THE UNIVERSITY OF BURDWAN

SYLLABUS FOR 3-YEAR DEGREE/4-YEAR HONOURS IN ZOOLOGY

UNDER CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMMES (CCFUP) AS PER NEP 2020

WITH EFFECT FROM 2023–2024

SCHEME AND SYLLABUS FOR SEMESTERWISE AND COURSEWISE CREDITS AND MARKS DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NATIONAL EDUCATION POLICY 2020 FOR 3-YEAR DEGREE/4-YEAR B.Sc. HONOURS IN ZOOLOGY

Semester	Course Type	Code with Course Title	Credits	Lect.	Tuto.	Pract./ Viva	Full Marks	Distribution of Marks		
								Theory	Pract./ Viva voce	Internal Assessment
I	Major Course	ZOOL1011: Non-Chordates	4	3	0	1	75	40	20	15
	Minor Course	ZOOL1021: Non-Chordates	4	3	0	1	75	40	20	15
	Inter/ Multi disciplinary	ZOOL1031: Introduction to Animalia	3	2	1	0	50	40	00	10*
	Ability Enhancement Course (AEC) [L_1-1 MIL]	Arabic/ Bengali/ Hindi/ Sanskrit/ Santali/ Urdu OR Equivalent Course from SWAYAM/ Any other UGC-recognised platform	2	2	0	0	50	40	0	10
	Skill Enhancement Course (SEC)	ZOOL1051: Apiculture OR Vermiculture	3	2	1	0	50	40	0	10**
	Common Value Added Course	VAC1061: Environmental Science/ Education	4	3	0	1	100	60	20	20
	Total		**20**				**400**			

*Internal assessment of 10 marks in case of Inter/Multidisciplinary will be based on practical portion of the course concerned.

**Internal assessment of 10 marks in case of SEC will be based on practical portion of the course concerned.

Semester	Course Type	Code with Course Title	Credits	Lect.	Tuto.	Pract./ Viva	Full Marks	Distribution of Marks		
								Theory	Pract./ Viva voce	Internal Assessment
II	Major Course	ZOOL2011: Chordates	4	3	0	1	75	40	20	15
	Minor Course	ZOOL2021: Chordates	4	3	0	1	75	40	20	15
	Inter/ Multi disciplinary	ZOOL2031: Applied Zoology I	3	2	1	0	50	40	00	10*
	Ability Enhancement Course (AEC) [L_2-1 IL]	ENGL2041: Functional English OR Equivalent Course from SWAYAM/ Any other UGC-recognised platform	2	2	0	0	50	40	00	10
	Skill Enhancement Course (SEC)	ZOOL2051: Sericulture OR Aquarium Fish keeping	3	2	1	0	50	40	00	10**
	Common Value Added Course	VAC2061: Understanding India/ Digital and Technological Solutions/ Health and wellness, Yoga Education, Sports and Fitness	4	3	1/0	0/1	100	80/60	00/20	20
	Total		**20**				**400**			

*Internal assessment of 10 marks in case of Inter/Multidisciplinary will be based on practical portion of the course concerned.

** Internal assessment of 10 marks in case of SEC will be based on practical portion of the course concerned.

Semester	Course Type	Code with Course Title	Credits	Lect.	Tuto.	Pract./ Viva	Full Marks	Distribution of Marks		
								Theory	Pract./ Viva voce	Internal Assessment
III	Major Course	ZOOL3011: Biochemistry	5	4	0	1	75	40	20	15
		ZOOL3012: Cell Biology	5	4	0	1	75	40	20	15
	Minor Course (Vocational Education and Training)	MSR3021: Medical Sales Representative OR HRM3021: Human Resource Management OR RSA3021: Retail Sales Associate	4	3	1	0	75	40	20	15
	Inter/ Multi disciplinary	ZOOL3031: Applied Zoology II	3	2	1	0	50	40	00	10*
	Ability Enhancement Course (AEC) [L_1-2 MIL]	……...3041: Arabic/ Bengali/ Hindi/ Sanskrit/ Santali/ Urdu or Equivalent Course from SWAYAM/ Any other UGC-recognised platform	2	2	0	0	50	40	00	10
	Skill Enhancement Course (SEC)	ZOOL3051: Animal Husbandry and Management OR Medical Diagnostics	3	2	1	0	50	40	00	10**
	Total		**22**				**375**			

*Internal assessment of 10 marks in case of Inter/Multidisciplinary will be based on practical portion of the course concerned.

**Internal assessment of 10 marks in case of SEC will be based on practical portion of the course concerned.

Semester	Course Type	Code with Course Title	Credits	Lect.	Tuto.	Pract./ Viva	Full Marks	Distribution of Marks		
								Theory	Pract./ Viva voce	Internal Assessment
IV	Major Course	ZOOL4011: Animal Physiology	5	4	0	1	75	40	20	15
		ZOOL4012: Disease Biology	5	4	0	1	75	40	20	15
		ZOOL4013: Comparative Endocrinology	5	4	0	1	75	40	20	15
	Minor Course	ZOOL4021: Wildlife Conservation	4	3	0	1	75	40	20	15
	Minor Course (Other than Zoology)	4031:	4	2	1	0	75	40	20	15
	Ability Enhancement Course (AEC) [English]	ENGL4041: Language and Creativity OR Equivalent Course from SWAYAM/ Any other UGC-recognised platform	2	2	0	0	50	40	0	10
	Total		**25**				**425**			

s

*Internal assessment of 10 marks in case of Inter/Multidisciplinary will be based on practical portion of the course concerned.

.

Semester	Course Type	Code with Course Title	Credits	Lect.	Tuto.	Pract./ Viva	Full Marks	Distribution of Marks		
								Theory	Pract./ Viva voce	Internal Assessment
V	Major Course	ZOOL 5011: Genetics	5	4	0	1	75	40	20	15
		ZOOL 5012: Molecular Biology	5	4	0	1	75	40	20	15
		ZOOL 5013: Animal Biotechnology	5	4	0	1	75	40	20	15
	Minor Course (Vocational Education and Training)	MSR5021: Medical Sales Representative OR HRM5021: Human Resource Management OR RSA5021: Retail Sales Associate	4	3	1	0	75	60	0	15
	Internship	INT 5081	2	0	0	2	50	00	(Project/ Field Diary: 30 + Viva voce: 20)	00
	Total		**21**				**350**			

s

Semester	Course Type	Code with Course Title	Credits	Lect.	Tuto.	Pract./ Viva	Full Marks	Distribution of Marks		
								Theory	Pract./ Viva voce	Internal Assessment
VI	Major Course	ZOOL 6011: Evolutionary Biology and Ethology	4	3	0	1	75	40	20	15
		ZOOL 6012: Ecology and Conservation Biology	4	3	0	1	75	40	20	15
		ZOOL 6013: Developmental Biology	4	3	0	1	75	40	20	15
		ZOOL 6014: Histology and Histochemistry	4	3	0	1	75	40	20	15
	Minor Course (Vocational Education and Training)	MSR6021: Medical Sales Representative OR HRM6021: Human Resource Management OR RSA6021: Retail Sales Associate	4	3	1	0	75	60	0	15
Total			**20**				**375**			
Grand Total: Semester I–VI			**128**				**2325**			

s

SEMESTER – I

MAJOR COURSE
ZOOL1011: Non-Chordates
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

The main objective of this syllabus is to acquaint the students with the diversity of animals (invertebrates) of this universe, especially their taxonomic position in the animal kingdom, as well as their physiology and organ systems.

Sl No.	Topics	Lectures (45)
1	**Unit 1: Basics of Animal Classification** Domain and Kingdom concept Definition: Taxonomy Classification, and Systematics Species concept: Typological, Biological, Evolutionary and Phylogenetic Important rules of Zoological Nomenclature (ICZN): Principles of: Priority, Synonymy, Homonymy and Typification Linnaean Hierarchy, Taxon, Phenon, and Category Basic principles of Phenetics and Cladistics	07
2	**Unit 2: Protista and Metazoa** **Protozoa:** General characteristics and schematic classification up to phyla (Levine et al., 1980); Locomotion in *Amoeba*, Conjugation in *Paramoecium* **Metazoa:** Classifying Metazoan phyla based on morphological and developmental criteria; Hypotheses of metazoan origin; Symmetry: Types and evolution	04
3	**Unit 3: Porifera** General characteristics and schematic classification up to order (Hyman, 1940) Canal system and spicules of sponges	03
4	**Unit 4: Cnidaria** General characteristics and schematic classification up to order (Ruppert and Barnes, 1994); Metagenesis of *Obelia*; Coral reef types and formation	04
5	**Unit 5: Ctenophora** General characteristics	01
6	**Unit 6: Platyhelminthes** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994)	02
7	**Unit 7: Nematoda** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994)	02
8	**Unit 8: Annelida** General characteristics and schematic classification up to order (Ruppert and Barnes, 1994); Metamerism: Types and origin; Nephridia: Structure and function	04
9	**Unit 9: Arthropoda** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994), Respiratory structures and function: Book gill, Book lung, Trachea; Eyes in Insects; Metamorphosis in insects: Types, chemistry, source of hormones	05

10	**Unit 10: Onychophora** Affinities and evolutionary significance	02
11	**Unit 11: Mollusca** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994); modification of foot; nervous system and torsion in Gastropods	04
12	**Unit 12: Echinodermata** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994); Water vascular system of *Asterias*; Structure of tube Feet; Larval forms in Echinodermata	04
13	**Unit 13: Hemichordata** General characteristics of phylum Hemichordata; relationship between non-chordates and chordates	03

Suggested readings

Anderson, D.T. (Ed.) (2001). Invertebrate Zoology. 2nd Edition. Oxford University.

Barnes, R.D. and Ruppert, E.E. (1994). Invertebrate Zoology. 6th Edition. Brooks Cole.

Barrington, E.J.W. (1981). Invertebrate Structure and Function. 2nd Edition. ELBS and Nelson.

Brusca, R.C. and Brusca, G.J. (2002). Invertebrates. 4th Edition. Sinauer Associates.

Chaki, K.K., Kundu, G. and Sarkar, S. (2011). Introduction to General Zoology. 4th Revised Edition. Vol 1. New Central Book Agency (P) Ltd.

Dhami, S. and Dhami, J.K. (2021). Invertebrate Zoology. 5th Edition. S. Chand and Co.

Hickman, C.P. Jr., Hickman, F.M. and Roberts, L.S. (2016). Integrated Principles of Zoology. 17th Edition. Times Mirror/Mosby College Publication. St. Louis.

Hyman, L.H. (1940). The Invertebrates (Vol-I). McGraw-Hill Book Company.

International Commission on Zoological Nomenclature (1999). International Code of Zoological Nomenclature. 4th Edition. The International Trust for Zoological Nomenclature, London.

Jordan, E.L. and Verma, P.S. (2009). Invertebrate Zoology. 5th Edition. S. Chand and Company Ltd., New Delhi.

Kapoor, V.C. (2008). Theory and Practice of Animal Taxonomy. 6th Edition. Oxford and IBH Publication.

Kotpal, R.L. (1988–1992). (All Series) Protozoa, Porifera, Coelenterata, Annelida, Arthropoda, Mollusca, Echinodermata. Rastogi Publications, Meerut.

Marshall, A.J. and Williams, W.D. (1972). Text Book of Zoology: Invertebrates, Volume-I. 7th Edition. Macmillan Publishers Limited, London.

Mayr, E. and Ashlock, P.D. (1991). Principles of Systematic Zoology. 2nd Edition. McGraw-Hill.

Meglitsch, P.A. and Schram, F.R. (1991). Invertebrate Zoology. Oxford University Press.

Parker, T.J. and Haswell, W. (1972). Textbook of Zoology, Volume I. Macmillan Press, London.

Pechenik, J.A. (2015). Biology of the Invertebrates, 7th Edition. McGraw-Hill.

Quicke, D.A.J. (1993). Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional.

Ruppert, E.E., Fox, R. and Barnes, R.D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. 7th Edition. Brooks Cole.

Sinha, K.S., Adhikari, S. and Ganguly, B.B. (1977). Biology of Animals. Vol. I. 3rd Edition. New Central Book Agency. Kolkata.

Verma, A. (2015). Principles of Animal Taxonomy. Narosa Publishing House Pvt. Ltd., New Delhi.

Practical components

Full marks: 20

1. Spot identification of Protozoa: *Amoeba, Euglena,* and *Paramoecium*
2. Spot identification of Porifera: *Sycon* and *Cliona*
3. Spot identification of Cnidaria: *Obelia, Pennatula,* and *Fungia*
4. Spot identification and significance of adult *Taenia solium* (Platyhelminthes) and *Ascaris lumbricoide*s (Nematoda)
5. Spot identification of the following specimens:
   Annelida: *Nereis, Pheretima* and *Hirudinaria*
   Arthropoda: *Balanus, Peneaus, Scylla* (Crab), *Carcinoscorpius*, *Anoplodesmus*, *Scolopendra, Periplaneta, Apis, Bombyx*, *Anopheles*, and *Culex*
   Mollusca: *Pila, Lamellidens, Chiton, Sepia,* and *Octopus*
   Echinodermata: *Asterias, Antedon, Ophiura, Echinus*, and *Holothuria*
   Hemichordata: *Balanoglossus*
6. Anatomy: Digestive system, and Central nervous system of *Periplaneta americana*
7. Mounting of the following specimens: Mouthparts of cockroach; head of adult mosquitoes

Examination pattern

Full Marks: 20

1. Anatomy (from item No. 6) anyone	(5×1) =5
2. Spot identification (any three from item nos. 1–5)	(3×2) =6
3. Temporary mounting from item no. 6 (any one)	(4×1) =4
4. Laboratory notebook	2
5. Viva voce	3

Suggested readings

Chatterjee, S. and Chakraborty, S. (2017). Practical Zoology. Nirmala Library, Kolkata.

Ghosh, K.C. and Manna, B. (2015). Practical Zoology. New Central Book Agency, Kolkata.

Lal, S.S. (2019). Practical Zoology Invertebrate. 12th Edition. Rastogi Publications, Meerut.

Sinha, J.K., Chatterjee, A.K. and Chattopadhyay, P. (2014). Advanced Practical Zoology. 3rd Edition. Books & Allied Ltd, Kolkata.

Verma, P.S. (2018). A Manual of Practical Zoology Invertebrates. S. Chand Publishing, New Delhi.

Course outcomes

At the end of the course, students learn the systematics and biology of non-chordates through their adaptive features and their body organisation.
They comprehend the identification of species and their evolutionary relationships.

MINOR COURSE

ZOOL1021: Non-Chordates

Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

The main objective of this syllabus is to introduce students to the diversity of animals (invertebrates) in the universe, emphasising their taxonomic position within the animal kingdom, as well as their physiology and organ systems.

Sl No.	Topics	Lectures (45)
1	**Unit 1: Basics of Animal Classification** Definition: Taxonomy, Systematics, and Classification Species concept: Typological, Biological, and Evolutionary Important rules of Zoological Nomenclature (ICZN): Principles of: Priority, Synonymy, Homonymy and Typification Linnaean hierarchy, Taxon, Phenon, and Category	06
2	**Unit 2: Protista and Metazoa** **Protozoa:** General characteristics and schematic classification up to phyla (Levine et al., 1980); locomotion in *Amoeba*, Conjugation in *Paramoecium* **Metazoa:** Evolution of symmetry and metamerism	03
3	**Unit 3: Porifera** General characteristics and schematic classification up to order (Hyman, 1940) Canal system and spicules of sponges	03
4	**Unit 4: Cnidaria** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994); Metagenesis of *Obelia*; Coral reef: Types and formation	04
5	**Unit 5: Ctenophora** General characteristics only	01
6	**Unit 6: Platyhelminthes** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994)	02
7	**Unit 7: Nematoda** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994)	02
8	**Unit 8: Annelida** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994); Nephridia: Structure and function	04

9	**Unit 9: Arthropoda** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994); Eyes in Insects; Metamorphosis: Types, chemistry, and source of hormones	05
10	**Unit 10: Onychophora** General characteristics Evolutionary significance	02
11	**Unit 11: Mollusca** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994); modification of foot; nervous system and torsion in Gastropods	05
12	**Unit 12: Echinodermata** General characteristics and schematic classification up to class (Ruppert and Barnes, 1994); Water vascular system of *Asterias*; structure of tube feet; Larval forms in Echinodermata	05
13	**Unit 13: Hemichordata** General characteristics Affinities of *Balanoglossus* with echinoderms and chordates	03

Suggested readings

Anderson, D.T. (Ed.) (2001). Invertebrate Zoology. 2nd Edition. Oxford University.

