Syllabus for
B.Sc. Zoology with Honours
FOUR YEAR FULL TIME PROGRAMME
(Eight - Semester Course)

In view of
National Education Policy (NEP) 2020,
And
University Grants Commission's Guidelines for the
Learning Outcomes-based Curriculum Framework (LOCF)
Under the Choice Based Credit System (CBCS)

COURSE CONTENTS

(A draft for implementing from 2022-23 Session)

Department of Zoology
Oriental College (Autonomous)
Takyel, Imphal

AFFILIATED TO MANIPUR UNIVERSITY, CANCHIPUR

Introduction:

Zoology is one of the major subjects of Basic Sciences and deals with all aspects of animal biology. The learning outcomes-based curriculum framework for B.Sc. degree in Zoology is structured, keeping in mind the aspirations of students, changing nature of the subject as well as the learning environment incorporating recent advancements, techniques to upgrade the skills of learners. The new structure is expected to enhance the level of understanding among students and maintain the standard programme of Zoology. The framework offers flexibility and innovation in syllabi designing and in methods adopted for teaching- learning process and learning assessment. The major objective is to elevate the subject knowledge of the students, making them critical thinkers and able to solve problems, issues related to Zoology logically and efficiently to provide our students a competitive edge in securing a career in academia, industry, research and development sectors. The Course structure has been formed as per the Ordinance for Undergraduate programme in Science and Arts of Oriental college (Autonomous).

Aim to the study of degree programme

The subject Zoology is one of the most fundamental branches of biology studied at undergraduate level. It helps to learn and understand the modern systemic aspects of animal diversity as well as contemporary subjects. Students will be able to know qualitatively and quantitatively analyse different parameters like Comparative Anatomy of Vertebrates, Cell Biology, Biochemistry, Evolutionary Biology, Principles of Genetics; Principles of Ecology, Developmental Biology, Animal behavior, Physiology, Immunology, Molecular Biology, Biotechnology, Bioinstrumentation and Bioinformatics with computational tools used in modern sciences. This will provide them ample opportunities to explore different care eravenues.

The Zoology degree program will also provide a platform to undergo in classical genetics which will enable to understand distribution of different traits among populations, their inheritance, ethnicity and correlate with contemporary and modern techniques like genomics, meta genomics, genome editing and molecular diagnostic tools. Practical and theoretical skills gained in this course will be helpful in designing different public health strategies for social welfare. The course has been designed to provide in-depth knowledge of applied subjects like Apiculture, Sericulture, Aquarium fish keeping, vermicomposting etc. ensuring the inculcation of employment skills so that students can make a career and become an entrepreneur in diverse fields. After completion of this course, students can contribute as policy makers in wildlife conservation, animal preservation, environment protection and public health.

Attributes to the study of Zoology

Some of the characteristic attributes of a graduate in Zoology may include disciplinary knowledge, effective communicator, critical thinker and problem solver, logical thinking and reasoning, team spirit, leadership quality, ethical awareness, life long learners etc.

Program Learning Outcome

The study of Zoology will enable to acquire complete knowledge of disciplinary as well as allied biological sciences. At the end of graduation, they should possess expertise which will provide them competitive advantage in pursuing higher studies in India or abroad and seek jobs in academia, research or industries.

Practical skills in biotechnology, biostatistics, bioinformatics and molecular biology can help a lot in pursuing career as a scientist. These methodologies will provide an extra edge to our students, who wish to undertake higher studies.

Deep understanding of discipline specific courses of zoology creates different types of professionals in the fields/subfields of zoology. Study of wild life management courses would gain expertise in identifying key factors of wild life management and will be great help when applying jobs in National parks and sanctuaries. Skill enhancement courses shall be making students successful entrepreneurs.

