pests: Fall army worm (*Spodoptera frugiperda*), cardamom capsule borer (*Conoganthes punctiferalis*), jute semilooper (*Anomissa bulifera*).

2. **Pest management**: Mechanical; Chemical; Biological; Integrated.

3. **Lac culture**: Life history of lac insect, culture method, lac processing, lac products, natural enemies of lac insect and their control.

4. **Parasitic insects and Acarines**:

a) General remarks on *Phlebotomous*, *Glossina*, *Tabanus* and head louse in relation to morphology, habit, habitat, life cycle and disease caused by them, mode of transmission.

b) General remarks on mites and ticks in relation to morphology, habitat, life cycle and diseases caused by them

Module -2: Entrepreneurial Opportunities in Aquaculture

1. Introduction to Entrepreneurship in Aquaculture: Definition and scope of entrepreneurship in aquaculture, Importance of entrepreneurship in the aquaculture industry, Overview of global and regional aquaculture markets.
2. Business Idea Generation and Opportunity Assessment: Identifying market needs and gaps in aquaculture.
3. Marketing and Sales Strategies in Aquaculture: Understanding the aquaculture value chain.
4. Developing marketing strategies for aquaculture products.
5. Innovation and Technology in Aquaculture: Role of technology in modern aquaculture, Innovations in aquaculture production systems (e.g., recirculating aquaculture systems, aquaponics), Sustainable practices and green technologies, Intellectual property and patenting in aquaculture.
6. Challenges and Future Trends in Aquaculture Entrepreneurship: Common challenges faced by aquaculture entrepreneurs, Emerging trends in aquaculture (e.g., alternative feeds).

References and suggested texts

1. Atwal, A. S. and Dhaliwal, G.S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi.

2. David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.

3. Futuyma, D. J. (1986). *Evolution*, Sinauer Associates, Inc., Sunderland, USA

4. Hennig, W. (1966). *Phylogenetic Systematics.* University of Illinois Press, Urbana, Chicago, London, vii + 263 p.

5. Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.

6. Kitching, I. J., Forey, P. L., Humphries, C. J. and Williams, D. (1998). *Cladistics: Theory and Practice of Parsimony Analysis* (*Systematics Association Special Volumes*). 2nd ed. OUP Oxford.

7. Lull, R.S. (1917). *Organic evolution*. The Mcmillan company, New York.

8. Mullen, G.R. and Durden, L.A. (2009). *Medical and Veterinary Entomology.* 2nd ed. Academic Press.

9. Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological control of Insect pests.* Lewis Publishers.

10. Rao, VKRV, 1984. Some Neglected Factors in Integrated Rural Development in Rural Development in India (Eds. Lakshman & Narayanan). Himalaya Publishing House, New Delhi.

ZOO-MJ-P-701: Economic Zoology and Entrepreneurial Opportunities in Aquaculture Lab:
2 Class Hours/week

1. Identification of -
   i) Pests and their damage symptoms of agricultural crops and stored grains from theoretical course.
   ii) Insect predators/parasitoids of economically important insects (Honey bee/ Silkworm).
2. Local fish market study: fish availability, transportation methods and market price.
3. Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

Course Outcomes: Knowledge on the morphology, bionomics, and control measures of various economically important arthropods, particularly insect pests and vectors, will be beneficial in planning better pest control strategies, economic growth, and management of insect vector borne diseases. Students will gain the ability to critically analyze entrepreneurial opportunities within the aquaculture sector, develop sustainable business models, and contribute to the growth of the bio-economy through innovative and ethical practices. They will also be equipped with the knowledge to start their ventures or contribute to existing industries.

ZOO-MJ-T-702: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VII	ZOO-MJ-T-702	Environmental Toxicology	4	40+20+15 = 75
	ZOO-MJ-P-702	Environmental Toxicology Lab	2	

OBJECTIVES OF THE STUDY: The study of Environmental Toxicology aims to understand the effects of toxic substances on the environment and living organisms, focusing on the sources, mechanisms, and consequences of pollutants. It seeks to evaluate the risks and impacts of chemicals, heavy metals, and nanoparticles on ecosystems, wildlife, and human health. Additionally, it promotes the development of strategies for reducing exposure and mitigating environmental harm.