Barnes, R.D. and Ruppert, E.E. (1994). Invertebrate Zoology. 6th Edition. Brooks Cole.

Barrington, E.J.W. (1981). Invertebrate Structure and Function. 2nd Edition. ELBS and Nelson.

Brusca, R.C. and Brusca, G.J. (2002). Invertebrates. 4th Edition. Sinauer Associates.

Chaki, K.K., Kundu, G. and Sarkar, S. (2011). Introduction to General Zoology. 4th Revised Edition. Vol 1. New Central Book Agency (P) Ltd.

Dhami, S. and Dhami, J.K. (2021). Invertebrate Zoology. 5th Edition. S. Chand and Co.

Hickman, C.P. Jr., Hickman, F.M. and Roberts, L.S. (2016). Integrated Principles of Zoology. 17th Edition. Times Mirror/Mosby College Publication. St. Louis.

Hyman, L.H. (1940). The Invertebrates (Vol-I). McGraw-Hill Book Company.

International Commission on Zoological Nomenclature (1999). International Code of Zoological Nomenclature. 4th Edition. The International Trust for Zoological Nomenclature, London.

Jordan, E.L. and Verma, P.S. (2009). Invertebrate Zoology. 5th Edition. S. Chand and Company Ltd., New Delhi.

Kapoor, V.C. (2008). Theory and Practice of Animal Taxonomy. 6th Edition. Oxford and IBH Publication.

Kotpal, R.L. (1988–1992). (All Series) Protozoa, Porifera, Coelenterata, Annelida, Arthropoda, Mollusca, Echinodermata. Rastogi Publications, Meerut.

Mayr, E. and Ashlock, P.D. (1991). Principles of Systematic Zoology. 2nd Edition. McGraw-Hill.

Meglitsch, P.A. and Schram, F.R. (1991). Invertebrate Zoology. Oxford University Press.

Parker, T.J. and Haswell, W. (1972). Textbook of Zoology, Volume I. Macmillan Press, London.

Pechenik, J.A. (2015). Biology of the Invertebrates, 7th Edition. McGraw-Hill.

Ruppert, E.E., Fox, R. and Barnes, R.D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. 7th Edition. Brooks Cole.

Practical components

Full marks: 20

1. Spot identification: Either from museum specimen or from photograph

   Group I: *Amoeba, Euglena, Paramecium, Sycon, Obelia, Physalia, Aurelia, Taenia solium, Ascaris lumbricoides, Nereis, Pheretima*, and *Hirudinaria*

   Group II: *Macrobrachium, Squilla, Carcinoscorpius, Trigoniulus, Chiton, Patella, Loligo, Sepia, Asterias, Ophiura, Echinus*, and *Balanoglossus*

2. Anatomy: Digestive and nervous system of cockroach
3. Mounting: Mouthparts of cockroach
4. Temporary staining and mounting of any zooplankton

Examination Pattern

Full Marks: 20

1. Anatomy from item no. 2	5
2. Spot identification (any three from item no. 1)	(3×2) =6
3. Mounting (one from item nos. 3 or 4)	4
4. Laboratory notebook	2
5. Viva voce	3

Suggested readings

Chatterjee, S. and Chakraborty, S. (2017). Practical Zoology. Nirmala Library, Kolkata.

Ghosh, K.C. and Manna, B. (2015). Practical Zoology. New Central Book Agency, Kolkata.

Sinha, J.K., Chatterjee, A.K. and Chattopadhyay, P. (2014). Advanced Practical Zoology. 3rd Edition. Books & Allied Ltd., Kolkata.

Course outcomes

At the end of the course, students will learn about the systematics, evolution and biology of non-chordates through their adaptive features and body organisation and comprehend the identification of species and their evolutionary relationships.

INTER/MULTI DISCIPLINARY

ZOOL1031: Introduction to Animalia

Credits – 3 (Theory: 2, Tutorial: 1)

Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

The specific learning goal for a general zoological overview of the animal world is to provide students with a working knowledge of fundamental concepts that will help in further understanding of the course curriculum for further advanced studies, interests and work.

This basic course introduces students to animal classification systems and their associated taxonomic group diagnostic features.

This will also help in developing and understanding and ability to apply basic zoological principles.

Sl No.	Topics	Classes (45)
1	**Unit 1:** Brief idea about the Kingdom Animalia; general characters Basic features of Kingdom Protista up to Phyla	02
2	**Unit 2:** Outline classification and general basic characters of Phyla Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Arthropoda, Mollusca and Echinodermata up to Class	16
3	**Unit 3:** General features of classes Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves and Mammalia	12
4	**Unit 4:** Life cycle of butterfly and toad	02
5	**Unit 5:** Basic and brief idea about ecosystem, population, community, habits and habitats; types of adaptations (Aquatic, volant, and desert)	05
6	**Unit 6:** Overview of different interactions among animals like competition and predation Commensalism, parasitism, mutualism, symbiosis, and amensalism with examples	08

Practical components

Full Marks: 10

Internal assessment of 10 marks in case of Multi-/Interdisciplinary will be based on the practical portion of the course concerned.

Examination pattern

1.	Visit to any zoological garden or museum	3
2.	Preparation and submission of a project report of the visit	4
3.	Viva voce	3

SKILL ENHANCEMENT COURSE

ZOOL1051: Apiculture

Credits – 3 (Theory: 2, Tutorial: 1)

Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

The objective of this course is to know the basic concepts of beekeeping by undergraduate students, and beginners. Students will get knowledge about different bees, culture techniques, honey harvesting, and knowledge diseases enemies of honey bees. The knowledge gained by the students can be utilised in the field or even to start their own enterprise after completion of the course.

Sl No.	Topics	Lectures (45)
1	**Unit 1:** History and importance of apiculture; the systematic position of bees; different species of common honey bees and their description	05
2	**Unit 2:** Life cycle of the honeybee; general morphology and different castes of honeybees; emphasis on mouth parts; non-*Apis* bee species	06
3	**Unit 3:** Structure of different beehives or honeycomb; colonial organisation; bee language and communications	04
4	**Unit 4:** Methods of keeping: Indigenous methods and their disadvantages	03
5	**Unit 5:** Apiary: Selection of good apiary site; selection of good bee	03
6	**Unit 6:** Modern methods of Apiculture: Discovery of the movable hive; Langstroth and Newton hive; description of modern movable beehive; accessory equipment used in beekeeping industry Extraction of honey; important points regarding the handling of bees	06
7	**Unit 7:** Products of Apiculture: Honey, wax, etc., chemical compositions; uses; other products like propolis, royal jelly, apitoxin, etc.	04
8	**Unit 8:** Diseases and enemies: Parasitic diseases, colony collapse disorder, other enemies	04
9	**Unit 9:** Types of beekeeping, economics: Stationary and migratory; Economics of beekeeping, position of this industry from the Indian perspective	05
10	**Unit 10:** Entrepreneurship in Apiculture: Beekeeping as a source of employment and livelihood; the role of Khadi and Village Industries Commission (KVIC) for beekeeping in India; proposal preparation for funding	05

Suggested readings

Ahsan, J. and Sinha, S.P. (2010). Handbook of Economic Zoology. S. Chand & Company Ltd.

Belsare, D.K., Singh, R.K., Belsare, S.D. and Deshmukh, R.H. (2019). Textbook of Apiculture (Beekeeping). Himalaya Publishing House.

Crane, E.E. (1999). The World History of Beekeeping and Honey Hunting. Taylor & Francis.

Gupta, S.A. (2024). A Textbook of Apiculture. Write and Print Publications, New Delhi.

Himadri, P. (2015). The Complete Book on Beekeeping and Honey Processing. 2nd Edition. NIIR Project Consultancy Services, New Delhi.

Howland, B. (2020). Bee Keeping for Dummies. 5th Edition. John Wiley and Sons.

Jayashree, K.V., Tharadevi, C.S. and Arumugam, N. (2014). Saras Apiculture. Saras Publication.

Khan, M.S. and Srivastava, P. (2011). Honey Bee Enemies and their Management. Published by Project Coordinating Unit, AICRP (HB & P) CCS HAU, Hisar.

National Bee Board. Pests and Diseases of Honeybees and their Management. Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India. NBB Bulletin, New Delhi. P. 30.

Rahaman, A. (2018). Apiculture in India. ICAR, Govt. of India.

Raj, H. (2020). Vinesh Text Book of Apiculture (Skill Enhancement Course) For B.Sc. (2nd Year H.P.U) (Jammu Univ. & G.C.W. Parade Sem. III). S. Vinesh & Co.

Ritter, W. (2006). Honey Bee Diseases and Pests: A Practical Guide. FAO. Rome, Italy. P.33.

Singh, S. (1962). Beekeeping in India. ICAR, Govt. of India.

Shukla, G.S. and Upadhyay, V.B. (2005). Economic Zoology. Rastogi Publication.

Practical components

Full Marks: 10

Internal Assessment of 10 marks in case of SEC will be based on the practical portion of the course concerned.

Examination pattern

1. Visit a Farm/Lab	04
2. Submit a report	03
3. Viva voce	03

Course outcomes

1. Get complete knowledge of honeybees and their different casts.
2. Get knowledge about artificial beehive and their uses for apiculture.
3. To know about different diseases on enemies of honeybees.
4. Able to know the techniques of honey extraction and handling of honeybees.
5. Get a brief idea about entrepreneurship in Apiculture.

OR

ZOOL1051: Vermiculture

Credits – 3 (Theory: 2, Tutorial: 1)

Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

Vermiculture is the study of commercial applications that utilise earthworms for degrading organic waste materials for sanitation and agricultural reuse. Earthworms degrade organic waste materials and convert them into vermicompost. The main objective of this course is to provide the students with knowledge of vermicomposting and its application in agriculture as well as entrepreneurship.

Sl No.	Topics	Lectures (45)
1	**Unit 1:** Earthworm morphology and anatomy: Taxonomic position, external features, internal anatomy	05
2	**Unit 2:** Habitat ecology and reproduction: Burrowers, casts, nocturnal, poikilothermic, ecological grouping: Epigeic, endogeic and anecic	05
3	**Unit 3:** Description of some important earthworm species: *Eisenia fetida*, *Eudrilus eugeniae*, and *Lumbricus rubellus*	05
4	**Unit 4:** Importance of earthworm in agriculture: Role in fertility of soil	05
5	**Unit 5:** Vermitechnology and vermiculture: Definition, history in different countries and India	05
6	**Unit 6:** Vermiculture: Methods, wormery, breeding technique, indoor and outdoor culture, mono-and polyculture, merits and demerits	07
7	**Unit 7:** Vermi composting of wastes: Different Methods, storage Vermi wash: Preparation and application	04
8	**Unit 8:** Diseases and predators/pathogen of earthworm Maintenance wormeries	04
9	**Unit 9:** Marketing and future perspective: Marketing of products of vermiculture, quality control, marketing techniques, demand study, advertisement, packing and transport, and financial support	05

Suggested readings

Bhatnagar, R.K. and Palta, R.K. (1996). Earthworms: Vermiculture and. Vermicomposting. Kalyani Publishers, New Delhi.

Edwards, C.A. and Bohlen, P.J. (1996). Biology and Ecology of Earthworms. 3rd Edition. Chapman & Hall. London.

Ismail, S.A. (2009). The Earthworm Book. 2nd Edition. Other India Press.

Lekshmy, M.S. and Santhi, R. (2012). Vermitechnology. Saras Publication.

Lee, K.E. (1985). Earthworm: Their ecology and relationship with soil and land use. Academic Press, Sydney.

Singh, K. (2014). A Textbook of Vermicompost, Vermiwash, and Biopesticides. Publisher-Biotech, marketed by Meripustak.

National Institute of Industrial Research (2010). The Complete Technology Book on Vermiculture and Vermicompost. NIIR, Delhi.

Practical components

Full Marks: 10

Internal Assessment of 10 marks in case of SEC will be based on the practical portion of the course concerned.

Examination pattern

1. Visit a Farm/Lab	04
2. Submit a report	03
3. Viva voce	03

Course outcomes

1. The Course has a broad scope foremployability
2. Students will gather knowledge on soil earthworms; their characteristic features, occurrence, and their role on soil fertility and solid waste management
3. Students will gather knowledge on vermicomposting technology in respect of the global level as well as the Indian perspective
4. Application of vermiculture products and their benefits in agriculture practice

SEMESTER – II

MAJOR COURSES

ZOOL2011: Chordates

Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

This course is designed to give a fundamental understanding of the diversity of phylum Chordata with emphasis on their origin, key characteristics, classification, distribution, and function. This course will enlighten students on the concepts of diversity, organisation, adaptation, and taxonomic status of chordates. The course will give an understanding of the systemic physiology of chordates.

Sl No.	Topics	Lectures (45)
1	**Unit 1: Origin of Chordata** Theories of Chordate origin Affinities with echinoderms and hemichordates (Deuterostome links)	03
2	**Unit 2: Introduction to Chordates** General characteristics of Phylum Chordata Subphyla under Chordata and their general features Classification of subphylum Urochordata up to class (Young, 1981) Advanced features of vertebrates over Protochordates Overview of Classification of subphylum Vertebrata up to class (Young, 1981) Retrogressive Metamorphosis in *Ascidia* Feeding Mechanism in *Branchiostoma*	06
3	**Unit 3: Agnatha** General characteristics and classification of Agnatha up to extant suborders (Young, 1981)	02
4	**Unit 4: Pisces** General characteristics and classification of Classes Chondrichthyes and Osteichthyes up to subclasses (Romer, 1959) Dipnoi: Anatomical peculiarities, distribution and significance Osmoregulation and parental care	05
5	**Unit 5: Amphibia** General characteristics and classification up to extant orders (Duellman and Trueb, 1986) Metamorphosis: Stages, anatomical and physiological changes, hormonal control Parental care	05

6	**Unit 6: Reptilia** General characteristics and classification up to living orders (Young, 1981) General features of poisonous and non-poisonous snakes Poison apparatus (types of fangs), chemical nature of venom, and biting mechanism in snakes	06
7	**Unit 7: Aves** General characteristics and classification up to living subclass (Young, 1981) Exoskeleton Principles and aerodynamics of flight Migration: Types, reasons, mechanisms, navigation, patterns and routes	06
8	**Unit 8: Mammalia** General characteristics and classification up to living orders (Young, 1981) Affinities of Prototheria Exoskeletal derivatives of mammals Echolocation in bats and whales Adaptive radiation in mammals with reference to locomotory Organs	07
9	**Unit 9: Functional Anatomy** Fish: Gill structure (basic) and mechanism of respiration, accessory respiratory organs, swim bladder Bird: Respiratory structures and functions Anamniotes and Amniotes: Kidney structure and function Bovine ruminant stomach: Special digestive structure and function	05

Suggested reading

Arora, M.P. (2024). Chordata I. Himalaya Publishing House Pvt. Ltd.

Chatterjee, A. and Chakraborty, C.S. (2017). Approach to a Text Book of Zoology. Nirmala Library, Kolkata.

Hildebrand, M. (1974). Analysis of Vertebrate Structure, 5th Edition. Wiley Publication.

Jordan, E.L. and Verma, P.S. (2006). Invertebrate Zoology and Chordate Zoology. S. Chand and Company Ltd. New Delhi.

Kardong, K.V. (2002). Vertebrates: Comparative Anatomy, Function, Evolution. Tata McGraw-Hill.

Kent, G.C. and Carr, R.K. (2001). Comparative Anatomy of the Vertebrates. 9th Edition. McGraw-Hill.

Khanna, S.S. and Kapoor, N. (2019). An Introduction to Fish Biology and Fisheries. Surjeet Publications, Delhi.

Kotpal, R.L. (1988-1992). (All Series) Pisces, Amphibia, Reptilia, Aves, Mammalia. Rastogi Publications.

Linzey, D.W. (2020). Vertebrate Biology. Johns Hopkins University Press, Baltimore.