COURSE STRUCTURE FOR HONOURS STUDENTS

***** Year 1 (Level 5) total credits for 2 semesters: 24x2=48							
Courses→	Core Course (18)	Discipline Specific Elective DSE (4)	Generic Elective GEC (6)	Skill Enhancement Course SEC (2)	Ability Enhancement Compulsory Course AECC (2)	Value Addition Course VAC (8)	Semester Wise credits
Credits → Semesters↓	18 x 6 = 108	4 x 6 = 24	6 x 6 = 36	2 x 4 = 8	2 x 4 = 8	2 x 8 = 16	
1	Zoo-HC 501 Zoo -HC 502			Zoo -SE 501	GEN-AE 1/ MAN-AE 1	VAC 1 VAC 2	24
2	Zoo -HC 503 Zoo -HC 504			Zoo -SE 502	EVS-AE 2	VAC 3 VAC 4	24
Exit option with Bachelor's Certificate in a Discipline on completion of courses equal to a minimum of 46 credits							
***** Year 2 (Level 6) total credits for 2 semesters: 26x2=52							
3	Zoo -HC 601 Zoo -HC 602 Zoo -HC 603		Zoo –HG 601			VAC 5	26
4	Zoo -HC 604 Zoo -HC 605 Zoo -HC 606		Zoo –HG 602			VAC 6	26
Exit option with Bachelor's Diploma in a Discipline on completion of courses equal to a minimum of 96 credits							
***** Year 3 (Level 7) total credits for 2 semesters: 26x2=52							
5	Zoo -HC 701 Zoo -HC 702	Zoo -HE 701/ Zoo –HE 701/ Zoo -HE 701	Zoo –HG 701			VAC 7	26
6	Zoo -HC 703 Zoo -HC 704	Zoo -HE 702/ Zoo -HE 702/ Zoo -HE 702	Zoo –HG 702			VAC 8	26
Exit option with Bachelor's Degree in a Discipline on completion of courses equal to a minimum of 140 credits							
***** Year 4 (Level 8) total credits for 2 semesters: 24x2=48							
7	Zoo -HC 801 Zoo -HC 802	Zoo -HE 801/ Zoo –HE 801/ Zoo -HE 801	Zoo –HG 801				24
8	Zoo -HC 803 Zoo -HC 804	Zoo -HE 802 Dissertation	Zoo –HG 802				24
Award of Bachelor's Degree with Honours in a Discipline on completion of courses equal to a minimum of 182 credits							
Total: CC: 18 courses, 18X6=108 credits; DSE: 4 courses, 4X6=24 credits; GEC: 6 courses, 6X6=36 credits; SEC: 2 courses, 2X4=8 credits; AECC: 2 courses, 2X4=8 credits; VAC: 8 courses, 2x8=16 credits. (altogether 40 courses/papers and 200 credits).							

CC: Core courses (18 papers of 6 credits each) - **Course code: HC**
AECC: Ability enhancement compulsory courses (2 papers of 4 credits each) - **Course code: AE**
SEC: Skill enhancement course (2 papers of 4 credits each) - **Course code: SE**
DSE: Discipline specific elective courses (4 papers of 6 credits each) - **Course code: HE**
GEC: Generic elective courses (6 papers of 6 credits each) - **Course code: HG**
VAC: Value addition courses (8 papers of 2 credits each) - **Course code: VA**

Note: A student opting Zoology as Honours course may take Generic Elective Papers from any other disciplines available in the college other than Zoology.