Module 1: Fundamentals of Toxicology

Scope and significance of toxicology, Divisions of toxicology: Environmental, forensic, industrial, and medical toxicology, Definition and classification of toxicants. Concept of key toxicological parameters: LD50, LC50, ED50, Dose-response relationship and factors influencing toxicity, Carcinogenic, mutagenic, and teratogenic effects of toxicants. Methods for testing chemical toxicity on insects and evaluating toxicity.

Module 2: Classification and Mode of Action of Pesticides

Classification of pesticides: **Organophosphates** – Mechanism of action and toxicity, **Carbamates** – Function and mode of action, **Pyrethroids** – Synthetic and natural forms, toxicity profile, **Neonicotinoids and Nitrogenous Insecticides** – Impact on insect nervous systems, **Fumigants, Attractants, Repellents, and Anti-feedants** – Chemical properties and applications. Environmental impact and bioaccumulation of pesticides.

Module 3: Toxicokinetics and Toxicodynamics

Absorption of toxicants: Routes of exposure (oral, dermal, inhalation), Distribution and bioavailability of toxic substances in biological systems, Metabolism of toxicants: Phase I and Phase II detoxification pathways, Elimination of toxicants: Renal, hepatic, and pulmonary excretion pathways, Factors affecting toxicity: Bioactivation, synergism, and antagonism.

Module 4: Toxicants of Public Health Concern

Pesticides and their impact on human health. Heavy metals toxicity: **Cadmium (Cd)** – Sources, toxicity, and health effects, **Mercury (Hg)** – Forms of mercury, bioaccumulation, and toxicity symptoms, **Arsenic (As)** – Contamination sources and toxic effects. Food additives and preservatives: Toxic effects, Safety concerns and regulations. Nanotoxicology: Toxic effects of nanoparticles.

Module 5: Toxicological Symptoms and Risk Assessment

Symptoms of poisoning due to: Organophosphorus insecticides, Carbamates and Pyrethroids, Plant-derived insecticides and bio-insecticides. Biomarkers for toxicity evaluation. Risk assessment and management of toxic exposure.

References and suggested texts

1. Ernest Hodgson – A text book of modern toxicology, Wiley-Blackwell (latest edition).
2. Lindsay Murray, Mark Little, Ovidiu Pascu and Kerry Hoggett- Toxicology handbook, Churchill Livingstone, Australia, (Latest edition.
3. David A. Wright and Pamela Welbourn- Environmental toxicology, Cambridge University Press, (Latest edition).
4. Woolley, D. and Woolley, A. (2017). Practical Toxicology- Evaluation, Prediction and Risk, Third edition, CRC press, Taylor and Francis Group/
5. Stine, K. E. and Brown, T. M. (2015). Principles of Toxicology, Third edition, CRC press, Taylor and Francis Group
6. Hayes, W. and Kruger, C. L. (2014). Hayes' Principles and Methods of Toxicology, VI edition, CRC press, Taylor and Francis Group.
7. Pandey, G. and Sahni, Y. (2013) Toxicology Laboratory manual. International E Publication.

ZOO-MJ-P-702: Environmental Toxicology Lab: **2 Class Hours/week**

1. Determination of LC50 / LD50 and 95% Confidence limit of any toxicant to a selected aquatic/ terrestrial organism.
2. Probit analysis (graphical/ Computational).

Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

COURSE OUTCOMES**:** Upon successful completion of this course, students will be able to:

a. Explain the fundamental concepts of toxicology, including dose-response relationships and the effects of toxicants on living organisms.
b. Classify and describe different groups of pesticides and their mode of action.
c. Understand the processes of toxicokinetics and toxicodynamics and their role in toxicity.
d. Identify key toxicants of public health concern and assess their impact on human and environmental health.
e. Recognize and describe the toxicological symptoms associated with exposure to various insecticides, including organophosphates, carbamates, and bio-insecticides.
f. Apply methods for testing chemical toxicity on insects and evaluate their effects in toxicological studies.