Mandal, F.B. (2013). Vertebrate Zoology. Oxford & IBH Publishing Co Pvt. Ltd., Delhi.

Pandey, K. and Shukla, J.P. (2021). Fish and Fisheries. Rastogi Publications, Meerut, Uttar Pradesh.

Parker, T. J. and Haswell, W. A. (1967). A Textbook of Zoology. Volume-II. MacMillan & Company Ltd., London.

Pough, F.H., Janis, C.M. and Heiser, J.B. (2009). Vertebrate life. 8th Edition. San Francisco: Benjamin Cummings.

Romer, A.S. and Parsons, T.S. (1986). The Vertebrate Body. 6th Edition. Saunders College Publication.

Saxena, R.A. and Saxena, S. (2019). Comparative Anatomy in Vertebrates. 2nd Edition. Viva Publication.

Sinha, K.S., Adhikari, S., Ganguly, B.B. and Bharati Goswami, B. (2012). Biology of Animals. Vol. II. 7th Edition. New Central Book Agency. Kolkata.
Srivastava, C.B.L. (2008). Fish Biology. Narendra Publishing House, Delhi.
Webb, J.E., Wallwork, J.A. and Elgood, J.H. (1981). Guide to Living Fishes. Red Globe Press, London.
Young, J.Z. (1981). The Life of Vertebrates. 3rd Edition. Oxford University Press.

Practical components

Full Marks: 20

1. Spot Identification of:

- Protochordate: *Balanoglossus,* and *Branchiostoma*
- Agnatha: *Petromyzon*, and *Myxine*
- Fish: *Scoliodon, Sphyrna, Pristis, Torpedo, Labeo bata, Labeo rohita, Catla catla, Cirrhinus mrigala, Puntius, Amblypharyngodon, Anabas testudineus, Ctenopharyngodon idella, Heteropneustes fossilis, Clarias batrachus, Exocetus,* and *Echenis*
- Amphibia*: Necturus, Duttaphrynus, Hyla,* Axolotl larva, and *Tylototriton*
- Reptilia: *Chelone, Varanus, Mabuya, Draco, Daboia, Ptyas, Naja, Bungarus,* and *Hydrophis*
- Aves: *Pycnonotus, Psittacula*, and *Halcyon*
- Mammalia: *Pipistrellus* and *Funumbulus*

2. Temporary staining and mounting of cycloid and ctenoid scales
3. Identification of poisonous and. non-poisonous snakes
4. Anatomy: Brain, Pituitary gland and Afferent branchial arterial system of carp; Pecten of fowl
5. Fish market survey to study different fish species and preparation of a survey report

Examination pattern

1. Anatomy from item no. 4	05
2. Spot identification (any three from item no. 1)	(3×2) =06
3. Staining and Mounting (one from item no. 2)	02
4. Laboratory notebook	02
5. Submit survey report	02
6. Viva voce	03

Suggested readings

Chatterjee, S. and Chakraborty, S. (2017). Practical Zoology. Nirmala Library, Kolkata.
Ghosh, K.C. and Manna, B. (2015). Practical Zoology. New Central Book Agency, Kolkata.
Sinha, J.K., Chatterjee, A.K. and Chattopadhyay, P. (2014). Advanced Practical Zoology. 3rd Edition. Books & Allied Ltd, Kolkata.
Misra, K.S. (2003). An aid to the identification of the common commercial fishes of India and Pakistan. Narendra Publishing House, Delhi.

Course outcomes

Key course outcomes include understanding the classification, evolutionary relationships, and adaptations of chordates, as well as the structure and function of their various organ systems.

MINOR COURSES

ZOOL2021: Chordates

Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

This course is designed to help the students gain a fundamental understanding of the diversity of phylum Chordata with emphasis on their origin, key characteristics, classification, distribution and functioning. This course will enlighten the students with the concept of diversity, organisation, adaptation and taxonomic status of Chordates. The course will give an understanding of the systemic physiology of chordates. There will be a discussion about the affinities of chordates to different groups.

Sl No.	Topics	Lectures (45)
1	**Unit 1: Origin of Chordata** Theories of Chordate origin Affinities with echinoderms and hemichordates (Deuterostome links)	02
2	**Unit 2: Introduction to Chordates** General characteristics of Phylum Chordata Subphyla under Chordata and their general features Classification of subphylum Urochordata up to class (Young, 1981) Advanced features of vertebrates over Protochordates Overview of Classification of subphylum Vertebrata up to class (Young, 1981) Retrogressive Metamorphosis in *Ascidia* Feeding Mechanism in *Branchiostoma*	08
3	**Unit 3: Agnatha** General characteristics and classification of Cyclostomata up to extant suborders (Young, 1981)	02
4	**Unit 4: Pisces** General characteristics and classification of Classes Chondrichthyes and Osteichthyes up to subclasses (Romer, 1959) Gill structure (basic) and mechanism of respiration, swim bladder, accessory respiratory organs Osmoregulation and parental care	07
5	**Unit 5: Amphibia** General characteristics and classification up to living orders (Duellman and Trueb, 1986) Metamorphosis: Stages, anatomical and physiological changes, hormonal control Parental care	06
6	**Unit 6: Reptilia** General characteristics and classification up to living orders (Young, 1981) General features of poisonous and non-poisonous snakes Poison apparatus (types of fangs), chemical nature of venom, and biting mechanism in snakes	07
7	**Unit 7: Aves** General characteristics and classification up to living orders (Young, 1981) Exoskeleton Principles and aerodynamics of flight	06

	Migration: Types, reasons, mechanisms, navigation, patterns and routes	
8	**Unit 8: Mammalia** General characteristics and classification up to living orders (Young, 1981) Affinities of Prototheria Exoskeletal derivatives of Mammals Echolocation in Bats and Whales Adaptive radiation in mammals with reference to locomotory organs	07

Suggested reading

Arora, M.P. (2024). Chordata I. Himalaya Publishing House Pvt. Ltd.

Chatterjee, A. and Chakraborty, C.S. (2017). Approach to a Text Book of Zoology. Nirmala Library, Kolkata.

Hildebrand, M. (1974). Analysis of Vertebrate Structure. 5th Edition. Wiley Publication.

Jordan, E.L. and Verma, P.S. (2006). Invertebrate Zoology and Chordate Zoology. S. Chand and Company Ltd. New Delhi.

Kardong, K.V. (2002). Vertebrates: Comparative Anatomy, Function, Evolution. Tata McGraw-Hill.

Kotpal, R.L. (1988-1992). (All Series) Pisces, Amphibia, Reptilia, Aves, Mammalia.

Romer, A.S. and Parsons, T.S. (1986). The Vertebrate Body. 6th Edition. Saunders College Publication.

Saxena, R.A. and Saxena, S. (2019). Comparative Anatomy in Vertebrates. 2nd Edition Viva Publication.

Sinha, K.S., Adhikari, S., Ganguly, B.B. and Bharati Goswami, B. (2012). Biology of Animals. Vol. II. 7th Edition. New Central Book Agency. Kolkata.

Young, J.Z. (1981). The Life of Vertebrates. 3rd Edition. Oxford University Press.

Practical components

Full Marks: 20

1. Spot Identification: Either from museum specimen or photograph

   Group I: *Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo, Catla, Cirrhinus, Labeo, Parexocoetus, Tylototriton, Duttaphrynus, Polypedates*

   Group II: *Lissemys, Chamaeleo, Draco, Daboia, Lycodon, Ptyas, Naja, Passer, Psittacula, Alcedo, Pteropus, Funambulus, Suncus*

2. Temporary staining and mounting of cycloid and ctenoid scales
3. Fish market survey to study different fish species and preparation of a survey report
4. Anatomy: Afferent branchial arterial system of carp; Pecten of fowl

Examination pattern

1.Anatomy from item no. 4	05
2.Spot identification (any three from item no. 1)	(3×2) =06
3.Staining and mounting	02
4.Laboratory notebook	02
5.Submit survey report	02
6.Viva voce	03

Suggested readings

Chatterjee, S. and Chakraborty, S. (2017). Practical Zoology. Nirmala Library, Kolkata.

Ghosh, K.C. and Manna, B. (2015): Practical Zoology. New Central Book Agency, Kolkata.

Misra, K.S. (2003). An aid to the identification of the common commercial fishes of India and Pakistan. Narendra Publishing House, Delhi.

Course outcomes

Key course outcomes include understanding the classification, evolutionary relationships, and adaptations of chordates, as well as the structure and function of their various organ systems.

INTER/MULTI DISCIPLINARY

ZOOL2031: Applied Zoology I

Credits – 3 (Theory: 2, Tutorial: 1)

Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

The primary objectives of studying sericulture and apiculture under applied zoology are to understand and utilise these practices for economic benefit, focusing on the production of silk and honey, respectively, and their related products. This involves learning about the biology, rearing techniques, and management of silkworms and honeybees, as well as the processing and marketing of their yields.

Sl No.	Topics	Lectures (45)
1	**Unit 1: Sericulture** History and present status of sericulture in India and West Bengal Mulberry and non-mulberry species in India Mulberry cultivation Morphology and life cycle of *Bombyx mori* Silkworm rearing techniques: Processing of cocoon, reeling Silkworm diseases, pests, parasitoids and their control	22
2	**Unit 2: Apiculture** Introduction and present status of apiculture in West Bengal Species of honeybees in India, life cycle of *Apis indica* Colony organisation, division of labour and communication Beekeeping as an agro-based industry Methods and equipment: Indigenous methods, extraction appliances, extraction of honey from the comb and processing Bee pasturage, honey and beeswax and their uses Pests and diseases of bees and their management	23

Suggested readings

Bairagi, K.N. (2014). Animal Disease. Anmol Publications Pvt. Ltd.

Cherian, M.C. and Ramachandran, S. (1952). Bee-keeping in South India. Government Press, Madras.

Eikichi, H. (1999). Silkworm Breeding (Translated from Japanese). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Ganga, G. (2003). Comprehensive Sericulture, Vol-II: Silkworm Rearing and Silk Reeling. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Jabde, P.V. (2008). Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac Culture. Discovery Publishing House.

Mahadevappa, D., Halliyal, V.G., Shankar, D.G. and Bhandiwad, R. (2000). Mulberry Silk Reeling Technology. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Roger, M. (1990). The ABC and XYZ of Bee Culture: An Encyclopedia of Beekeeping. Kindle Edition.

Sathe, T.V. (2004). Vermiculture and Organic farming. Daya Publishing House.

Shukla, G.S. and Upadhyay, V.B. (2002). Economic Zoology. Rastogi Publishers.

SWAYAM. Applied and Economic Zoology. webhttps://swayam.gov.in/nd2_cec20_ge23/preview

Yadav, M. (2003). Economic Zoology. Discovery Publishing House.

Practical components

Full Marks: 10

Internal Assessment of 10 marks in case of Multi-/Interdisciplinary will be based on Practical Portion of the course concerned.

1.	Visit a Farm/Lab	04
2.	Submit a report	03
3.	Viva voce	03

Course outcomes

1. Comprehensive knowledge of different aspects of Applied Zoology.
2. Understanding of culture processes and rearing of different economically important animals.
3. To know about different diseases those are enemies of economically important animals.
4. Get a brief idea about the advantages and limitations of different economically important animals.

SKILL ENHANCEMENT COURSE

ZOOL2051: Sericulture
Credits – 3 (Theory: 2, Tutorial: 1)
Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

The syllabus for Sericulture at the undergraduate level, aligned with NEP, has been developed. The primary aim of creating this new syllabus is to provide students with a solid understanding of sericulture. Students will gain knowledge about mulberry plant cultivation, various silkworm species, cultivation techniques, silk production, and the diseases and pests of silkworms. They can apply this knowledge to start their enterprise after completing the course.

Sl No.	Topics	Lectures (45)
1	**Unit 1:** History of sericulture; the systematic position of silk moths; different species of silk moths, their description	05
2	**Unit 2:** Biology of mulberry plants: Description of mulberry; salient features of family Moraceae; Phytogeography of the genus *Morus* and its species Morphology and anatomy of mulberry plant; different cultivars of mulberry; floral biology of mulberry: structure of male and female flowers, catkins	06
3	**Unit 3:** Mulberry cultivation: Processes of cultivation, irrigation process, application of both inorganic and organic fertilizers Diseases of mulberry plant leaf: Leaf spot, powdery mildew, leaf rust, leaf blight Diseases of mulberry root: Root rot disease, root knot disease Pest management of mulberry plants, major and minor pests: name, infestation, prevention, and control	06
4	**Unit 4:** Silkworm morphology: Egg, larva, pupa, and adult of *Bombyx mori* Anatomy of *Bombyx mori*: Digestive System: Larva; Reproductive System: Adult; Silk gland: Larva	04
5	**Unit 5:** Silkworm Diseases of *Bombyx mori*: Protozoan disease, bacterial disease, fungal disease, viral disease, sotto Silkworm pests of *Bombyx mori*: Uzi fly, ants, dermestid beetles	04
6	**Unit 6:** Mulberry silkworm rearing: Model rearing house, rearing appliances, disinfection, disinfectants, bed cleaning, feeding of worms Rearing: Techniques of rearing of different stages of larvae	05
7	**Unit 7:** Harvesting of cocoon: Sex determination of cocoon, harvesting of cocoon	03

8	**Unit 8:** Post cocoon and silk collection technology: Cocoon Stifling (sun drying, steam stifling, hot air stifling) and storage Deflossing, cocoon riddling, mixing or blending, cocoon cooking, brushing Types of reeling machines, reeling operation, reeling end formation, degumming, bleaching, dyeing silk yarn Twisting, Reeling, Re-reeling, lacing, skinning and testing of raw silk material Weaving of silk	08
9	**Unit 9:** Entrepreneurship sericulture: Sericulture source of employment and livelihood; the role of CSB in supporting and guiding entrepreneurship	04

Suggested readings

Choudhury, P.C. (1997). Mulberry cultivation, CSRTI, Mysore. Cultivation Technology for Chawki Mulberry Garden.

Choudhury, P.C. (1972). Handbook of Silkworm Rearing. Agriculture Technique Manual 1, CSRTI, Mysore, Tokyo, Japan, Fuji Publishing Co. Ltd.

CSRTI (1996). Sericulture: New technologies, Mysore.

Charsley, S.R. (1982). Culture and Sericulture. Academic Press Inc., New York, U.S.A.

Dandin, S.B. and Giridhar, K. (2010). Handbook of Sericulture Technologies. Central Silk Board, Bangalore, India.

FAO. (1988). Mulberry Cultivation. FAO Agricultural Services Bulletin No.73/1. Rome. 127pp.

Ganga, G. and Sulochana Chetty, J. (1991). An Introduction to Sericulture. Oxford and IBH Publishing.

Jayaram, H. (2005). Mulberry Cultivation and Physiology. Central Silk Board, Bangalore.

Govindan, R., Ramakrishna, N. and Sannappa, B. (2004). Advances in Disease and Pest Management in Sericulture. Seri Scientific Publishers, Bangalore.

Jolly, M.S., Chowdhury, S.N. and Sen, S.K. (1975). Non-mulberry Sericulture in India. Central Silk Board, Bombay, India.

Nataraju, B., Sathya Prasad, K., Manjunath, D. and Aswani, K.C. (2005). Silkworm Crop Protection. Central Silk Board, Bangalore, India.

Website of CSB: https://silks.csb.gov.in/una/wp-ontent/themes/Common_District/una/sgf-frame.html

Practical components

Full Marks: 10

Internal Assessment of 10 marks in case of SEC will be based on Practical Portion of the course concerned.