Semester wise Course and Credit details

Sem↓	Course	Course code	Title	Credits	Remarks
1	Core course 1	ZOO-HC 501	Non-chordates 1: Protista to Pseudocoelomates	4	Compulsory
	Core course 1 practical	ZOO-HC 501P	,,	2	
	Core course 2	ZOO-HC 502	Principles of Ecology	4	
	Core course 2 practical	ZOO-HC 502P	,,	2	
	Skill Enhancement Course 1	ZOO-SE 501	Apiculture / Aquarium Fish keeping	4	It can choose any one from the given courses
	Ability Enhancement	GEN-AE-1/ MAN-AE-1	English / MIL Communication	4	Compulsory
	Value Addition Course 1	VAC 1	---	2	Compulsory (choose any one)
	Value Addition Course 2	VAC 2	---	2	Compulsory (choose any one)
Credits of first semester				24	
2	Core course 3	Zoo -HC 503	Non-chordates II: Coelomates	4	Compulsory
	Core course 3 practical	ZOO-HC 503 P	,,	2	
	Core course 4	ZOO-HC 504	Cell Biology	4	
	Core course 4 practical	ZOO-HC 504 P	,,	2	
	Skill Enhancement Course 2	ZOO-SE 502	Sericulture / Medical Diagnostics	4	It can choose any one from the given courses
	Ability Enhancement	EVS-AE 2	Environmental Science	4	Compulsory
	Value Addition Course 3	VAC 3	---	2	Compulsory (choose any one)
	Value Addition Course 4	VAC 4	---	2	Compulsory (choose any one)
Credits of second semester				24	
3	Core course 5	ZOO-HC 601	Diversity of Chordates	4	Compulsory
	Core course 5 practical	ZOO-HC 601 P	,,	2	
	Core course 6	ZOO-HC 602	Physiology: Controlling and Coordinating Systems	4	
	Core course 6 practical	ZOO-HC 602 P	,,	2	
	Core course 7	ZOO-HC 603	Fundamentals of Biochemistry	4	
	Core course 7 practical	ZOO-HC 603 P	,,	2	
	Generic Elective 1	ZOO-HG 601	Animal Diversity	4	It can choose from other disciplines other than Zoology available in the college
	Generic Elective 1 practical	ZOO-HG 601 P	,,	2	
	Value Addition Course 5	VAC 5	---	2	Compulsory (choose any one)
	Credits of third semester			26	

4	Core course 8	ZOO-HC 604	Comparative Anatomy of Vertebrates	4	Compulsory
	Core course 8 practical	ZOO-HC 604 P	,,	2	
	Core course 9	ZOO-HC 605	Physiology: Life Sustaining systems	4	
	Core course 9 practical	ZOO-HC 605 P	,,	2	
	Core course 10	ZOO-HC 606	Biochemistry of Metabolic processes	4	
	Core course 10 practical	ZOO-HC 606 P	,,	2	
	Generic Elective 2	Zoo -HG 602	Human Physiology	4	It can choose from other disciplines other than Zoology available in the college
	Generic Elective 2 practical	ZOO-HG 602 P	,,	2	
	Value Addition Course 6	VAC 6	---	2	Compulsory (choose any one)
	Credits of fourth semester			26	
5	Core course 11	ZOO-HC 701	Molecular Biology	4	Compulsory
	Core course 11 practical	ZOO-HC 701 P	,,	2	
	Core course 12	ZOO-HC 702	Principles of Genetics	4	
	Core course 12 practical	ZOO-HC 702 P	,,	2	
	Discipline Specific Elective 1	ZOO-HE 701/ ZOO-HE 701/ ZOO-HE 701	Fish & Fisheries / Biology of Insecta / Microbiology	4	Compulsory (Choose any one)
	Discipline Specific Elective1Practical	ZOO-HE 701P/ ZOO-HE 701P/ ZOO-HE 701P	,,	2	
	Generic Elective 3	ZOO-HG 701	Environment and Public Health	4	It can choose from other disciplines other than Zoology available in the college
	Generic Elective 3 practical	ZOO-HG 701 P	,,	2	
	Value Addition Course 7	VAC 7	---	2	Compulsory (choose any one)
Credits of fifth semester				26	
6	Core course 13	ZOO-HC 703	Developmental Biology	4	Compulsory
	Core course 13 practical	ZOO–HC 703P	,,	2	
	Core course 14	ZOO-HC 704	Evolutionary Biology	4	
	Core course 14 practical	ZOO-HC 704 P	,,	2	
	Discipline Specific Elective 2	ZOO-HE 702/ ZOO-HE 702/ ZOO-HE 702	Parasitology/ Reproductive Biology/ Biotechniques	4	Compulsory (choose any one)
	Discipline Specific Elective 2 practical	ZOO-HE702 P/ ZOO-HE702 P/ ZOO-HE 702 P	,,	2	