ZOO-MJ-T-703: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VII	ZOO-MJ-T-703	Genomics, Molecular Biology and Basic Methods in Animal Biology	4	40+20+15 = 75
	ZOO-MJ-P-703	Genomics, Molecular Biology and Basic Methods in Animal Biology Lab	2	

OBJECTIVES OF THE STUDY: Major objective of this core paper is to introduce to the students to contemporary molecular techniques for manipulation of genome that could assist them towards advanced understanding of biological processes in broad range of host organisms.
Basic Methods course is meant to impart knowledge to students on different techniques in Biological Sciences. The course is designed in such a way that the students get to understand the various different techniques that are used in biology; from the classical age-old methods to the present-day modern versions of various techniques.

Module 1: Genomics

Genome Mapping and Mapping genomes: physical maps, EST, SNPs as physical markers, radiation hybrids, FISH, optical mapping, gene maps, integration of physical and genetic maps.

Genome Sequencing Technologies: sequencing genomes: high-throughput sequencing, strategies of sequencing, recognition of coding and noncoding regions and annotation of genes, quality of genome-sequence data, base calling and sequence accuracy.

Module 2: Molecular Biology

DNA replication, transcription and translation in prokaryotes and eukaryotes.

Gene regulation in prokaryotes and eukaryotes.

Types of DNA repair mechanisms.

Module 3: Methods in animal Biology

Microscopy: Basic concepts of light and electron microscopy (magnification, resolution, limit of resolution, chromatic aberrations).

Histochemical and immunological techniques: Fixatives (types and function), Stains (Periodic acid - Schiff and Feulgen reactions). Common immunohistochemical reactions (Avidin-Biotin Complex (ABC) method, and Labeled StreptAvidin Biotin (LSAB) method). Antibody generation and antigen-antibody interaction.

Biophysical methods: Common spectroscopic methods, Electromagnetic radiation, Principle of spectroscopy.

Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

Molecular Techniques: PCR, Western and Southern blot, Northern Blot.

Methods in field biology: Methods of estimating population density of animals, sampling methods in the study of behavior.

References and suggested texts

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA[Latest edition].
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK.
3. Cell and Molecular Biology. DeRobertis and De Robertis
4. Molecular Biology of the Gene, 2017, James D. Watson, A. Baker Tania, P. Bell Stephen (Author), Gann Alexander, Levine Michael, Losick Richard
5. Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition, ISBN-13: 9780136043027
6. Principles of Genetics, 7th Edition, D. Peter Snustad, Michael J. SimmonsISBN: 978-1-119-14228-7 2015
7. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 2018, ISBN: 9781316677056
8. Biochemistry Laboratory: Modern Theory and Techniques, Latest Edition, Rodney Boyer, Pearson Prentice Hall™ is a trademark of Pearson Education, Inc.ISBN-10: 0-13-604302-X, ISBN-13: 978-0-13-604302-7

ZOO-MJ-P-703: Genomics and Basic Methods in Animal Biology Lab**: 2 Class Hours/week**

1. Identification of chromosomal aberration in Drosophila images.
2. Study of mutant phenotypes of Drosophila
3. Solving problems on linkage and chromosomal mapping.
4. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila* larvae / *Chironomous* larvae

Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

COURSE OUTCOMES: This course is expected to deliver knowledge of how organisms, populations and species evolve, besides providing answer some of the most fundamental questions on human genome, disease and functions of gene.

ZOO-MI-T-401: 9 Modules, 3 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
V	ZOO-MI-T-401	Basic Methods in Animal Biology	3	25+15+10 = 50
	ZOO-MI-P-401	Basic Methods in Animal Biology Lab	1	

OBJECTIVES OF THE STUDY: Major objective of this ability enhancement compulsory paper is to impart knowledge to the students on contemporary molecular techniques for genetic manipulation that could help them in better understanding of biological processes in broad range of host organisms. Lectures will specifically address the historical standard techniques with emphasis on principles of various methods used in biological research.