1. Identification of any one stage of mulberry silkworm with characters 02
2. Visit a sericulture farm and submit report 05
3. Viva voce 03

Course outcomes

1. Get complete knowledge of silkworms and their different types
2. Get knowledge about the technology of silkworm culture and the making of silk
3. To know about different diseases of enemies of silkworms
4. Get a brief idea about entrepreneurship in sericulture

OR

ZOOL2051: Aquarium Fish Keeping
Credits – 3 (Theory: 2, Tutorial: 1)
Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

1. The course will impart basic knowledge of the ornamental fish industry and introduce its scope as a career development avenue for entrepreneurs or aquaculturists
2. Students will be able to know the fundamentals of the aquarium fish industry
3. Students will understand the biological features of aquarium fish
4. Students will get to know the food and feeding habits of aquarium fish
5. Students will become aware of the transportation of fish
6. Students will gain practical experience through exposure to the technology, production, functioning, and operation of an aquarium in ornamental fish farms, hatcheries, and fish feed production plants during study tours or field visits

Sl No.	Topics	Lectures (45)
1	**Unit 1: Overview** The potential scope of aquarium fish industry as cottage industry Exotic and endemic species of aquarium fish	04
2	**Unit 2: Aquaria** Aquarium setup and accessories Types of aquarium filters; types of filtration methods (Mechanical, Chemical and Biological); precautions to be taken for an ideal aquarium Criteria of selection for aquarium fishes	08
3	**Unit 3: Biology of Aquarium Fish** Biology (Breeding, feeding, economic importance, etc.), sexual dimorphism of aquarium fish Freshwater ornamental fishes – Guppy, Goldfish and Angelfish Brackish ornamental fishes – Black Molly, Swordtail and Ray fish Marine ornamental fishes – Anemone fish, Moorish idol, Butterfly fish	08
4	**Unit 4: Food and Feeding of Aquarium Fishes** Use of live fish food organisms (advantages and disadvantages of live food) Preparation and composition of formulated fish feeds Aquarium fish as larval predators	07
5	**Unit 5: Aquarium Fish Diseases** Parasitic, bacterial, viral, protozoan, fungal and deficiency diseases	05
6	**Unit 6: Breeding Habits** Hatching and production of monosex fishes	04
7	**Unit 7: Fish Transportation** Live fish transport Conditioning, packaging and forwarding techniques and quarantine methods Factors associated with live fish transport	03
8	**Unit 9: Maintenance** General Aquarium maintenance; Water quality requirements: Maintenance and Temperature control; Budget for setting up an Aquarium/ornamental fish farm as a Cottage Industry	06

Suggested readings

Bond, C.E. (1996). Biology of Fishes. 2nd Edition. Saunders Publication.

Herbert, R.A. (1998). Aquarium Setting Up (Fish: Keeping and Breeding Them in Captivity). Chelsea House Publications.

Jhingran, V.G. (1982). Fish and Fisheries in India. 3rd Edition. Hindustan Publication Corp, India.

Lowe, H. (2005). Beginner's Guide to Aquarium Fish and Fish Care. Abhishek Press, New Delhi.

Muruganandam, M. (2012). Transport techniques of fish seeds and live fishes to and from watershed ponds. Central Soil & Water Conservation Research & Training Institute, ICAR.

Pandey, K. and Shukla, J.P. (2013). Fish and Fisheries. Rastogi Publication.

Srivastava, C.B.L. (1999). Fish Biology. Narendra Publishing House.

Srivastava, C.B.L. (2002). Aquarium Fish Keeping. Kitab Mahal, Allahabad.

Sandford, G. (1998). The Tropical Freshwater Aquarium Problem Solver: Practical and Expert Advice on Keeping Fish and Plants. Tetra Press.

Practical components

Full Marks: 10

Internal assessment of 10 marks in case of SEC will be based on practical portion of the course concerned.

1. Study of biology (Breeding, feeding, economic importance, etc.) and submission of report of any two species of aquarium fish (Guppy, Molly, Sword tail, Goldfish, Angel fish, Bluemorph, Anemone fish, and Butterfly fish) 04
2. To write a project proposal for setting up a small aquarium fishkeeping as a cottage industry to a funding agency for the self-employment of youths, or for helping poor farmers after visiting a farm/enterprise 03
3. Viva voce 03

Suggested readings

Jain, A.K., Sinha, A. and Saini, V.P. (2021). Policy Issues on Ornamental Fisheries Development in India. Ornamental Fisheries Training and Research Institute, India.

Jayashree, K.V., Tharadevi, C.S. and Arumugam, N. (2015). Home Aquarium and Ornamental Fish Culture. Saras Publication, Periyavilai, Tamil Nadu.

Mahapatra, B.K., Datta, S., Pailan, G.H., Sardar, P., Son, A.R. and Dasgupta, S. (2015). Ornamental Fish breeding, Culture & Trade. ICAR-CIFE, Mumbai.

Saha, S. (2022). Concept of Aquarium Fish Keeping. Techno World, Kolkata.

Swain, S.K., Sarangi, N. and Ayyappan, S. (2010). Ornamental Fish Farming. ICAR, New Delhi.

Course outcomes

1. Know about basic needs to set up an aquarium, i.e., dechlorinated water reflector, filters, scavenger, aquatic plants, etc. and the ways to make it cost-effective.
2. Manage fish diseases.
3. Prepare the proper dosage of different kinds of natural and synthetic fish feed.
4. Develop personal skills in the maintenance of aquarium.
5. Become aware of aquarium as commercial, decorative items and of scientific values.

SEMESTER – III

MAJOR COURSES
ZOOL3011: Biochemistry
Credits – 5 (Theory: 4, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

This study aims to foster enthusiasm among students for Biochemistry, highlighting its importance within the broader context of Zoology. Through this course, learners will develop an understanding of the fundamental chemistry that underpins biological processes, allowing them to independently tackle challenges in both biology and chemistry. The curriculum includes the analysis of molecular structure and function, as well as the many chemical reactions that occur within living cells. It seeks to ignite a sense of curiosity in students, encouraging them to explore the complex mechanisms of various biomolecules and their interconnections. This programme also aims to motivate students to pursue advanced studies in Biochemistry and related interdisciplinary fields, equipping them with the skills necessary for both salaried and entrepreneurial careers.

Sl. No.	Topics	Lectures (60)
1	**Unit 1. Water** Unique properties, weak interactions in aqueous systems, ionization of water, buffers, water as a reactant and fitness of the aqueous environment	03
2	**Unit 2. Carbohydrates** Structure and Biological importance of Carbohydrates: Monosaccharides, Disaccharides, Polysaccharides. Derivatives of monosaccharides. Carbohydrate metabolism: Glycolysis, Citric acid cycle, Pentose phosphate pathway, Gluconeogenesis	10
3	**Unit 3. Protein** General and Electrochemical properties of α-amino acids; Essential and non-essential amino acids and their physiological importance. Structures and classification of proteins. Forces responsible for maintenance of secondary and tertiary structure of protein. Protein metabolism: Transamination, Deamination, Urea cycle	14
4	**Unit 4. Lipid** Structure and significance of lipids: Physiologically important saturated and unsaturated fatty acids, triacylglycerols, phospholipids, sphingolipids, glycolipids, and steroids Lipid metabolism: β-oxidation of fatty acids	10
5	**Unit 5. Nucleic Acid** Structure: Purines, Pyrimidines, Nucleosides, Nucleotides, Nucleic acids. Types of DNA and RNA, Complementarity of DNA, Hypo- and Hyperchromicity of DNA	08
6	**Unit 6. Enzymes** Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes. Mechanism of enzyme action; Enzyme kinetics; Derivation of Michaelis-Menten Equation, Lineweaver-Burk plot; Enzyme inhibition; Allosteric enzymes; Factors affecting rate of enzyme-catalysed reactions	10
7	**Unit 7. Oxidative Phosphorylation** Redox systems; Overview of the mitochondrial respiratory chain, Mitochondrial uncoupling	05

Suggested readings

Berg, J.M., Tymoczko, J.L., Gatto, G.J. Jr. and Stryer, L. (2015). Biochemistry. 8th Edition. W.H. Freeman and Co., New York.

Campbell, M.K., Farrell, S.O. and McDougal, O.M. (2018). Biochemistry. 9th Edition. Cengage.

Chatterjee, M.N. and Shinde, R. (2012). A Textbook on Medical Biochemistry. 8th Edition. Jaypee Publication. New Delhi.

Cox, M.M. and Nelson, D.L. (2008). Leininger's Principles of Biochemistry. 5th Edition. W.H. Freeman and Co., New York.

Das, D. (2022). Biochemistry. Academic Publisher.

Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, 2nd Edition. BIOS Scientific Publishers Ltd., U.K.

Jain, J.L., Jain, M.S., and Jain, N. (2004). Fundamentals of Biochemistry. 7th Edition. S. Chand Publishing. New Delhi.

Kennelly, P.J., Botham, K.M., McGuinness, O.P., Rodwell, V.W. and Weil, P.A. (2023). Harper's Illustrated Biochemistry. 32nd Edition. McGraw-Hill.

Maheswari, N (2008). Clinical Biochemistry. Jaypee Publication. New Delhi.

Pratt, C.W. and Cornely, K. (2017). Essential Biochemistry. 4th Edition. Wiley.

Sathyanarayana, U. and Chakrapani, U. (2007). Biochemistry. 3rd Edition. Books and Allied (P) Ltd, Kolkata.

Voet, D. and Voet, J.G. (2010). Biochemistry. 4th Edition. John Wiley and Sons, Inc.

Zubay, G.L. (1998). Biochemistry. 4th Edition. McGraw-Hill.

Practical components

Full Marks: 10

1. Preparation of phosphate buffer saline (PBS) of pH 7.4 and 8.3
2. Measurement of pH of an unknown solution by pH meter
3. Qualitative tests of functional groups in carbohydrates (Benedict's test), proteins (Biuret test), and lipids (Saponification number)
4. To study the enzymatic activity of salivary amylase
5. Quantitative estimation of protein by Lowry Method
6. Paper chromatography of amino acids (hands-on/virtual)
7. Demonstration of protein sample preparation and separation by SDS-PAGE (hands-on/virtual)

Examination pattern

Full Marks: 20

1. One question from item nos. 1 and 2	(6×1) = 5
2. One question on the quantitative test from item nos. 3	(8×1) = 6
3. One question from item no. 4 and 5	(4×1) = 4
4. Laboratory notebook	2
5. Viva voce	3

Outcome of the course

1. This topic is designed to help learners to understand the objectives of studying Biochemistry.
2. The learner will get a clear concept of the structures and enzymatic reactions of different biomolecules in the living system.
3. Learners will cope with the fast and far-reaching advancement of biological sciences in this century and be able to update themselves with the emerging concept of Biochemistry.
4. Students will develop a deep interest in this subject, which is very important for daily life and also for different competitive examinations.

ZOOL3012: Cell Biology
Credits – 5 (Theory: 4, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

To provide an overview of the different structures involved in cellular organisation, both within and outside the cell; outline knowledge of cell division and signalling; and offer a detailed understanding of key subcellular components involved in the transport of molecules to and from the cell, as well as in the synthesis of various proteins and ATP.

Sl. No.	Topics	Lectures (60)
1	**Unit 1. Plasma Membrane** Membrane Lipids and Proteins. Architecture of plasma membrane based on the Fluid Mosaic Model (Singer and Nicolson, 1972; Nicolson, 2014) Transport across membrane: LDL receptor-mediated endocytosis, simple diffusion (O_2 and CO_2 transport), facilitated diffusion (Glucose transportation, Na^+ and K^+ transportation), primary active transport (Na^+-K^+ anti-transportation), and secondary active transport (Na^+-glucose co-transportation)	12
2	**Unit 2. Cellular Organisation** Extracellular Matrix: Components and Their Role Cytoskeleton: Basic structure and dynamics of actin, microtubule, and lamin; microtubule-associated motor proteins Cell junctions: Occluding junction (tight junction and septate junction), anchoring junction (cell-cell and cell-matrix), and communicating junction (gap junction)	10
3	**Unit 3. Cytoplasmic Organelles – I** Endoplasmic Reticulum: Structure and function (Co-translational translocation of proteins through ER membrane, glycosylation and chaperone-mediated folding of protein) Golgi Apparatus: Structure and functions of individual compartments, vesicular transport and cisternal maturation model of Golgi Lysosome: Structure and functions Protein sorting and mechanisms of vesicular transport	12
4	**Unit 4. Cytoplasmic Organelles – II** Mitochondria: Outline structure, structure of F_oF_1 complex, Mitochondrial respiratory chain, and generation of proton motive force, chemiosmotic and binding-change hypotheses of ATP Synthesis Nucleus: Nuclear pore complex and transportation of mRNA through nuclear pore complex Nucleosome, solenoid, and zigzag model of DNA packaging, nucleolus	10
5	**Unit 5. Cell Division** Cell cycle and its regulation in vertebrates; role of cyclins Mitotic and meiotic cell divisions. Basic process; MTOC and its role in chromosome movement Cancer: Properties of cancer cells in brief	10
6	**Unit 6. Cell Signaling** Overview of cell signaling transduction pathways; Types of signaling molecules and receptors (Classification and examples only) Basic concept of apoptosis, cytological features of an apoptotic cell	06

Suggested readings

Bruce, A., Dennis, B., Levis, J., Martin, R., Keith, R. and Watson, J. (2008). Molecular Biology of the Cell. 5th Edition. Garland Publishing Inc., New York and London.

Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.

Hardin, J., Bertoni, G. and Klein Smith, J.L. (2012). Becker's World of the Cell. 8th Edition. Pearson Benjamin Cummings, San Francisco.

Harvey, L. (2004). Molecular Cell Biology. 5th Edition. W.H. Freeman.

Karp, G. (2008). Cell and Molecular Biology: Concepts and Applications. 5th Edition. John Wiley.

Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Martin, K.C., Michael Yaffe, M. and Amon, A. (2021). Molecular Cell Biology. 9th Edition. W.H. Freeman.

Pal, A. (2011). Textbook of Cell and Molecular Biology 3rd Edition. Boks and Allied, Kolkata.

Plopper, G., Sharp, D. and Siroski, E. (2015). Lewin's Cell. 3rd Edition. Johns and Bartlett Publishers.

Pollard, T.D., Earnshaw, W.C., Lippincott-Schwartz, J. and Johnson, G. (2023). Cell Biology. 4th. Edition. Elsevier.

Reed, J.C. and Green, D.R. (2011). Apoptosis: Physiology and Pathology. Cambridge University Press.

Weinberg, R.A. (2014). Biology of Cancer. 2nd Edition. Garland Science, Taylor, and Franklin.

Practical components

1. Basic idea of light and dark field of microscopy and components of microscopes (demonstration)
2. Preparation of squamous epithelial cell (fixation and staining)
3. Micrometry: Calibration of ocular and stage micrometer and measurement of any cell
4. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
5. Squash preparation of grasshopper testis and study of the various stages of meiosis
6. Study of mitotic index from onion root tip cells

Examination pattern

Full Marks: 20

1. One question on squash preparation from item nos. 4, 5 and 6 ..... (6×1) = 05
2. Preparation of slide/micrometry from item nos. 2 and 3 ..... (4×1) = 04
3. Identification of stages of mitotic and meiotic cell division ..... (2×4) = 06
4. Laboratory notebook 02
5. Viva voce 03

Suggested readings

Chatterjee, S. and Chakraborty, S. (2017). Practical Zoology. Nirmala Library, Kolkata.

Ghosh, K.C. and Manna, B. (2015). Practical Zoology. New Central Book Agency, Kolkata.

Sinha, J.K., Chatterjee, A.K. and Chattopadhyay, P. (2014). Advanced Practical Zoology. 3rd Edition. Books & Allied Ltd, Kolkata.

Outcome of the course

1. The students will learn about the different subcellular components-their structure, function and biochemical properties, organisation at cellular level with respect to extracellular matrix, cytoskeleton, cell junction, cell signaling and cell division.

2.They will also have outline knowledge of cancer cells and apoptosis.

INTER/MULTI DISCIPLINARY

ZOOL3031: Applied Zoology II

Credits – 3 (Theory: 2, Tutorial: 1)

Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

The programme in Applied Zoology concentrates on using combined methods within zoological science. It facilitates the connection of current issues and scientific approaches in managing and protecting natural resources. Students acquire both theoretical and practical knowledge in data collection and analysis. Building on this experience, they will be able to develop advanced procedures and recognise trends in sustainable resource use, while also preventing reduced animal welfare, health deterioration of stocked animals, biological invasions, parasitic diseases, and irreversible resource depletion.