	Generic Elective 4	ZOO-HG 702	Insect vectors and diseases	4	It can choose from other disciplines other than Zoology available in the college
	Generic Elective 4 practical	ZOO-HG 702 P	,,	2	
	Value Addition Course 8	VAC 8	---	4	Compulsory (choose any one)
Credits of sixed semester				26	
7	Core course 15	ZOO-HC 801	Animal Biotechnology	4	Compulsory
	Core course 15 practical	ZOO-HC 801 P	,,	2	
	Core course 16	ZOO-HC 802	Immunology	4	
	Core course 16 practical	ZOO-HC 802 P	,,	2	
	Discipline Specific Elective 3	ZOO-HE 801/ ZOO-HE 801/ ZOO-HE 801	Endocrinology/ Wild life Conservation & Management/ Research Methodology	4	Compulsory (Choose any one)
	Discipline Specific Elective 3 practical	ZOO-HE 801P/ ZOO-HE 801P/ ZOO-HE 801P	,,	2	
	Generic Elective 5	ZOO-HG 801	Aquatic Biology	4	Compulsory
	Generic Elective 5 practical	ZOO-HG 801P	,,	2	
Credits of seventh semester				24	
8	Core course 17	ZOO-HC 803	Animal behaviour and Chronobiology	4	Compulsory
	Core course 17 practical	ZOO-HC 803 P	,,	2	
	Core course 18	ZOO-HC 804	Biostatistics and Bioinformation	4	
	Core course 18 practical	ZOO-HC 804 P	,,	2	
	Discipline Specific Elective 4	ZOO-HE 802	Dissertation		Compulsory
	Generic Elective 6	Zoo-HG 802	Animal cell Biotechnology		Compulsory
	Generic Elective 6 practical	ZOO-HG 802 P	,,		
Credits of eighth semester				24	

HONOURS CORE COURSES	
CC I	Non-chordates I: Protista to Pseudocoelomates
CC II	Perspectives in Ecology
CC III	Non-chordates II: Coelomates
CC IV	Cell Biology
CC V	Diversity of Chordates
CC VI	Physiology: Controlling and Coordinating Systems
CC VII	Fundamentals of Biochemistry
CC VIII	Comparative Anatomy of Vertebrates
CC IX	Physiology: Life Sustaining Systems
CC X	Biochemistry of Metabolic Processes
CC XI	Molecular Biology
CC XII	Principles of Genetics
CC XIII	Developmental Biology
CC XIV	Evolutionary Biology
CC XV	Animal Biotechnology
CC XVI	Immunology
CC XVII	Animal behaviour (Ethology) and Chronobiology
CC XVIII	Biostatistics and Bioinformation

DISCIPLINE SPECIFIC ELECTIVE COURSES	
DSE 1	Fish and Fisheries
DSE 2	Biology of Insecta
DSE 3	Microbiology
DSE 4	Parasitology
DSE 5	Reproductive Biology
DSE 6	Biotechniques
DSE 7	Endocrinology
DSE 8	Wild Life Conservation and Management
DSE 9	Research Methodology

GENERIC ELECTIVE COURSES	
GE 1	Animal Diversity
GE 2	Human Physiology
GE 3	Environment and Public Health
GE 4	Insect vectors and diseases
GE 5	Aquatic biology
GE 6	Animal cell biotechnology

SKILL ENHANCEMENT COURSES	
SEC 1	Apiculture
SEC 2	Aquarium Fish Keeping
SEC 3	Sericulture
SEC 4	Medical Diagnostics

CORE COURSE I:

ZOO-HC 501: NON-CHORDATES I; PROTISTS TO PSEUDOCOELOMATES

Learning Objectives:

- To enable the students to develop an appreciation for the biodiversity of invertebrate species with impart knowledge about co-existence of different forms of living organisms ranging from unicellular to multicellular animals.