Module 1: Basic Methods in Animal Biology

Microscopy: Basic concepts of light and electron microscopy (magnification, resolution, limit of resolution, chromatic aberrations).

Histochemical and immunological techniques: Tissue processing, microtomy, fixatives (types and function), staining. Antibody generation and antigen-antibody interaction.

Biophysical methods: Common spectroscopic methods, Electromagnetic radiation, Principle of spectroscopy.

Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

References and Suggested Texts

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA[Latest edition].
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK.
3. DeRobertis and De Robertis Cell and Molecular Biology. Lea and Febiger.
4. Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition, ISBN-13: 9780136043027
5. Immunology Kuby W.H. Freeman and Company.
6. Murphy, K and Casey W. (2016). *Janeway's Immunobiology*. 8thed.Garland Science.
7. Roitt, I. M. and Delves, P. J. (2017). *Roitt's Essential Immunology*. 13th ed. Blackwell Science Ltd.
8. Wilson and Walker's (2018). *Principles and Techniques of Biochemistry and Molecular Biology.8th ed.* Cambridge University Press.

ZOO-MI-P-401: Basic Methods in Animal Biology Lab: 2 Class Hours/week

1. Demonstration of different microscopes functioning and principles
2. Histochemical reactions for: Carbohydrates, protein and lipid.
3. Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

ZOO-MJ-T-801: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VIII	ZOO-MJ-T-801	Endocrinology and Developmental Biology	3	25+15+10 = 50
	ZOO-MJ-P-801	Endocrinology and Developmental Biology Lab	1	

OBJECTIVES OF THE STUDY: The study of Endocrinology aims to explore the structure and function of endocrine glands and the hormones they produce. It seeks to understand how hormones regulate various physiological processes such as growth, metabolism, reproduction, and homeostasis. Additionally, the course examines hormonal disorders and the development of therapeutic strategies for managing endocrine diseases.

Module 1: Endocrinology

1. Classification of hormones; general principles, nature of hormone receptors (cell surface receptors and intracellular receptors), and hormone signaling pathways (G-protein coupled receptors, Receptor Tyrosine Kinases, and steroid hormone signaling).
2. Biosynthesis, secretion and regulation of hormones: biosynthesis of Insulin, Post-Translational event and release.
3. Biosynthesis and function of steroid and thyroid hormones (T_3 and T_4) and their regulations.
4. Neuroendocrine system and neuro-secretion: neural control of glandular secretion; hypothalamic pituitary unit, neuroendocrine feedback.
5. Hormones in reproduction: Estrus cycle and menstrual cycle.
6. GI tract hormones: source, composition and function.
7. Molecular basis of endocrinopathies: Disorders of pituitary hormone axis, Hashimoto's thyroiditis metabolic bone diseases, Cushing syndrome, Addison's diseases, diabetes.

Module 2: Development Biology

1. spermatogenesis, Oogenesis; Types of eggs, Fertilization (External and Internal): Planes and patterns of cleavage;
2. Embryonic induction and concept of organizers. Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each).

References and suggested texts

1. Endocrinology- Fox T, Brooks A, Baidya B. JP Medical London (latest edition).
2. Jameson JL. Harrison's Endocrinology. McGraw Hill Education (latest edition).
3. Goodendocrman HM. Basic Medical endocrinology. Academic press (latest edition).
4. Endocrinology-Mac E Hadley and Jon E Levine. Pearson (latest edition).
5. Introduction to endocrinology- Chandra S Negi. PHI (latest edition).
6. General endocrinogy-Turmer CD and Bagnara JT. East-West press Pvt. Ltd. (latest edition).
7. Vertebrate endocrinology-Norris DO. Elsevier academic press (latest edition).
8. Basic endocrinology, an interactive approach-Neal JM. Blackwell Science (latest edition).

Endocrine physiology-Molina PE. McGraw Hill Lange (latest edition).

ZOO-MJ-P-801: Endocrinology and Developmental Biology Lab: **2 Class Hours/week**

1. Demonstration/virtual lab of castration and ovariectomy in rat /mice.
2. *In vitro* study of motility of epididymal spermatozoa.
3. Estrous Cycle Stages from rat/ mice: Preparation and Identification.

Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

COURSE OUTCOME: Students will gain a comprehensive understanding of the endocrine system's role in maintaining bodily functions. They will be able to analyse hormonal imbalances and their impact on health, and acquire skills to diagnose and manage endocrine disorders.

ZOO-MJ-T-802: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VIII	ZOO-MJ-T-802	Fish Biology	3	25+15+10 = 50
	ZOO-MJ-P-802	Fish Biology Lab	1	

OBJECTIVES OF THE STUDY: Various biological aspects of fish viz. Respiratory organs, Excretion, Electroreception, Reproduction in fish, migration etc. are in this paper, Fish biology.

Details of module

Respiratory organs: Water breathing, Air-breathing, Swim bladder.

Excretion and osmoregulation in fish.

Reproduction in fish: reproductive strategies, oviparity, viviparity, ovo-viviparity, parental care, maturity stages, breeding cycle.

Structure and physiology of endocrine glands in fishes.

Electroreception in fish, Electric organs, Neuromast organ.

Determination of age of fish by scale and hard parts.

Poisonous and venomous fish.

Fish migration: Types, Theories and Significances

References and suggested texts

1. Bond, C. E. (1996). *Biology of Fishes*. 2nd ed. Saunders Pub.
2. Evans, D. H. (1998). *The Physiology of Fishes*. CRC Press.
3. Hoar and Randall. *Fish Physiology,* Volumes I-XV (1969-onwards, Academic Press)
4. Encyclopedia of Fish Physiology. 2011. Anthony P. Farrell, E.D. Stevens, J.J. Cech&
5. J.G. Richards (Eds). Academic Press, UK.
6. Fish Physiology. (Series) W.S.Hoar and D.J. Randall (Series Eds). Academic Press, UK.
7. The Physiology of Fishes. 2013. Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK.

ZOO-MJ-P-802: Fish Biology Lab: 2 Class Hours/week

1.Urinogenital system of teleost.

2.Study of scales and otolith in fish age determination.

3.Display of pituitary gland of fish.

4. Histological study of pituitary glands, gills, kidney, liver, intestine, testis and ovary of fish (from prepared slides).

5.Study of museum specimens of fishes having electric organs and venomous organs.

Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

Course Outcomes: Upon successful completion of this lab content students would be able to trained to diagnose, identify and detect some important parasites and also different fish physiological organs.

ZOO-MJ-T-803: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VIII	ZOO-MJ-T-803	Research Methodology	3	25+15+10 = 50
	ZOO-MJ-P-803	Research Methodology Lab	1	

OBJECTIVES OF THE STUDY: 1. To provide a comprehensive understanding of research design, data collection methods, and statistical analysis in scientific research.
2. To equip students with the skills needed to critically evaluate research literature and identify research gaps.
3. To teach ethical principles and best practices in conducting scientific research, including data integrity and reproducibility.
4. To enable students to develop the skills to formulate research questions, design experiments, and present research findings effectively.

Details of Module

Introduction to Research Methodology: Research – Definition, Importance, Characteristics – Types of Research - Research question – Importance of Survey of Literature – formulation of research question and objectives – Formulation of hypothesis – types of hypothesis - Research process – research design – developing a research plan - Types of research methods

Types of data: Sources of data - Methods of collecting data – Sampling methods.

Quantitative research methods: Frequency distribution – Presentation of data – Descriptive statistics – Correlation analysis.

Ethical Aspects of Undertaking Research: Research Philosophy, Approaches to Theory Development in Research, Ethical Judgements in Research.

Managing Scientific Conduct: Concept of Academic Integrity: Integrity Concepts, Academic integrity; Scientific Misconduct and Research Fraud (Falsification, Fabrication and Plagiarism).

Publication Ethics: Concept of Publication Ethics, Research Ethics: Concept and Objectives, Ethics Committee.

Scientific Writing: Structure and components of Scientific Reports, Preparation of Project Proposal, Preparation of manuscript for Seminar Presentation and Publication of Research paper.