Sl. No.	Topics	Lectures (45)
1	**Unit 1. Fish Culture** Common fish used for culture Fishing crafts and gear Ornamental fish culture: Freshwater ornamental fishes – biology, breeding techniques Construction and maintenance of aquarium: Construction of home aquarium, materials used, setting up of freshwater aquaria, aquarium plants, ornamental objects, cleaning the aquarium, maintenance of water quality; control of snail and algal growth Modern techniques of fish seed production	15
2	**Unit 2. Prawn Culture** Culture of fresh and marine water prawns; preparation of farm Preservation and processing of prawn, and export of prawn	05
3	**Unit 3. Vermiculture** Scope of Vermiculture Types of earthworms Habit categories – epigenic, endogenic and anecic; indigenous and exotic species Methodology of vermicomposting: Containers for culturing, raw materials required, preparation of bed, environmental prerequisites, feeding, harvesting and storage of vermicompost Advantages of vermicomposting Diseases and pests of earthworms	12
4	**Unit 4. Lac Culture** History of lac and its organisation, lac production in India Life cycle, host plants and strains of lac insect Lac cultivation: Local practice, improved practice, propagation of lac insect, inoculation period, harvesting of lac Lac composition, processing, products, uses and their pests	13

Suggested readings

Bairagi, K.N. (2014). Animal Disease. Anmol Publications Pvt. Ltd.

Bard, J. (1986). Handbook of Tropical Aquaculture.

Cherian, M.C. and Ramachandran, S. (1952). Bee-keeping in South India. Government Press, Madras.

Eikichi, H. (1999). Silkworm Breeding (Translated from Japanese). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Ganga, G. (2003). Comprehensive Sericulture, Vol-II: Silkworm Rearing and Silk Reeling. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Jabde, P.V. (2005). Textbook of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac Culture. Discovery Publishing House, New Delhi.

Mahadevappa, D., Halliyal, V.G., Shankar, D.G. and Bhandiwad, R. (2000). Mulberry Silk Reeling Technology, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Parker, R. (2012). Aquaculture Science. 3rd Edition. Delmar, Cengage Learning, USA.

Pillay, T.V.R. and Kutty, M.N. (2005). Aquaculture Principles and Practices. 2nd Edition. Blackwell Publishing Ltd.

Roger, M (1990). The ABC and XYZ of Bee Culture: An Encyclopedia of Beekeeping, Kindle Edition.

Santhanam, R. (1990). A Manual of Aquaculture. Oxford & IBH Publications.

Sathe, T.V. (2004). Vermiculture and Organic Farming. Daya Publishing House.

Shukla, G.S. and Upadhyay, V.B. (2005). Economic Zoology. Rastogi Publication.

Singh, R.K.P (2003). Economics of Aquaculture. Danika Publishing Company.

SWAYAM. Applied and Economic Zoology. web https://swayam.gov.in/nd2_cec20_ge23/preview

Yadav, M. (2003). Economic Zoology. 1st Edition. Discovery Publishing House.

Outcome of the course

Applied Zoology deals with the application of zoological knowledge for the benefit of mankind. It also deals with the animal world that is associated with the economy, health and welfare of humans. So, from the course:

1. Students can understand concepts of fisheries, fishing tools and site selection.
2. Students can understand parasites and epidemiology of parasites in humans and animals, Types of breeds in animal farming and poultry farming, along with their management.
3. Students also become efficient about Aquaculture systems, induced breeding techniques and post-harvesting techniques.

SKILL ENHANCEMENT COURSE

ZOOL3051: Animal Husbandry and Management

Credits – 3 (Theory: 2, Tutorial: 1)

Full Marks. 50 (Theory: 40+ Internal Assessment**: 10)**

Course objectives

The course aims to provide knowledge of Animal Husbandry, including its significance, types, and breeds. Modern systems of rearing and breeding animals have been incorporated so that students will develop interest in this topic and be able to start entrepreneurship, either for regular earnings or for extra income alongside their regular source of income in the future.

Sl. No.	Topics	Lectures (45)
1	**Unit 1. Dairy Science** Overview of dairy science and its importance in agriculture Cattle breeds (Indian and exotic), farming practices for Milch breeds Nutritional components of milk: Proteins, fats, carbohydrates, vitamins, and minerals Benefits of Colostrum: Immunoglobulins, growth factors, and nutrients Milk examination: Physical examination: Colour, odour, taste, and texture; Chemical examination: Fat content, protein content, lactose, pH, and adulterants; Microbiological examination: Pathogens, spoilage microorganisms, and hygiene indicators Fermented milk products: Curd: Production process, nutritional benefits, and microbial content; Cheese: Types, production techniques, and nutritional value; Yogurt: Fermentation process, health benefits, and varieties	12
2	**Unit 2. Poultry Science** Importance of poultry science in the agricultural sector Types of poultry breeds (Asian: Aseel, Kadaknath; English: Sussex, Orpington; Mediterranean: Leghorn, Minorca). Poultry management with reference to broiler and layer Eggs: Nutritional benefits of eggs. Preservation of egg: Methods, impact on shelf-life and quality Different breeds of ducks, farming of ducks in India Brief idea of Quail farming in India	12
3	**Unit 3. Animal Breeding** Importance of breeding in animal husbandry. Breeding Techniques: Inbreeding, outbreeding and cross-breeding in cattle and poultry birds Artificial insemination technique: Techniques, equipment, benefits and challenges Practical applications in cattle and poultry breeding	10
4	**Unit 4. Poultry and Cattle Diseases** Importance of disease management in livestock; different viral, bacterial and parasitic diseases of cattle and poultry birds (Name of diseases, symptoms, diagnosis and treatment) Vaccination programme to combat different diseases: Vaccination schedules for cattle	11

	and poultry, Importance of vaccination in disease prevention	

Suggested readings

Banerjee, G.C. (2019). Textbook of Animal Husbandry. 8th Edition. Oxford and IBH Publishing Co Pvt. Ltd.

Suryavanshi, J. (2022). Animal Husbandry: Handbook of Dairy, Poultry, sheep, Goat, Pig. Shashwat Publication.

Sastry, N.S.R. and Thomas, C.K. (2016). Livestock Production Management. Paperback. Kalyani Publisher.

Banerjee, G.C. (2019). Principles of Animal Nutrition and Feeds. Revised Edition. Oxford and IBH Publishing.

Das, D., Das, B.C., Nayak, N., Jena, B. and Sahu, A.R. (2022). Textbook on Poultry Management. Narendra Publishing House.

Chuhan, H.V.S. and Roy, S. (2018). Poultry Diseases, Diagnosis and Treatment. New Age International Publishers.

Kumar, V. (2023). Pig Production and Management. New India Publishing Agency.

Yadav, P.K., Kumar, D., Kumar, R. and Mahesh, M.S. (2024). Handbook of Livestock and Poultry Production and Management. Narendra Publishing House.

Rachael, B. (2023). Quail Farming for Beginners: The Ultimate Comprehensive Guide. Rachael, B Publishing.

Practical components

Full Marks: 10

Internal Assessment of 10 marks in case of SEC will be based on the practical portion of the course concerned

Practical must include a visit to any Poultry farm or Animal Husbandry Farm by students.

1. Visit a Farm 4
2. Submit a report 3
3. Viva voce 3

Outcome of the course

1. This paper is designed to understand the objectives of studying Husbandry and its management techniques. Students will cope with the topic and update themselves with the emerging concept of this topic.
2. Students will get knowledge about the technique of farming different economically important animals.
3. Students will get encouragement about entrepreneurship in Husbandry.

OR

ZOOL3051: Medical Diagnostics

Credits – 3 (Theory: 2, Tutorial: 1)

Full Marks. 50 (Theory: 40+ Internal Assessment: 10)

Course objectives

This Skill Enhancement Course aims to enlighten students on the health status of patients with simple diagnostic tests and evaluations. This course will help to make students self-sufficient in future. They are expected to be adept at laboratory techniques.

Sl. No.	Topics	Lectures (45)
1	**Unit 1. Medical Diagnostics** Scope and its importance	03
2	**Unit 2. Diagnostics Methods for Analysis of Blood** Blood composition, Preparation of blood smear and Differential Leucocyte Count (D.L.C.) using Leishman's stain. Platelet count using hemocytometer, Erythrocyte Sedimentation Rate (E.S.R), Packed Cell Volume (P.C.V.)	10
3	**Unit 2. Diagnostic methods for Analysis of Urine** Physical characteristics: Abnormal constituents	04
4	**Unit 3. Non-Communicable Diseases** Causes, types, symptoms, complications, diagnosis and prevention of diabetes (Type I and Type II), hypertension (Primary and Secondary)	06
5	**Unit 4. Communicable Diseases** Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis, and Malaria	06
6	**Unit 5. Clinical Biochemistry** Liver function test (LFT), Lipid profiling, testing of blood glucose using Glucometer/Kit and serum creatinine, albumin	03
7	**Unit 6. Clinical Microbiology** Antibiotic sensitivity test, Swab Test	03
8	**Unit 7. Tumours** Types (Benign/Malignant), detection and metastasis	02
9	**Unit 8. Medical Imaging Technologies** Principles and applications of medical imaging technologies: X-Ray, USG, MRI, and PET/CT scan (using photographs)	04

Suggested readings

Banatvala, N. and Bovet, P. (2023). Noncommunicable Diseases: A Compendium. 1st Edition. Routledge.

Burbridge, B. and Mah, E. (2017). Undergraduate Diagnostic Imaging Fundamentals. University of Saskatchewan.

Devlin, T.M. (Editor) (2010). Textbook of Biochemistry with Clinical Correlations, 7th Edition. Wiley.

Haidekker, M.A. (2013). Medical Imaging Technology. Springer, New York.

Joshi, K. and Gupta, S.K. (2024). Human Cancer Diagnosis and Detection Using Exascale Computing. Scrivener Publishing LLC

Maheshwari, N. (2022). Clinical Microbiology & Parasitology for DMLT Students. 4th Edition. Jaypee Brothers Medical Publishers.

Maheshwari, N. (2022). Clinical Pathology, Haematology and Blood Banking (for DMLT Students). 4th Edition. Jaypee Brothers Medical Publishers.

Mukherjee, K.L. and Chakravarthy, A. (2022). Medical Laboratory Technology: Procedure Manual for Routine Diagnostic Test. Volume 1, II and III. 4th Edition. CBS Publishers & Distributors Pvt. Ltd.

Ossandon, M., Prickril, B. and Rasooly, A. (2025). Cancer Detection and Diagnosis: A Handbook of Emerging Technologies. 1st Edition. CRC Press.

Papadaki, S.M.A., McPhee, S.J. and Rabow, M.W. (Eds.) (2016). Current Medical Diagnosis and Treatment. McGraw-Hill.

Prakash, G. (2012). Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand and Co. Ltd.

Rayner, M., Wickramasinghe, K., Williams, J., McColl, K. and Mendis, S. (2017) (Eds.). An introduction to population-level prevention of non-communicable diseases. Oxford University Press.

Sahadulla, M.I. and Uduman, S.A. (2020). Comprehensive Textbook of Infectious Diseases. 2nd Edition. Jaypee Digital.

Sastry, A.S., Bhat, K.S. and Janagond, A. (2016). Essentials of Medical Microbiology. Jaypee Brothers Medical Publishers.

Webber, R. (2019). Communicable Diseases: A Global Perspective. 6th Edition. CABI.

Sanjay, H.S. and Niranjana, M. (2023). Medical Imaging. Scrivener Publishing LLC.

Practical components

Full Marks: 10

Internal Assessment of 10 marks in the case of SEC will be based on the practical portion of the course concerned.

1.	Visit to a pathological laboratory	4
2.	Submission of report	3
3.	Viva voce	3

Outcome of the course

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

1. learn a basic understanding of the structure of the human body.
2. learn aspects related to medical diagnosis.
3. learn to perform tests that help in the diagnosis and treatment of diseases.
4. handle laboratory instruments.
5. be economically self-sufficient.

SEMESTER – IV

MAJOR COURSES
ZOOL4011: Animal Physiology
Credits – 5 (Theory: 4, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

To understand various functional components of an organism. To explore the complex network of these functional components. To comprehend the regulatory mechanisms for the maintenance of function of the body.

Sl. No.	Topics	Lectures (60)
1	**Unit 1. Digestion** Structural organisation and functions of gastrointestinal tract and associated glands; importance of GI tract hormones; digestion and absorption of carbohydrates, lipids, and proteins	10
2	**Unit 2. Respiration** 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	08
3	**Unit 3. Circulation** Structure of mammalian heart; cardiac cycle, and cardiac output Components of blood, structure and functions of haemoglobin; homeostasis; blood clotting system; hemopoiesis and its regulation	08
4	**Unit 4. Thermoregulation and Osmoregulation** Physiological classification based on thermal biology; osmoregulation in aquatic vertebrates; external osmoregulatory organs in invertebrates	05
5	**Unit 5. Renal System** Structure of nephron; juxta-glomerular apparatus; mechanism of counter-current exchange and urine formation; regulation of acid-base balance	05
6	**Unit 6. Nervous System** Structure of neuron; resting membrane potential; origin of action potential and its propagation across the myelinated and unmyelinated nerve fibres; types of synapses, synaptic transmission and neuro-muscular junction; reflex action and its types	06
7	**Unit** 7. **Muscular System** Different types of muscle, ultrastructure of skeletal muscle, molecular and chemical basis of muscle contraction, origin and conduction of cardiac impulses	06
8	**Unit 8. Reproductive System** Basic structure of testis and ovary; hormones of testis and ovary; physiology of reproduction (oestrus and menstrual cycle)	05

9	**Unit 9. Sensory System** Eye: Physiological anatomy, photoreceptors, visual pathway, visual reflexes, defects of image formation Ear: Physiological anatomy, auditory pathway, mechanism of hearing	07

Suggested readings

Guyton, A.C. and Hall, J.E. (2006). Guyton and Hall Textbook of Medical Physiology, International Edition. 14th Edition. Intech, Elsevier.

Hill, R.W., Wyse, G.A. and Anderson, M. (2022). Animal Physiology. 5th Edition. Sinauer Associates Inc.

Hoar, W.S. (1984). General and Comparative Physiology. 3rd Edition. Prentice-Hall of India.

Barrett, K.E., Barman, S.M., Brooks, H.L. and Yuan, J.X.-J. (2019). Ganong's Review of Medical Physiology. 26th Edition. McGraw-Hill Education.

Moyes, C.D. and Schulte, P.M. (2016). Principles of Animal Physiology. 3rd Edition. Pearson Education.

Randall, D., Burggren, W. and French, K. (2002). Eckert's Animal Physiology – Mechanisms and Adaptation. 5th Edition. W.H. Freeman.

Schmidt Nielsen, K. (1994). Animal Physiology: Adaptation and Environment. Low Price Cambridge Edition.

Sherwood, L. (2004). Human Physiology: From Cells to Systems. 5th Edition. Thomson Brooks Cole.

Tortora, G.J. and Derrickson, B.H. (2017). Tortora's Principles of Anatomy and Physiology. 15th Edition. John Wiley and Sons.

Willmer, P., Stone, G. and Johnston, I. (2004). Environmental Physiology of Animals. 2nd Edition. Wiley Blackwell.

Practical components

1. Estimation of Haemoglobin in human blood using Sahli's haemoglobin meter
2. Differential staining of human blood corpuscles using Leishman stain
3. Determination of Bleeding Time (BT) and Clotting Time (CT) using a suitable method
4. Determination of Blood Group
5. Determination of Erythrocyte Sedimentation Rate (ESR)
6. Experiment on the knee jerk by a suitable method

Examination pattern

Full Marks: 20

1. One question from item no. 1and 4	04
2. One question from item nos. 2 and 5	04
3. One question from item no. 3	04
4. One question from item no. 6	03
5. Laboratory notebook	02
6. Viva voce	03

Suggested readings

Chatterjee, S. and Chakraborty, S. (2017). Practical Zoology. Nirmala Library, Kolkata.

Ghosh, K.C. and Manna, B. (2015). Practical Zoology. New Central Book Agency, Kolkata.

Mukherjee, K.L. and Chakravarthy, A. (2022). Medical Laboratory Technology: Procedure Manual for Routine Diagnostic Tests. Volume I, II and III. 4th Edition. CBS Publishers & Distributors Pvt. Ltd.

Sinha, J.K., Chatterjee, A.K. and Chattopadhyay, P. (2014). Advanced Practical Zoology. 3rd Edition. Books & Allied Ltd, Kolkata.