Learning Outcomes:

- On completion of the course the student should be able to know the general organization of Non-chordates as a group and know the taxonomy and characteristic features of the various Non-chordate phyla.
- The student should also understand the architecture and functions of a cell and its organelles.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Protista, Parazoa and Metazoa **20 marks 12 lectures**

General characteristics and Classification up to classes for Protista. Study of *Euglena, Amoeba* and *Paramecium*. Life cycle and pathogenicity of *Plasmodium vivax* and *Entamoeba histolytica*

Locomotion and Reproduction in Protista, General characters of Parazoa,

Evolution of symmetry and segmentation of Metazoa

Unit 2: Porifera **10 marks 6 lectures**

General characteristics and Classification up to classes

Canal system and spicules in sponges

Unit 3: Cnidaria and Ctenophora **20 marks 12 lectures**

General characteristics and Classification up to classes

Metagenesis in Obelia./ Polymorphism in Cnidaria. Corals and coral reefs

General characteristics and Evolutionary significance of Ctenophora.

Unit 4: Platyhelminthes **10 marks 6 lectures**

General characteristics and Classification up to classes.

Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*

Unit 5: Nemathelminthes **15 marks 9 lectures**

General characteristics and Classification up to classes

Morphology, Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*.

Parasitic adaptations in helminthes.

ZOO-HC 501 P: NON-CHORDATES I: PROTISTS TO PSEUDOCOELOMATES

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Study of whole mount of *Euglena, Amoeba and Paramecium,* Binary fission and Conjugation in *Paramecium; Miracidium larva, Sporocyst, Redia, Cercaria, Metacercaria larva of Fasciola*.	7
2. Study of *Sycon* (T.S. and L.S.), T. S. *Ascaris* (male and female)	3
3. Study of *Hyalonema, Euplectella, Spongilla Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora* One specimen/slide of any ctenophore.	8
4. Study of adult *Fasciola hepatica, Taenia solium* and their life cycles (Slides/micro-photographs). Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)	4
5. Practical record.	3

To submit a Project Report on any related topic on life cycles/coral/ coral reefs.

Note: Classification to be followed from "Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition"

SUGGESTED READINGS

- L.H. Hyman 'The Invertebrates' Vol I, II and V. – M.C. Graw Hill Company Ltd.
- Kotpal, R.L. 1988 - 1992 Protozoa, Porifera, Coelenterata, Helminthes, Arthropoda, Mollusca, Echinodermata. Rastogi Publications, Meerut.
- E.L. Jordan and P.S. Verma 'Invertebrate Zoology' S. Chand and Company.
- Parker, T.J. and Haswell 'A text book of Zoology' by, W.A., Mac Millan Co. London.
- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition
- . Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson

CORE COURSE II
ZOO-HC 502: PRINCIPLES OF ECOLOGY

Learning Objectives:

- To educate the students about the basic environmental phenomena like ecosystem, energy flow through the ecosystem and biogeochemical cycles. To enable the students, understand the adaptations of the animals to their environment

Learning Outcomes:

- Students understand anticipate, analyse and evaluate natural resource issues and act on a lifestyle that conserves nature.
- The students understand and appreciate the diversity of ecosystems and applies beyond the syllabi to understand the local lifestyle and problems of the community.
- The students will be able to link the intricacies of food chains, food webs and link it with human life for its betterment and for non-exploitation of the biotic and abiotic components.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction to Ecology **10 marks 6 lectures**

History of ecology, Autecology and synecology, Levels of organization,
Laws of limiting factors, Study of physical factors

Unit 2: Population **25 marks 15 lectures**

Unitary and Modular populations

Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion Exponential and logistic growth, r and K strategies Population regulation - density-dependent and independent factors.

Population interactions, Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition and Predation, functional and numerical responses.

Unit 3: Community **15 marks 9 lectures**

Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Ecotone and edge effect; Ecological succession with one example

Theories pertaining to climax community

Unit 4: Ecosystem **20 marks 12 lectures**

Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies.