Data Science & Statistical Tools: Statistical packages (Excel®, SPSS®).

References and suggested texts

1. C.R. Kothari, Gaurav Garg (2019) Research Methodology: Methods and Techniques
2. Callahan D. & Bok S., 1996, Ethics Teaching in Higher Education. Plenum Press, New York, USA.
3. David B. Resnik, 1998, The Ethics of Science: An Introduction. Routledge publisher, USA.
4. Kapur J.N., 1996, Ethical Values for Excellence in Education and Science, Wishwa Prakashan, New Delhi.
5. Tripathi A.N., 2008, Human Values. New Age International Publishers, New Delhi.

ZOO-MJ-P-803: Research Methodology Lab: **2 Class Hours/week**

Frequency distribution, presentation of data, descriptive statistics and correlation using Excel and/or SPSS.

Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

Course Learning Outcomes: Students will be able to design and execute scientific research projects independently, apply appropriate research methodologies, and analyze data with precision. They will also gain proficiency in critically reviewing scientific literature and presenting research outcomes, preparing them for future research careers or advanced academic pursuits.

[For Honours Without Research Students]

ZOO-MJ-T-804, ZOO-MJ-P-804, ZOO-MJ-T-805 and ZOO-MJ-P-805

(These papers are mandatory only for the students opting for Honours without Research)

ZOO-MJ-T-804: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VIII	ZOO-MJ-T-804	Human Genetics and Medical Diagnostic Techniques	4	40+20+15 = 75
	ZOO-MJ-P-804	Human Genetics and Medical Diagnostic Techniques Lab	2	

OBJECTIVES OF THE STUDY: 1. To provide a comprehensive understanding of the principles of human genetics, including inheritance patterns, genetic variation, and molecular mechanisms of genetic diseases.
2. To equip students with the knowledge and skills to apply modern genetic and molecular diagnostic techniques in the identification of genetic disorders.
3. To explore the ethical, legal, and social implications of genetic testing and medical diagnostics in healthcare.
4. To foster critical thinking in the interpretation of genetic data for clinical diagnosis and personalized medicine.

Module 1: Human Genetics

1 Basic concept of Human genetics: Introduction to the structure of human genome.

2. Genome Mapping: Human genome and its Mapping. Human Genome Project.

3. Human Karyotype: Introduction to Karyogram, Karyotype and Karyotyping; Banding Techniques.

Module 2: Medical Diagnostic Techniques

1. Chromosome Anomalies and Structural Variants.

2. Molecular Pathology: Loss of function, Gain of function; Mitochondrial disorders.

3. Genetic analysis of thalassemia and sickle-cell anemia.

4. Human Genetics and Diagnosis: Genetic Testing-Genetic, Biochemical, Molecular; Genetic Counselling.

References and suggested texts

1. "Thompson & Thompson Genetics in Medicine" by Robert L. Nussbaum, Roderick R. McInnes, and Huntington F. Willard
2. "Human Molecular Genetics" by Tom Strachan and Andrew Read
3. "Principles of Medical Genetics" by Thomas D. Gelehrter, Francis S. Collins, and David Ginsburg
4. "Medical Genetics" by Lynn B. Jorde, John C. Carey, and Michael J. Bamshad
5. "Emery's Elements of Medical Genetics" by Peter D. Turnpenny and Sian Ellard
6. "Molecular Diagnostics: Fundamentals, Methods and Clinical Applications" by Lela Buckingham and Maribeth L. Flaws
7. "Henry's Clinical Diagnosis and Management by Laboratory Methods" by Richard A. McPherson and Matthew R. Pincus
8. "Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics" by Carl A. Burtis, David E. Bruns, and Edward R. Ashwood
9. "Principles and Practice of Clinical Chemistry and Molecular Diagnostics" by Amitava Dasgupta and Amer Wahed