Virtual Labs (Suggestive sites) https://www.vlab.co.in; https://sites.dartmouth.edu

Outcome of the course

At the end of the course, the student will be able to:

1. develop the skills to identify different types of blood cells
2. enhance basic laboratory skills like keen observation, analysis and discussion
3. learn the functional attributes of different organ systems of the body

ZOOL4012: Disease Biology
Credits – 5 (Theory: 4, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

The specific learning goals for disease biology are to explore the causes of diseases of the animal world and to provide students with a working knowledge of fundamental concepts and molecular mechanisms leading to diseases. This will help in further understanding of the immune responses facilitating recovery and protection, also examining the mechanism of action of disease therapies and investigating the physiological and ecological factors that influence the frequency of disease occurrence.

Sl. No.	Topics	Lectures (60)
1	**Unit 1. Basic Concepts of Disease** Endemic, epidemic, pandemic; acute and chronic, communicable, and non-communicable; infectious and contagious; zoonotic, waterborne borne and nosocomial diseases	04
2	**Unit 2. Communicable Diseases** Mode of transmission, pathogenesis, and management Bacterial: Cholera, Tuberculosis Viral: RNA (AIDS, SARS), DNA (Pox) and naked (rhinovirus) Protozoans: Malaria, Amoebiasis Helminthes: Lymphatic Filariasis, Taeniasis	20
3	**Unit 3. Non-Communicable Diseases** Risk Factors, pathophysiology, and management Gastrointestinal diseases: Diarrhoea, Irritable Bowel Syndrome, and Cirrhosis of liver Cardiovascular diseases: Atherosclerosis, Ischemic heart disease, and Myocardial infarction Diabetes: Types 1 and 2, and Gestational diabetes Kidney diseases: Glomerular Nephritis, and Nephrolithiasis Respiratory disease: Chronic Obstructive Pulmonary Disease (COPD)	18
4	**Unit 4. Asthma and Allergy** Basic concept and types Mechanism of allergic reaction, Diagnostic test, and prophylactic measures	08
5	**Unit 5. Epidemiology, Prevalence, Clinical Features and Preventive Strategies** Protein Energy Malnutrition (PEM), Vitamin A Deficiency (VAD), Iron Deficiency Disorders (IDD)	10

Suggested readings

Banatvala, N. and Bovet, P. (2023). Noncommunicable Diseases: A Compendium. 1st Edition. Routledge.

Bogitsh, B.J. and Cheng, T.C. (2000). Human Parasitology. 2nd Edition. Academic Press, New York.

Chetambath, R. and Panicker, V. (Editors) (2021). Clinical Allergy and Asthma Management in Adolescents and Young Adults. 1st Edition. CRC Press.

Cox, F.E.G. (1993). Modern Parasitology. 2nd Edition. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.

Dimmock, N.J. Easton, A.J. and Leppard, K.N. (2007). Introduction to Modern Virology. 6th Edition. Wiley-Blackwell, London.

McCance, K.L. and Huether, S.E. (2019). Pathophysiology: The Biologic Basis for Disease in Adults and Children. 8th Edition. Elsevier, Amsterdam.

O'Hehir, R.E. Holgate, S.T., Khurana Hershey, G.K. and Sheikh, A. (2022). Allergy Essentials. 2nd Edition. Elsevier.

Roberts, L.S., Janovy, J. and Nadler, S. (2013). Gerald D. Schmidt & Lary S. Roberts' Foundation of Parasitology. 9th Edition. McGraw-Hill International.

Schmidt, G.D. and Roberts, L.S. (2001). Foundation of Parasitology. 3rd Edition. McGraw Hill Publishers.

Shils, M.E., Shike, M., Ross, A.C., Caballero, B. and Cousins, R.J. (2005). Modern Nutrition in Health and Disease. 10th Edition. Lippincott Williams and Wilkins.

Smyth, J.D. (1994). Animal Parasitology. 3rd Edition. Cambridge University Press.

Tripathi, K.D. (2013). Essentials of Medical Pharmacology. 7th Edition. Jaypee Brothers Medical Publishers.

Willey, J.M., Sandman, K.M. and Wood, D.H. (2020). Prescott's Microbiology, 11th Edition. McGraw-Hill Education, New York.

Practical components

1. Identification of *Ancylostoma duodenale*: Male and female, *Fasciola hepatica*, Microfilaria of *Wuchereria bancrofti*, *Entamoeba histolytica*, *Plasmodium* spp.
2. Quantitative estimation of glucose by GOD-POD
3. Demonstration of estimation of total IgE (EIA method)
4. Total count (TC) and Differential count (DC) of blood
5. A survey report of diabetes mellitus distribution among different age groups and income groups
6. Identification of patients with reasons (photographs): Rickets, Marasmus, and Kwashiorkor
7. Identification of *Salmonella* antigen in serum (Using Widal Test teaching kit)

Examination pattern

Full Marks: 20

1.	One question from item no. 2	05
2.	One question from item no. 4	05
3.	Identification of any two from item nos. 1 and 6	(2.5×2) = 05
4.	Laboratory notebook	02
5.	Viva voce	03

Outcome of the course

At the end of the course, the student will be able to understand:

1. innate and adaptive immunity, including the process of inflammation
2. how microbial pathogens (viruses, bacteria, and parasites) evade host defences and cause disease
3. how deregulation of cellular growth and differentiation causes disease
4. the pathobiology of the circulation, including the process of thrombosis and infarction
5. the interactions between infectious organisms and their hosts, with particular reference to emerging infections
6. some common bacterial species that may be associated with human and animal diseases

ZOOL4013: Comparative Endocrinology
Credits – 5 (Theory: 4, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

The objective of comparative endocrinology is to understand how hormones and the endocrine systems that produce them have evolved across different species. This area also investigates the mechanisms of hormone action, the role of the environment in regulating hormone function, and the role of hormones in development, behaviour, and reproduction.

Sl. No.	Topics	Lectures (60)
1	**Unit 1. Overview** Endocrine system, classification of hormones, modes of hormone secretion and transport, feedback mechanism, neurosecretion and neurohormones	07
2	**Unit 2. Invertebrate Endocrine System and Physiology** Insect hormones: Types and their release sites; endocrine regulation of insect growth, moulting and metamorphosis Vertebrate-type hormones in crustaceans: X-organ, Y-organ, and other endocrine organs	08
3	**Unit 3. Vertebrate Endocrine System** Hypothalamo-hypophysial axis Functional aspects and regulation of hormones of endocrine glands: pituitary, pineal, thyroid, parathyroid, pancreas and adrenal Role of hormones in homeostasis: Glucose and calcium Hormonal control of osmoregulatory functions Endocrine control of gestation, parturition, and lactation Hormonal regulation of spermatogenesis and oogenesis	25
4	**Unit 4. Molecular Mechanism of Hormone Actions at Cellular Level** Endocrine receptors, mechanisms of action of steroid and peptide hormones (emphasizing the role of second messengers)	10
5	**Unit 5. Applied Endocrinology** Common endocrine disorders in humans, endocrine-disrupting chemicals (EDCs) Hormone mimics and their applications in insect pest management Bioassays of hormones using RIA and ELISA	10

Suggested readings

Barresi, M.J.F. and Gilbert, S.F. (2019). Developmental Biology. 12th Edition. Sinauer Associates.

Bentley, P.J. (1998). Comparative Vertebrate Endocrinology. 3rd Edition. Cambridge University Press.

Chapman, R.F., Simpson, S.J. and Douglas, A.E. (2012). The Insects: Structure and Function. 5th Edition. Cambridge University Press.

Klowden, M. (2013). Physiological Systems in Insects, 3rd Edition. Academic Press.

Nation, J.L. Sr. (2016). Insect Physiology and Biochemistry. 3rd Edition. CRC Press. Taylor and Francis.

Goodman, H.M. (2009). Basic Medical Endocrinology. 4th Edition. Academic Press.

Negi, C.S. (2009). Introduction to Endocrinology. Prentice Hall India Learning Private Limited. New

Delhi.
Nelson, R.J. and Kriegsfeld, L.J. (2016). An Introduction to Behavioral Endocrinology. 5th Edition. Sinauer Associates, Inc. Publishers, Sunderland.
Nijhout, H.F. (1994). Insect hormones. Princeton University Press. Princeton, New Jersey.
Norris, D.O. (2006). Vertebrate Endocrinology. 4th Edition. Academic Press.
Molina, P.E. (2018). Endocrine Physiology. 5th Edition. McGraw-Hill.
Tembhare, D.B. (2012). Invertebrate Endocrinology. Himalaya Publishing House.
Yadav, B.N. (2021). Mammalian Endocrinology, 5th Edition. Vishal Publishing Co. Jalandhar.

Practical components

1. Dissect and display of endocrine glands in laboratory-bred rats
2. Study of permanent slides of the endocrine glands (Thyroid, Adrenal, Pancreas, Testis, and Ovary)
3. Tissue fixation, embedding in paraffin, microtomy, and slide preparation of mammalian testis
4. Study of vaginal smear of rats for identification of different stages of estrous cycle
5. Effect of hormone mimic on the metamorphosis of Lepidopteran insect
6. Demonstration of hormone assay through ELISA from the available teaching kit

Examination pattern

Full Marks: 20

1.	One question from item no.1	04
2.	One question from item no. 3	04
3.	One question from item no. 4	03
4.	Identification of any two from item no. 2	(2×2) = 04
5.	Laboratory notebook	02
6.	Viva voce	03

Outcome of the course

1. Students understand how the different endocrine systems function
2. They know the structures and molecular modes of action of a large variety of vertebrate and invertebrate hormones and understand how metazoan hormones and their functional mechanisms have evolved
3. Hormones as mediators of growth, development, phenotype, behaviour, reproduction, and epigenetic effects are covered and connected to relevant current events

MINOR COURSE
ZOOL4021: Wildlife Conservation
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

To provide a knowledge of the (a) various aspects of wildlife, including their values, depletion, conflicts with human beings and principles of conservation and various ecological attributes, (b) management and legal protection of different natural habitats and threatened species, and (c) different tools and techniques related to wildlife study.

Sl. No.	Topics	Lectures (45)
1	**Unit 1. Overview** Definition and importance of wildlife; Threatened wildlife and IUCN threat categories (Ver. 3.1, 2001) ─ Extinct, Extinct in Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened and Least Concern species with examples from Indian fauna; Red Data Book Concept of conservation: *In situ* (National parks, Sanctuaries, Community reserve, Conservation Reserves) and *ex-situ* methods of conservation Biosphere Reserves: Concept of Man and Biosphere Program (MAB), characteristics, examples from India	15
2	**Unit 2. Basic Concepts in Wildlife Ecology** Energy flows through ecosystems: linear and Y-shaped food chains, food webs and ecological pyramids Population attributes: density, natality, mortality, dispersal, sex ratio and age; survivorship curves Population growth: Exponential and logistic growth Community characteristics: Species diversity (richness and abundance), keystone species, ecotone, and edge effect; concept of niche	20
3	**Unit 3. Species-Specific Conservation** Conservation status, habit and habitat, threats, and conservation management of the following animals in India: Tiger, Olive Ridley turtles, Great Indian Bustard, Himalayan Musk Deer, Greater One-Horned Rhinoceros and Ganges River Dolphin	10
4	**Unit 4. Man and Wildlife** Causes of human-wildlife conflict, consequences and mitigation of conflict with special reference to project elephant in India	5
5	**Unit 5. Management Planning of Protected Areas** Design and management of nature reserve; concept of wildlife corridor; joint forest management (Arabari JFM) Ecotourism/Wildlife Tourism in forests: Positive and Negative impacts Wildlife (Protection) Act, 1972 [with amendments], problems in wildlife protection; role of WWF, IUCN, CITES, TRAFFIC, NBWL, WCMC	10

Suggested readings

Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5th Edition. The Wildlife Society, Allen Press.

Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.

International Union for Conservation of Nature and Natural Resources. (2012). IUCN Red List Categories and Criteria Version 3.1. 2nd Edition. IUCN, Gland, Switzerland.

Molles, Jr. M.C. (2005). Ecology: Concepts and Applications. 3rd Edition. McGraw-Hill.

Odum, E.P. and Barret, G.W. (2005). Fundamentals of Ecology. 5th Edition. Thompson Brooks/Cole.

Pullin, A.S. (2002). Conservation Biology. Cambridge University Press.

Saha, G.K. and Majumdar, S. (2016). An Introduction to Wildlife Biology: Indian Perspective. PHI Learning, New Delhi.

Smith, R.L. and Smith, T.M. (2001). Ecology and Field Biology. 6th Edition. Benjamin Cummings.

Smith, T.M and Smith, R.L. (2006). Elements of Ecology. 6th Edition. Pearson Education.

Sodhi, N.S. and Ehlich, P.R. (2010). Conservation Biology for All. Oxford University Press.

Practical components

1. Calculation of density and diversity indices (using Shannon-Weiner index) from natural/hypothetical community by quadrat method
2. Study of animal evidence (pugmarks and hoof marks, horns and antlers, scats and pellets, nests, etc. by photographs) and equipment in the field (GPS, binocular, camera trap, compass, radio tracker)
3. Pugmark analysis and census method
4. Visit to any habitat of wildlife importance (Protected Areas, Biosphere Reserves, Wetlands and Ramsar Sites, Zoological and Botanical Gardens) and submission of field report

Examination pattern

Full Marks. 20

1. One question from item no. 1	(7×1) = 06
2. Identification from item no. 2 (any two)	(2×2) = 04
3. One question from item no. 3	02
4. Field Visit Report	03
5. Lab notebook	02
6. Viva voce	03

Course outcome

At the end of the course, students will learn about the importance of wildlife and conservation in and around our surroundings as well as wildlife habitats and their relation to different ecological principles, emerging cases of man–animal conflict and impact of ecotourism on wildlife, with a general knowledge on the different legal structures associated with wildlife.

SEMESTER – V

ZOOL5011: Genetics
Credits – 5 (Theory: 4, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

- To develop conceptual clarity of Mendelian principles of inheritance and other forms and patterns
- To introduce the concept of sex determination and its types, sex-linked, sex- influenced and sex-limited genes
- To develop an understanding of genetic variability within a population and learn how genetic changes take place

Sl. No.	Topics	Lectures (60)
1	**Unit 1: Mendelism and its Deviation** Blending inheritance, particulate theory, pair factor rule, law of dominance, law of segregation, chromosomal theory of inheritance, chromosomal basis of segregation, independent assortment Deviation of Mendelism: Incomplete dominance, codominance, multiple alleles, epistasis and pleiotropy Sex-influenced genes, sex-limited genes and sex-linked genes (Examples from *Drosophila* and human)	15
2	**Unit 2: Linkage and Crossing Over** Linkage (complete, incomplete) Construction of linkage map by three-point test cross Coefficient of coincidence and interference Molecular basis of crossing over (Holliday Model, 1964)	10
3	**Unit 3: Sex Determination** Mechanism of sex determination in *Drosophila* and Human Dosage compensation in *Drosophila* and Human Parental imprinting in human	07
4	**Unit 4: Mutation** Types of gene mutations, detection of mutations in *Drosophila*: CLB method, attached X method Mutagens: Physical and chemical, molecular basis of spontaneous and induced mutations Chromosomal aberrations: Variations in number and structure	09

5	**Unit 5: Extra-Chromosomal Inheritance** Comparison of nuclear and extra-nuclear inheritance Maternal effects: Kappa particle in *Paramoecium*, shell coiling in *Limnaea*	05
6	**Unit 6: Transposable Genetic Elements** Transposons in bacteria Ac-Ds elements in maize and P elements in *Drosophila* Transposons in humans (LINE, SINE, Alu)	05
7	**Unit 7: Genetic Basis of Diseases** Concept of oncogene, activation of oncogene (mutation, gene amplification and chromosomal rearrangement) Tumour suppressor genes (Rb and p53 genes) Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anaemia) Human karyotype and karyotyping; Banding techniques	09

Suggested readings

Brooker, R.J. and Robert, J. (2024). Genetics: Analysis and Principles. 8th Edition. Mc Graw Hill.

Dobzhansky, T. (1970). Genetics of the Evolutionary Process. Columbia University Press.

Griffiths, A.J.F., Doebley, J., Peichel, C. and Wassarman, D.A. (2020). Introduction to Genetic Analysis. 12th Edition. W.H. Freeman.