Nutrient and biogeochemical cycle with one example of Nitrogen cycle Human modified ecosystem

Unit 5: Applied Ecology **5 marks 3 lectures**

Ecology in Wildlife Conservation and Management

ZOO-HC 502 P: PRINCIPLES OF ECOLOGY

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Making an ecosystem in a wide-mouthed bottle.	4
2. Determination of population density in a natural/hypothetical community by	
3. quadrate method and calculation of Shannon-Weiner diversity index for the	
4. same community. Studying insect diversity in a habitat	9
5. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO2	9
6. Practical record.	3

SUGGESTED READINGS

- M.P. Arora, 'Ecology' Himalaya Publishing company.
- P.D. Sharma, Environmental Biology'.
- P.R. Trivedi and Gurdeep Raj. 'Environmental Ecology'
- Veer Bala Rastogi, "Ecology and Animal Distribution"
- P.K. Gupta, "Text Book of Ecology and Environment"
- Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
- Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Robert Leo Smith Ecology and field biology Harper and Row publisher
- Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Pres

SKILL ENHANCEMENT COURSES

ZOO-SE 501: APICULTURE

Learning Objectives:

- To understand the knowledge of biology of bees and bee culture and also improve the standard of beekeeping amongst amateur beekeepers. To identify the disease found in bees and preventive measures. Give the knowledge of Bee Keeping, Modern Methods in employing artificial

Learning outcomes:

- After completing this programme, students will be able to Understand bee biology and behaviour, types of bees and Life cycle.
- Have an idea of beekeeping systems and beekeeping equipments, installation of hives tools.
- Bees plays an important in pollination of many flowering plants.
- Honey produced by apiculture which is a delicious and highly nutritious food.

THEORY (Credits 4 & 100 marks) (One lecture is equivalent to one hour duration)

Unit 1: Biology of Bees 20 marks 12 lectures

History, Classification and Biology of Honey Bee. Types of Honey Bees, morphological structure, Social Organization of Bee Colony, caste system and Biology of Honey Bees.

Unit 2: Rearing of Bees 25 marks 15 lectures

Bee rearing (Indigenous and Modern) Methods, Beehives – Newton and Langstroth Bee Pasturage, Selection of Bee Species for Apiculture, Bee Keeping Equipments, Methods of Extraction of Honey (Indigenous and Modern).

Unit 3: Diseases and Enemies 15 marks 9 lectures

Bee Diseases and Enemies Control and Preventive measures.

Unit 4: Bee Economy 25 marks 15 lectures

Products of Apiculture Industry: Composition and properties of Honey; Economic importance of Honey; Bee wax, Propolis, Royal jelly, Pollen and their uses. etc. Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens

Unit 5: Visit to a Apiculture industry / Bee rearing site and Submission of Project report.

15 marks 9 lectures

SUGGESTED READINGS

- Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
- Bisht D.S., Apiculture, ICAR Publication.
- Singh S., Beekeeping in India, Indian council of Agricultural Research, NewDelhi.

ZOO-SE 501: AQUARIUM FISH KEEPING

Learning objectives:

- To know the technique of rearing /maintaining fishes in an aquarium. To understand socio-economy and diversity of fishes and analyse the impact of the aquarium fish trade on social and natural. To give an idea of aquarium fishes, their types, sexes, etc. with preparation and composition of formulated fish feeds.

Learning outcomes:

- The students should be able to know the biology of aquarium fishes, their nutritional requirements and care.
- Can identify the equipment and requirements for setting up an aquarium.
- Maintaining good water quality is the single most important thing that an aquarium owner can do to ensure the health of their fish.
- Fishes are known to attract financial benefits and wealth.

THEORY (Credits 4 & 100 marks) (One lecture is equivalent to one hour duration)

Unit1: Introduction to Aquarium Fish Keeping 15 marks 9 lectures

The potential scope of Aquarium Fish Industry as a Cottage Industry, Exotic andEndemic species of Aquarium Fishes.

Unit 2: Biology of Aquarium Fishes 25 marks 15 lectures

Common characters and sexual dimorphism of Fresh water and Marine Aquarium fishes such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish, Butterfly fish Shark and Tiger shark. Aquarium fishes of Manipur.

Unit 3: Food, feeding and Transportation of Aquarium fishes 30 marks 18 lectures

Use of live fish feed organisms. Preparation and composition of formulated fish feeds, Different types of fish feeds.

Live fish transport - Fish handling, packing and forwarding techniques.