ZOO-MJ-P-804: 2 Class Hours/week

1. Demonstration of human chromosomes and preparation of karyotypes.
2. Solving problems on human population genetics.
3. Study of chromosomal aberrations in human with respect to number, translocation, deletion etc. from the photographs and images.
4. DNA extraction and study of the quantity and quality (UV spectroscopy and Agarose Gel Electrophoresis).
5. Lab notebook with labelled diagrams, methods (wherever applicable) and results. *Viva-voce.*

Course Outcomes: Students will be able to understand the genetic basis of human diseases and apply molecular diagnostic techniques to identify genetic mutations. They will also develop the ability to evaluate genetic data for disease risk assessment and guide personalized treatment options. Graduates will be prepared to contribute to clinical diagnostics, genetic counseling, and research in human genetics and genomics, while understanding the ethical considerations in genetic testing.

ZOO-MJ-T-805: 7 Modules, 4 Class Hours/week

Semester	Course Name	Course Detail	Credits	Total Award
VII	ZOO-MJ-T-805	Animal Biotechnology	4	40+20+15 = 75
	ZOO-MJ-P-805	Animal Biotechnology Lab	2	

OBJECTIVES OF THE STUDY: To introduce students to the fundamental concepts and scope of animal biotechnology; to provide knowledge of molecular techniques used in gene manipulation, including recombinant DNA technology, cloning vectors, and gene transfer methods; to understand the principles and applications of genetically modified organisms (GMOs) and their role in biomedical research; to familiarize students with animal cell culture techniques, hybridoma technology, and their applications in medicine and industry; to explore advanced biotechnological approaches such as gene therapy, molecular diagnostics, and stem cell therapy.

Module 1: Introduction to Animal Biotechnology

Concept and Scope of Animal Biotechnology. Organization of *E.coli* genome.

Module 2: Molecular Techniques in Gene manipulation

Recombinant DNA technology, Restriction endonucleases. Cloning Vectors & their features: Plasmids, Phage vectors, Cosmids, Phagemids, BAC and YAC. Construction of Genomic libraries and cDNA libraries. Transformation techniques: Cloning in bacteria and detection technique of clone. Agarose and Polyacrylamide Gel Electrophoresis, Southern, Northern and Western blotting, Polymerase chain reaction: RAPD & RT PCR, DNA Fingerprinting.

Module 3: Genetically Modified Organisms

Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection. Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock-out mice.

Module 4: Animal Cell Culture Techniques and Applications

Animal cell culture, Expressing cloned genes in mammalian cells, Hybridoma technology, Stem cell therapy and regenerative medicine, Gene therapy.

References and suggested texts

1. Brown, T.A. (2010) Gene Cloning and DNA Analysis. VI Edition, Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
2. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
3. Primrose, S.B., and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. VII Edition, Blackwell publishing (Oxford, UK)
4. Clark, D. P. and Pazdernik, N.J. (2012) Biotechnology, Academic Press.
5. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) Recombinant DNA Genes and Genomes-A Short Course. III Edition, Freeman and Co., N.Y., USA.
6. Verma A. S., Singh, A. (2014). Animal Biotechnology: Models In Discovery and Translation. Academic Press.
7. Srivastava, A.K., Singh, R.K., Yadav, M.P. (2018) Animal Biotechnology, CBS Publications.

ZOO-MJ-P-805: Animal Biotechnology Lab: **2 Class Hours/week**

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation of culture media.
3. Demonstration of genomic DNA from *E. coli*.
4. To study following techniques through photographs/dry lab/virtual lab/demonstration - Southern Blotting, Northern Blotting, Western Blotting, PCR, DNA fingerprinting.

   Lab notebook with labelled diagrams, methods (wherever applicable) and results; *Viva-voce*.

Course Outcomes: Upon successful completion of this course, students will be able to demonstrate an understanding of the structure and organization of animal genomes, particularly in model organisms like *E. coli*; apply molecular biology techniques, including recombinant DNA technology, PCR, and electrophoresis, in genetic research and diagnostics; analyze the process of creating genetically modified animals and their applications in medical and industrial biotechnology; perform basic animal cell culture techniques and understand their significance in genetic engineering, pharmaceutical production, and disease treatment.