Hartl, D.L. and Cochrane, B. (2019). Genetics: Analysis of Genes and Genomes. 9th Edition. Jones and Bartlett Publishers, Burlington, Massachusetts.

Hartwell, L., Goldberg, M.L., Reynolds, A.E. and Lee, M. (2021). Genetics: From Genes to Genomes. 7th Edition. McGraw-Hill Education.

Klug, W.S., Cummins, M.R., Spencer, C. and Palladino, M.A. (2020). Concepts of Genetics. 12th Edition. Pearsons Publication.

Pierce, B.A. (2020). Genetics: A Conceptual Approach. 7th Edition. McMillan Learning.

Russell, P.J. (2009). iGenetics: A Molecular Approach. 3rd Edition. Pearson (Benjamin Cummings).

Snustad, D.P. and Simmons, M.J. (2015). Principles of Genetics. 7th Edition. John Wiley and Sons, Inc.

Streips, U.N. and Yasbin, R.E. (Eds.). (2004). Modern Microbial Genetics. 2nd Edition. Wiley.

Strickberger, M.W. (2012). Genetics. 3rd Edition. Pearson/Prentice Hall India.

Tamarin, R.H. (2008). Principles of Genetics. 7th Edition. McGraw-Hill.

Trun, N. and Trempy, J. (2009). Fundamental Bacterial Genetics. John Wiley and Sons.

Practical components

1. Chi-square Analysis: Test for Goodness of Fit. Mendelian monohybrid and dihybrid ratios
2. Problems of Linkage maps in *Drosophila*
3. Identification of Chromosomal aberrations in polytene chromosomes of *Drosophila*/Chironomid larvae — deletion, inversion (paracentric and pericentric), ring chromosome (from photographs/prepared slides)
4. Study of Human karyotypes, normal and abnormal (Down syndrome, Klinefelter syndrome, Turner syndrome, Cri-du-Chat syndrome, Chronic Myeloid Leukaemia Karyotypes) (from Photographs)
5. Pedigree analysis of some human inherited traits (autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive, and Y-linked)

Examination pattern

Full Marks: 20

1. One question from item nos.1 or 2	06
2. One question from item no. 5	05
3. Identification of any two from item nos. 3 and 4	(2×2) = 04
4. Laboratory notebook	02
5. Viva voce	03

Course outcomes

1. Integrate the knowledge of the principles of inheritance
2. Imbibe the concept of chromosomes, multiple alleles, linkage, crossing over, and sex determination
3. Compare the structure and types of chromosomes, genetic disorders and cancer

ZOOL5012: Molecular Biology

Credits – 5 (Theory: 4, practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

To give an idea of the relationship between DNA, RNA and protein synthesis, to study the interaction of different factors regulating these processes and the different processes of DNA repair.

Sl. No.	Topics	Lectures (60)
1	**Unit 1: DNA Replication** Enzyme and protein factors associated with replication; mechanism of replication in prokaryotes Replication and maintenance of telomeres	10
2	**Unit 2: Transcription** Fine structure of gene Transcription: RNA polymerases, transcription factors, initiation, elongation and termination of transcription in prokaryotes Promoters and factors of class I, class II and class III genes of eukaryotes	10
3	**Unit 3: Modification and Processing of Primary Transcripts** Capping and Poly A tail formation in mRNA Spliceosome-mediated splicing of RNA, self-splicing of group I and group II introns RNA editing (gRNA-mediated)	10
4	**Unit 4: Translation** Genetic code: Degeneracy and Wobble hypothesis Role of aminoacyl-tRNA synthetase in proofreading and editing Mechanism of translation in prokaryotes	10
5	**Unit 5: Posttranslational Modification** Methylation, acetylation, phosphorylation, hydroxylation, glycosylation	03
6	**Unit 5: Gene Regulation** Regulation of DNA replication in prokaryotes: DNA methylation Regulation of transcription in prokaryotes: lac-operon and trp-operon (attenuation) Regulation of transcription in eukaryotes: Activator, silencer, enhancer and repressor Gene silencing (siRNA and miRNA-mediated)	10
7	**Unit 6: DNA Repair Mechanism** Molecular basis of: Photoreactivation repair, Nucleotide and base excision repair, SOS repair, Rec BCD model of repair in prokaryotes	07

Suggested readings

Allison, L.A. (2012). Fundamental Molecular Biology. John Wiley and Sons.

Bruce, A., Dennis, B., Julian, L., Martin, R., Keith, R. and Watson, J. (2022). Molecular Biology of the Cell, 7th Edition. W.W. Norton and Company, New York.

Cooper, G.M. and Kenneth, W.A. (2023). The Cell: A Molecular Approach. 9th Edition. Oxford University Press.

Karp, G., Iwasa, J. and Marshall, W. (2019). Karp's Cell and Molecular Biology. 9th Edition. John Wiley and Sons.

Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. (2018). Lewin's genes XII. Jones and Bartlett Learning.

Lackie, J.M., Coote, J.G., Lloyd, C.W. and Blackshaw, S.E. (2013). Dictionary of Molecular Biology. 5th Edition. Elsevier/Academic Press.

Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Martin, K.C., Yaffe, M. and Amon, A. (2021). Molecular Cell Biology. 9th Edition. W.H. Freeman-Macmillan Learning.

Pollard, T.D., Earnshaw, W.C., Lippincott-Schwartz, J. and Johnson, G. (2022). Cell Biology. 4th Edition. Elsevier.

Turner, P., McLennan, A., Bates, A. and White, M. (2005). BIOS Instant Notes in Molecular Biology. 3rd Edition. Taylor and Francis.

Twyman, R. (1998). Advanced Molecular Biology: A Concise Reference. 1st Edition. Garland Science.

Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). Molecular Biology of the Gene. 8th Edition. Pearson.

Practical components

1. Demonstration of agarose gel electrophoresis for DNA
2. Isolation of genomic DNA from any suitable source
3. Quantification of DNA by Diphenylamine (DPA) method
4. Study and interpretation of electron micrographs/ photographs showing: DNA replication; Transcription; Split genes
5. Visit to a Molecular Biology Lab

Examination pattern

Full Marks: 20

1. One question from item No. 2	05
2. One question from item No. 3	04
3. Two identifications from item nos. 1 and 4	(2×2) = 04
4. Submission of lab visit report	02
5. Laboratory notebook	02
6. Viva voce	03

Course outcomes

The students will be able to understand the molecular basis of various biological processes and the diverse mechanisms of gene regulation.

ZOOL5013: Animal Biotechnology
Credits – 5 (Theory: 4, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

- To understand Biotechnology, which is a major tool in modern research, especially in biological sciences, medical sciences, forensic science, and environmental science
- To know the various techniques for research work
- It is truly regarded as the scientific technology of the twenty-first century

Sl. No.	Topics	Lectures (60)
1	**Unit 1: Overview** Aims and scope, applications in biotechnology	05
2	**Unit 2: Principles of Gene Manipulation** Cloning vectors: Plasmids, cosmids, phagemids, lambda bacteriophage, M13, BAC, YAC, MAC, and expression vectors (characteristics) Restriction enzymes and their types, DNA modifying enzymes	10
3	**Unit 3: Recombinant DNA Technology** Insertion of foreign DNA into vector, introduction of vector into host, selection (antibiotic selection and blue-white selection) Construction of genomic and cDNA libraries and screening by colony and plaque hybridisation Polymerase Chain Reaction, DNA fingerprinting, and DNA microarray DNA sequencing: Sanger method	15
4	**Unit 4: Applications of Genetic Engineering** Production of cloned and transgenic animals: Nuclear transplantation, retroviral method, DNA microinjection Applications of transgenesis: Production of molecular pharming, production of donor organs, knockout mice Blotting techniques: Southern, Northern and Western	20
5	**Unit 5: Culture Techniques and Applications** Type of animal cell cultures, cryopreservation, and animal cell culture for vaccine development	10

Suggested readings

Brown, T.A. (2010). Gene Cloning and DNA Analysis: An Introduction. 6th Edition. Wiley-Blackwell, Chichester.

Butler, J.M. (2010). Fundamentals of Forensic DNA Typing. 3rd Edition. Elsevier Academic Press, Amsterdam.

Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Edition. ASM Press: Washington, DC.

Harisha, S. (2007). Biotechnology Procedures and Experiments Handbook. Infinity Science Press. New Delhi.

Mosier, N.S. and Ladisch, M.R. (2011). Modern Biotechnology: Connecting Innovations in

Microbiology and Biochemistry to Engineering Fundamentals. John Wiley and Sons, Hoboken.

Primrose, S.B. and Twyman, R.M. (2007). Principles of Gene Manipulation and Genomics. 8th Edition. Blackwell Publishing.

Singh, B.D. (2015). Biotechnology: Expanding Horizons. 4th Edition. Kalyani Publishers. New Delhi.

Satyanarayana, U. and Chakrapani, U. (2020). Biotechnology. Books and Allied (P) Ltd.

Weaver, R.F. (2012). Molecular Biology. 5th Edition. McGraw-Hill, New York.

Practical components

1. Construction of linear restriction map from the data provided.
2. Calculation of transformation efficiency from the data provided.
3. Study and identification of the following techniques through photographs
   i. Southern Blotting
   ii. Northern Blotting
   iii. Western Blotting
   iv. DNA Sequencing (Sanger method)
   v. PCR
   vi. DNA fingerprinting
4. Review of a scientific research paper on Animal Biotechnology

Examination pattern

Full Marks: 20

1.	One question from item no. 1	(4 ×1) = 04
2.	One question from item no. 2	(4×1) = 04
3.	Identification of any two techniques from item no. 3	(2×2) = 04
4.	Submission of review report	03
5.	Laboratory notebook	02
6.	Viva voce	03

Course outcomes

At the end of the course, the students will be able to develop the skill of modern techniques of biological tools at the molecular level of research; enhance basic laboratory skills like keen observation, analysis, and discussion; learn the functional attributes (molecular level) of different cell type and disorder of the various cell and help in diagnosis of the different disorders.

SEMESTER – VI

ZOOL6011: Evolutionary Biology and Ethology
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

1. Evolutionary Biology is a foundational science that explores the origin of life, various theories of evolution, animal evolution, and evolutionary genetics. Understanding evolutionary biology provides insights into how organisms have evolved over time and the processes that drive these changes

2. Ethology is an important branch of Zoology today. Understanding animal behaviour is crucial for students, as it aids in the conservation process and promotes better coexistence with other species

Sl. No.	Topics	Lectures (45)
1	**Unit 1: Origin of Life** Urey-Miller experiment, Chemogeny: Oparin concept: from the origin of hydrocarbon to complex organic molecules, Haldane's Hot dilute soup concept (in brief), Compartmentalisation (Protocell: microspheres, coacervate, liposome) Concept of RNA world	04
2	**Unit 2: Theories of Evolution** Lamarckism in brief, Darwinism (theory of common descent, gradualism and natural selection), modern synthetic theory Selection: modes of selection, fitness, absolute fitness, relative fitness, coefficient of selection, heterozygous superiority, evolutionarily stable strategy (ESS) Mimicry and colouration: Types, examples, significance, evolutionary perspective Phenotypic plasticity: Definition, types, mechanisms, significance	06
3	**Unit 3: Population Genetics** Hardy-Weinberg Equilibrium: Explanation with examples and factors affecting it Founder effect, bottleneck phenomenon, genetic drift theory and neutral evolution, molecular clock	05
4	**Unit 4: Evolution of Horse and Man** Evolutionary trends; phylogeny of horse Unique hominid characteristics; comparative anthropogeny Place and time of origin; major fossil evidence	03
5	**Unit 5: Speciation and Geological Time scale** Speciation: Modes and mechanisms Geological time scale: Extinction events with emphasis on Big Die and K-T mass extinction	05
6	**Unit 6: Zoogeography** Classification of zoogeographical realms, Wallace line Distribution of Mammals in different realms Continental drift and its impact on the distribution of animals	03

7	**Unit 7: Basics of Animal Behaviour** Definition of ethology and ethogram, instinct (innate) and learned behaviour, animal cognition (example: Chimpanzees); Stereotype behaviours: Orientation reflexes, associative learning, classical and operchant conditioning, habituation, imprinting, fixed action pattern (FAP)	06
8	**Unit 8: Altruism** Definition, idea of kin selection, W.D. Hamilton's formula Eusociality in honeybees Reciprocal altruism in vampire bat	05
9	**Unit 9: Sexual Behaviour** Protogyny and protoandry with examples, anisogamy and Bateman gradient dimorphism, Inter-sexual and runaway selection, intra-sexual selection	05
10	**Unit 10: Biological Rhythm** Biological clocks, Circadian rhythm	03

Suggested readings

Agarwal, V.K. (2018). Animal Behaviour (Ethology). S Chand and Company.

Alcock, J. and Rubenstein, D.R. (2022). Animal Behavior: An Evolutionary Approach. 12th Edition. Sinauer Associates (Oxford University Press).

Davies, N.B., Krebs, J.R. and West, S.A. (2012). An Introduction to Behavioural Ecology. 4th Edition. Wiley-Blackwell.

Dobzhansky, T., Ayala, F.J., Stebbins, J.L. and Valentine, J.W. (1977). Evolution. San Francisco, W.H. Freeman.

Drickamer, L.C., Vessey, S.H. and Jakob, E.M. (2001). Animal Behaviour: Mechanisms, Ecology, Evolution. 5th Edition. McGraw-Hill Science Engineering.

Dugatkin, L.A. (2025). Principles of Animal Behavior. 5th Edition. University of Chicago Press.

Emiliani, C. (1992). Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press.

Futuyma, D.J. (2005). Evolution. Sinauer Associates Inc.

Futuyma, D.J. and Kirkpatrick, M. (2022). Evolution. 5th Edition. Sinauer Associates (Oxford University Press Inc).

Hartl, D.L. (2005). Principles of Population Genetics. 4th Edition. Sinauer Associates.

Kotpal, R.L. (2019). Modern Textbook of Zoology: Invertebrates. 12th Edition. Rastogi Publications.

Mathur, R. (2018). Animal Behaviour. 6th Edition. Rastogi Publications.

Rastogi, V.B. (2022). Organic Evolution (Evolutionary Biology). 14th Edition. MedTech Science Press.

Ridley, M. (2003). Evolution: Changing Patterns of Inclusion and Exclusion. 3rd Edition. Blackwell Science (Wiley).

Stearns, S.C. and Hoeskstra, R.F. (2005). Evolution. Blackwell Science Ltd.

Strickberger, M.W., Hall, B.K. and Hallgrimsson, B. (2013). Strickberger's Evolution: The Integration of genes, organisms, and populations. 5th Edition. Jones and Bartlett Learning.

Wilson, E.O. (2000). Sociobiology – The New Synthesis. 25th Anniversary Edition. Belknap Press, Harvard University Press.

Practical components

1. Study of fossils from models/ pictures
2. Study and confirmation of Hardy-Weinberg Law by Chi-square analysis
3. Birds [Study of nests: Baya Weaver Bird (Babui), Tailor bird, Crow] and social insects [study of bee hive, wasp nests]
4. Behavioural test of Rat by T/Y Maze
5. Ethogram preparation from video clips/ornamental fish
6. Visit a Forest/Wildlife Sanctuary/National Park/Biosphere Reserve/ Biodiversity Park/Zoological Park to study the activities of animals and prepare a field report

Examination pattern

Full Marks: 20

1. Identification from item nos. 1 and 3 (any two identifications)	(2×2) = 04
2. One question from item no. 2	(5×1) = 05
3. One question from item nos. 4 or 5	4×1 = 04
4. Submission of field report	02
5. Laboratory notebook	02
6. Viva voce	03

Course outcomes

1. Students will get knowledge of the history of life on earth and the causal processes of evolution
2. Students will gather knowledge about the causes of the extinction of species and the application of genetics in evolution
3. Students will be able to learn some essential aspects of Evolutionary Biology and acquire an understanding of the subject
4. Knowledge of animal behaviours increases the students' understanding of how behaviours help animals survive, reproduce, and interact with nature
5. Knowledge of wildlife will help in their conservation, and human-animal coexistence rather than conflict
6. Study of animal behaviour can help to develop new approaches and ideas for the conservation and management of wildlife

ZOOL6012: Ecology and Conservation Biology

Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

Understanding ecology and biodiversity provides a thorough knowledge of the interactions between organisms and their environment, including various ecosystem components and functions that are important for maintaining biodiversity, as well as the role of species, populations and communities in ecological processes.