Unit 4: Maintenance of Aquarium 15 marks 9 lectures

General Aquarium maintenance, budget for setting up an Aquarium Fish Farm as a Cottage Industry.

Unit 5: Visit to a Aquarium cottage industry and Submission of Project report.

15 marks 9 lectures

SUGGESTED READINGS:

- Encyclopedia of Aquarium and Pond Fish, 1 October 2019 by David Alderton
- The Complete Aquarium Guide, 3 November 2005by Thierry Maite-Allain
- Eyewitness Handbook: Aquarium Fish, Flexibound – Import, 7 October 1993
  by Dick Mills
- Aquarium Fish: A Definitive Guide to Identifying and Keeping Freshwater and Marine Fishes Paperback – Illustrated, 1 May 2020
  by Gina Sandford

CORE COURSE III

ZOO-HC 503: NON-CHORDATES II: COELOMATES

Learning Objectives:

- To understand the Animal diversity around us with their principles of classification and terminology. To enable the students to understand the difference in their morphology and functional anatomy. To impart in depth knowledge to students about the different modes of living and structural modification acquired to suit varied living conditions.

Learning outcomes:

- The student will be able to understand classify and identify the diversity of animals with the importance of classification.
- The student knows his role in nature as a protector, preserver and promoter of life which he has achieved by learning, observing and understanding life.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction to Coelomates, Annelida **15 marks 9 lectures**

Evolution of coelom and metamerism. General characteristics and Classification up to classes. Excretion and Reproduction in Annelida. Trochophore larva – Structure, affinities and evolutionary significance.

Unit 2: Onychophora, Arthropoda **20 marks 12 lectures**

General characteristics and Evolutionary significance of Onychophora

General characteristics and Classification up to classes. Mouth parts of insects, Vision and Respiration in Arthropoda, Metamorphosis in Insects, Social life in bees and termites

Unit 3: Mollusca **15 marks 9 lectures**

General characteristics and Classification up to classes. Respiration in Mollusca, Torsion and detorsion in Gastropoda, Pearl formation in bivalves, Structure and affinities of Neopilina.

Unit 4: Echinodermata **15 marks 9 lectures**

General characteristics and Classification up to classes, Water-vascular system in Asteroidea, Larval forms in Echinodermata, Affinities with Chordates.

Unit 5: Minor Phyla **10 marks 6 lectures**

Introduction to Minor phyla, Distinguishing characters and examples of Nemertinea, Rotifera, Acanthocephala, Echiuroidea, Bryozoa, Brachiopoda, Sipunculida and Phoronida.

ZOO-HC 503 P: NON-CHORDATES II: COELOMATES

PRACTICAL (Credits 2 &25 marks); 15 lectures

		marks
1.	Study of following specimens: Annelids - *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Bonellia, Pheretima, Hirudinaria;* Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta, termites and honey bees.* Onychophora – *Peripatus.* Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus* Echinodermates - *Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria and Antedon.*	9
2.	Study of digestive and nervous system of *Pheritima and Periplaneta.*	6
3.	Temporary mounts – Mouth parts of Cockroach and mosquito. Spermatheca, septal nephridia and pharyngeal nephridia of earthworm, Parapodia of Neries.	4
4.	Study of permanent slides on T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm.	3
5.	Practical Record	3

Submission of Project Report on any related topic to larval forms (crustacean, mollusc and echinoderm)

Note: Classification to be followed from "Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition"

SUGGESTED READINGS

- L.H. Hyman 'The Invertebrates' Vol I, II and V. – M.C. Graw Hill Company Ltd.
- Kotpal, R.L. 1988 - 1992 Protozoa, Porifera, Coelenterata, Helminthes, Arthropoda, Mollusca, Echinodermata. Rastogi Publications, Meerut.
- E.L. Jordan and P.S. Verma 'Invertebrate Zoology' S. Chand and Company.
- Parker, T.J. and Haswell 'A text book of Zoology' by, W.A., Mac Millan Co. London.
- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition
- Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
- Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.