In this era of rapid biodiversity loss, conservation biology focuses on protecting wildlife and other components of biodiversity. This is achieved through various management strategies, efforts, and policies implemented at local, national, and global levels.

Sl No.	Topics	Lectures (45)
1	**Unit 1: Overview** Autecology and synecology, Levels of organisation Laws of limiting factors, temperature and its effects on organisms	03
2	**Unit 2: Population** Attributes: Density, natality and mortality, age pyramids, life tables, survivorship curves, dispersal, dispersion Dynamics: Patterns and equations of growth forms (Exponential and Logistic), Lotka-Volterra model, r/k strategies, competition Regulation: Density-dependent and -independent	07
3	**Unit 3: Community** Community structure, types and characteristics Vertical stratification (forest community), ecotone and edge effect Niche concept: Niche width and overlap, fundamental and realised niche Ecological succession: Concept of community change (terrestrial)	07
4	**Unit 4: Ecosystem** Types of ecosystems with examples Food chain: Linear and Y-shaped food chains Food web, ecological pyramids and ecological efficiencies Energy flow through ecosystem	07
5	**Unit 5: Biological Diversity** Definition, hierarchy (genetic, species and ecosystem), diversity in spatial scale (α, β and γ), species richness, heterogeneity, abundance and evenness Diversity indices: Shannon-Wiener index, Simpson index, and Sørensen index Megadiverse countries: Biodiversity conservation policies, endemism Biodiversity hotspots: Concepts, criteria, distribution and importance, hottest hot spots Keystone species, charismatic species, umbrella species, unique species, flagship species Biological Diversity Act, 2002	08

6	**Unit 6: Basic Concept of Conservation Biology** Concept of conservation: *in situ* (Biosphere Reserves, National Parks, Wildlife Sanctuaries, Community Reserve, Conservation Reserves) and *ex-situ* (Germplasm bank, Field gene bank, Captive breeding, Zoological Park, Aquaria, etc.)	05
7	**Unit 7: Overview of Wildlife** Definition and importance of wildlife; Threatened wildlife in India (Tiger, Asiatic lion, red panda, hoolock gibbon, golden langur, Himalayan newt, Olive Ridley Turtle, and Great Indian Bustard) IUCN Red List categories and criteria (Version 3.1, 2001) Red Data Book, Stud Book	04
8	**Unit 8: Management Planning of Wildlife in Protected Areas** Wildlife (Protection) Act, 1972 Wildlife conservation projects: Tiger, Rhino and Great Indian Bustard in India and their management challenges	04

Suggested readings

Begon, M. and Townsend, C.R. (2020). Ecology: From Individuals to Ecosystems. 5th Edition. Wiley.

Begon, M., Harper, J.L. and Townsend, C.R. (2006). Ecology: Individuals, Populations and Communities. 4th Edition. Blackwell Science.

Bookhout, T.A. (1996). Research and Management Techniques for Wildlife and Habitats, 5th Edition. The Wildlife Society, Allen Press.

Caughley, G. and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.

Chapman, R. L. and Reiss, M.J. (1998). Ecology – Principles and Applications. 2nd Edition. Cambridge University Press.

Dash, M.C. (2001). Fundamentals of Ecology. 2nd Edition. Tata McGraw-Hill Company.

Faurie, C., Ferra, C., Medori, P. and Devaux, J. (2001). Ecology-Science and Practice. Oxford and IBH Publishing Company Pvt. Ltd.

Gupta, I.J. and Mondal, D.K. (2005). Red Data Book (Part 2) – Butterflies of India. Director, Zoological Survey of India, Kolkata.

International Union for Conservation of Nature and Natural Resources. (2012). IUCN Red List Categories and Criteria Version 3.1. 2nd Edition. IUCN, Gland, Switzerland.

Krebs, C.J. (2009). Ecology: The experimental analysis of distribution and abundance. 6th Edition. Benjamin Cummings.

Mittermeier, R.A., Myers, N. and Mittermeier, C.G. (2000). Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions, Conservation International.

MoEF (2006). Perspective on Biodiversity: A Vision for Megadiverse Countries. Verma, D. D., Arora, S. and Rai, R.K. (Eds.). Ministry of Environment & Forests, New Delhi.

Molles, Jr. M.C. and Sher, A.A. (2021). Ecology: Concepts and Applications. 9th Edition. McGraw-Hill.

Odum, E.P. and Barret, G.W. (2005). Fundamentals of Ecology. 5th Edition. Thompson Brooks/Cole.

Pullin, A.S. (2002). Conservation Biology. Cambridge University Press.

Ricklefs, R.E. and Miller, G.L. (2000). Ecology. 4th Edition. W.H. Freeman and Company.

Saha, G.K. and Majumdar, S. (2007). Threatened Mammals of India – Ecology & Management. Daya Publishing House, New Delhi.

Saha, G.K. and Majumdar, S. (2016). An Introduction to Wildlife Biology: Indian Perspective. PHI Learning, New Delhi.

Saharia, V.B. (1998). Wildlife in India. Natraj Publishers.

Smith, R.L. and Smith, T.M. (2001). Ecology and Field Biology. 6th Edition. Benjamin Cummings.

Smith, T.M. and Smith, R.L. (2015). Elements of Ecology. 9th Edition. Pearson Education.

Sodhi, N.S. and Ehlich, P.R. (2010). Conservation Biology for All. Oxford University Press.

Stiling, P.D. (2014). Ecology: Global insights and investigations. 2nd Edition. McGraw-Hill Higher Education.

Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.

Tikader, B.K. (1983). Threatened Animals of India. Publisher, Zoological Survey of India.

Vié, J.C., Hilton-Taylor, C., Pollock, C., Ragle, J., Smart, J., Stuart, S.N. and Tong, R. (2008). The IUCN Red List: A key conservation tool. In: Vié, J.C., Hilton-Taylor, C. and Stuart, S.N. (Editors). Review of The IUCN Red List of Threatened Species. IUCN, Gland, Switzerland.

Woodroffe, R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict, or Coexistence. Cambridge University.

Practical components

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Animal Census techniques: Transect and Quadrat Estimations, Pitfall and Light-traps. Statistical analysis of data
3. Determination of population density in a natural/hypothetical community by the quadrat method and calculation of the Shannon-Weiner diversity index for the same community
4. Study of an aquatic ecosystem: Measurement of area, determination of temperature, pH, and free CO_2; determination of zooplankton diversity, density and abundance
5. Visit to any area of conservation importance (Protected Area/Forest/Wetland and Sea shore/Biodiversity Park/Zoological parks and Botanic Gardens) and submission of field report

Examination pattern

Full Marks: 20

1. One question from item no. 1	(5×1) = 05
2. One question from item no. 3	(4×1) = 04
3. One experiment from item no. 4	04
4. Field Visit Report	02
5. Laboratory notebook	02
6. Viva voce	03

Suggested Readings

Desharnais, R. and Bell, J. (2001). Ecology Version Student Lab Manual, 'Biology Labs On-Line'. Pearson, Lab Manual Edition.

Krebs, C.J. (2016). Ecology: The Experimental Analysis of Distribution and Abundance. Pearson Education Limited, Noida, India.

Silvy, N.J. (2012). The Wildlife Techniques Manual: Vol 1 (Research) and Vol 2 (Management). The Johns Hopkins University Press.

Sutherland, W.J. (2006). Ecological Census Techniques: A Handbook. 2nd Edition. Cambridge University Press.

Vodopich, D.S. (2010). Ecology Lab Manual. McGraw-Hill Higher Education.

Course outcomes

Students will get knowledge of the fundamentals of ecological organisation, limiting factors and different attributes related to population, community and ecosystem levels of organisation. Students will gather knowledge on different aspects of biodiversity, including its levels, species diversity measures and indices, megadiverse countries and biodiversity hot spots. Knowledge of wildlife and conservation biology will help to increase awareness among students regarding the importance of wildlife and different biodiversity components in maintaining a healthy relation between man and environment. The students will be able to learn about different management techniques to protect the threatened wild animals and ecosystems, like the tigers, hoolock gibbon, red panda, snow leopard, pygmy hog, golden langur, etc. in India.

ZOOL6013: Developmental Biology
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

Study of Developmental Biology aims to provide an understanding of the development of a single cell into an organised grouping of cells, which is programmed at specific times to become specialised

Sl. No.	Topics	Lectures (45)
1	**Unit 1: Overview of Developmental Processes** Cellular potency, cell-to-cell interaction, germ cell migration Pattern formation, Differential gene expression Spermatogenesis and Oogenesis (Mammal) Molecular events of fertilisation (Block to polyspermy) (Sea urchin and mammal)	11
2	**Unit 2: Early Embryonic Development** Cleavage: Planes and patterns Blastulation, Fate map, cell lineage Embryonic induction Primary organiser, Spemann and Mangold Experiment Nieuwkoop centre	
3	**Unit 3: Late Embryonic Development** Gastrulation in frog and chick Development of eye in chick Extra-embryonic membranes in birds Placenta: structure, types and functions	12
4	**Unit 4: Postembryonic Development** Regeneration: Types and limb formation in salamander In vitro fertilisation and embryo transfer technology Stem cells: Sources, types and their use in human welfare	07
5	**Unit 5: Developmental Genetics of *Drosophila*** Homeotic genes and pattern formation	05

Suggested readings

Balinsky, B.I. (1981). An Introduction to Embryology. 5th Edition. Holt Rinehart and Winston.

Carlson, B. (2019). Human Embryology and Developmental Biology. 6th Edition. Elsevier.

Gilbert, S.F. (2023). Developmental Biology. 13th Edition. Oxford University Press.

Kalthoff, K. (2001). Analysis of Biological Development. 2nd Edition. McGraw-Hill Publishers.

Moody, S.A. (2014). Principles of Developmental Genetics. 2nd Edition. Elsevier/Academic Press,

Amsterdam.

Slack, J.M.W. (2006). Essential Developmental Biology. 2nd Edition. Blackwell Publishing.

Twyman, R.W. (2001). Instant Notes on Developmental Biology. Viva Books Private Ltd.

Verma, P.S. and Agarwal, V.K. (1995). Chordate Embryology. S. Chand and Co., New Delhi.

Wolpert, L., Beddington, R., Jessell, T., Lawrence, P., Meyerowitz, E. and Smith, J. (2015). Principles of Development. Oxford University Press.

Practical components

1. Study of different eggs (*Drosophila*, Frog and Chick)
2. Study of whole mount and section of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
3. Study of permanent slides: Primitive streak (13 and 18 hours), 24, 33, 48, and 72 hours of chick embryos
4. Study of different types of placentae (photomicrograph/ slides)
5. Study of life stages of *Drosophila melanogaster*/Chironomid midge/Blue bottle fly/Flesh fly (photomicrograph/mounted in slides/preserved specimens in alcohol)
6. Lab visits and submission of project report on *Drosophila* culture/chick embryo development

Examination pattern

Full Marks: 20

1. One question from item no. 5	05
2. Three identifications from item nos. 2, 3 and 4	(2×3) = 06
3. Lab visits and submission of report	04
4. Laboratory notebook	02
5. Viva voce	03

Course outcomes

Upon successful completion, students will have the knowledge and skills to:

1. Explain the molecular and genetic background of animal development
2. Describe the evolutionary history of complex multicellular life forms
3. Compare environmental influences in the development and homeostasis of cells

ZOOL6014: Histology and Histochemistry
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Practical: 20; Internal Assessment (Evaluation+Attendance): 10+05=15)

Course objectives

Students will learn Bioanalytical Techniques, including mammalian tissue structure, histopathological changes in diseases, and permanent slide preparation. They will explore immunofluorescence, protein identification, and cell morphology alterations. The course covers immunohistochemistry, cryotechniques, enzyme histochemistry, and histochemical methods for detecting carcinomas using immunofluorescent techniques.

Sl. No.	Topics)	Lectures (45)
1	**Unit 1: Objectives and Applications** Tissue fixation: Objectives, methods Chemical fixatives: Types and chemistry of fixation Physical methods: Freezing and microwave fixation, choice of fixatives, fixation artefacts Embedding and microtomy: Methods, problems, and remedies of microtomy, including cryostat and freezing microtome	14
2	**Unit 2: Biological Dyes and Stains** Properties, classification, source, and uses of haematoxylin, eosin, carmine, and orcein	05
3	**Unit 3: Functional Morphology (Mammalian)** Histological organisation of stomach, intestine, liver, pancreas, testis, ovary, kidney, spleen, and thymus	10
4	**Unit 4: Histochemistry** Principles, methodology and applications of histochemical techniques: PAS and Feulgen Metallic and Azo dye methods for alkaline phosphatase, acid phosphatase and adenosine triphosphatase	08
5	**Unit 5: Immunohistochemistry** Principles, methods of application of Immunohistochemistry and immunofluorescence techniques for localisation of proteins *In situ* hybridisation of nucleic acids	08

Suggested readings

Bancroft, J.D. and Gamble, M. (2002). Theory and Practice of Histological Technique. Churchill Livingstone.

Bloom, W. and Fawcett, D.W. (1998). A Textbook of Histology. 12th Edition. W.B. Saunders Company.

Fawcett, D.W., Ronald, P. and William, B. (2002). Bloom and Fawcett's: Concise Histology. 2nd Edition. Arnold, London.

Friefelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology. 2nd Edition. W.H. Freeman and Co., San Francisco (Reprint 1999).

Glauert, A.M. (1975). Fixation, Dehydration and Embedding of Biological Specimens. Elsevier, New York and North-Holland.

Gurr, G.T. (1956). A Practical Manual of Medical and Biological Staining Techniques. Interscience, New York.

Junqueira, L.C. and Carneiro, J. (2005). Basic Histology: Text and Atlas. 11th Edition. McGraw-Hill Lange Medical Publication, New York.

Kiernan, J.A. (2008). Histological and Histochemical Methods: Theory and Practice. 4th Edition. Scion, Bloxham, UK.

Leeson, T.S., Leeson, C.R. and Paparo, A.A. (1988). Text/Atlas of Histology. 1st Edition. W. B. Saunders Company, Philadelphia.

Pearse, A.G.E. (1980). Histochemistry, Theoretical and Applied. Vol. 1. 4th Edition. Churchill Livingstone, New York.

Reoschenko, V.P. (2012). DiFiore's Atlas of Histology with Functional Correlations. 12th Edition. Wolter Kluwer, Netherlands.

Ross, M.H., Kaye, G.I. and Pawlina, W. (2003). Histology: A Text and Atlas. 4th Edition. Lippincott Williams and Wilkins, Philadelphia.

Ross, M.H. and Reith, E. (1985). Histology: A Text and Atlas. Harper and Row Publishers.

Sharma, B.K. (1991). Techniques in Microscopy and Cell Biology. Tata-McGraw Hill, New Delhi.

Singh, I. (2010). Text Book of Human Histology with Colour Atlas and Practical Guide. Jaypee brothers' Medical Publishers Ltd., Delhi.

Stoward, P.J. and Pearse, A.G.E. (1991). Histochemistry: Theory and Practical. 4th Edition. Churchill Livingstone.

Weesner, F.M. (1965). General Zoological Techniques. The William and Wilkins Company.

Practical components

1. Fixation, dehydration, embedding, section cutting, staining, and mounting of rat tissues (Liver, kidney, spleen, and testis) (Haematoxylin and eosin staining)
2. Histochemical reactions for carbohydrates, DNA/RNA
3. Observation of permanent slides of mammalian organs – stomach, intestine, spleen, liver, ovary, and testis
4. Submission of permanently prepared slides (any five tissues)

Examination pattern

Full Marks: 20

1. One question from item no. 1	(5×1) = 04
2. One question from item no. 2	(5×1) = 05
3. Identification of permanent slides	(2×2) = 04
4. Submission of permanent slides	02
5. Laboratory notebook	02
6. Viva voce	03

Course outcomes

The study of mammalian tissues at the histological level involves understanding their structural organisation and disease-induced morphological alterations. It explores the relationship between aetiology, pathogenesis, and histopathological changes. Key techniques include permanent slide preparation, immunofluorescence, immunohistochemistry, and enzyme histochemistry, which aid in protein localisation and carcinoma detection.