CORE COURSE IV

ZOO-HC 504: CELL BIOLOGY

Learning Objectives:

- Cell Biology deals with the detailed study of a cell including cell structure, cellcomposition, cell organelles and the interaction of cells with other cells and the larger environment in which they exist.

Learning outcomes:

- The students will understand the importance of cell as a structural and functional unit of life.
- The students understand and compare between the prokaryotic and eukaryotic system and extrapolates the life to the aspect of development.
- The dynamism of bio membranes indicates the dynamism of life. Its working mechanism and precision are responsible for our performance in life.
- The cellular mechanisms and its functioning depends on endo-membranes and structures. They are best studied with microscopy.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Overview of Cells and Plasma Membrane 22 marks 13 lectures

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions.

Various models of plasma membrane structure Transport across membranes: Active and Passive transport, Facilitated transport Cell junctions: Tight junctions, Desmosomes, Gap junctions

Unit 2: Endomembrane System 10 marks 6 lectures

Structure and Functions: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes.

Unit 3: Mitochondria and Peroxisomes 15 marks 9 lectures

Mitochondria: Structure and function of mitochondria, Semi-autonomous nature, Endo-symbiotic hypothesis, Chemi-osmotic hypothesis of mitochondria. Structure and function of Peroxisomes.

Unit 4: Cytoskeleton and Nucleus 18 marks 11 lectures

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments Unit Structure Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus. Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome).

Unit 5: Cell Division and Cell Signaling 10 marks 6 lectures

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

ZOO-HC 504 P: CELL BIOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.	6
2. Temporary and permanent squash preparation of testis of Grasshopper/Cockroach for the study of various stages of meiosis.	8
3. Study of permanent slide of various stages of meiosis.	4
4. Study of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.	4
5. Practical Record	3

SUGGESTED READINGS

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

SKILL ENHANCEMENT COURSES

ZOO-SE 502: SERICULTURE

Learning objectives:

- It also involves giving students a thorough knowledge about the cultivation of food plants, maintenance of the farm, seed technology, silkworm rearing and silk reeling. Train the students in identifying the diseases and pests of the food plants. Students get to learn about the quality of various things like leaf, seed cocoon, commercial cocoon and fibre so that they can get maximum return when actually practiced.

Learning outcomes:

- After completion of the course the students will be able to understand: Morphology of silkworm and its anatomical features like silk gland and secretion of silk.
- Scientific way of silkworm rearing technology of young and late age silkworm for raising assured cocoon crops.
- Must have an idea of characteristics of microbial organisms that causes diseases to silkworm. Control and prevention of pests and diseases.

THEORY (Credits 4 & 100 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction and Biology of Silkworm 25 marks 15 lectures

Sericulture: Definition, history and present status; Silk route

Types of silkworms, Distribution and Races - Exotic and indigenous races,

Mulberry and non-mulberry Sericulture

Life cycle of Mulberry and Tasar Silkworm, Structure of silk gland and secretion of silk.

Unit 2: Rearing of Silkworms 25 marks 15 lectures

Selection of mulberry variety and establishment of mulberry garden, Rearing house and rearing appliances

Disinfectants: Formalin, bleaching powder, Resham Keet Oushadh (RKO),

Silkworm rearing technology: Early age and Late age rearing, Description of types of mountages, Spinning, harvesting and storage of cocoons. Post cocoon processing – Stifling and reeling.

Unit 3: Pests and Diseases 20 marks 12 lectures

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates

Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial

Control and prevention of pests and diseases

Unit 4: Prospects of Sericulture in India: 15 marks 9 lectures

Sericulture industry in different states, potential in mulberry and non-mulberry sericulture.

Economic importance of silk.

Unit 5: Visit to various sericulture centres and Submission of Project report.

15 marks 9 lectures

SUGGESTED READINGS

- Manual on Sericulture; Food and Agriculture Organisation, Rome 1976
- Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB,Bangalore
- Silkworm Rearing and Disease of Silkworm, 1956, Ptd. By Director of Ptg., Stn. &Pub. Govt. Press, Bangalore
- Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR & TI, Mysore.
- Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub. Co.Ltd., Tokyo, Japan1972.
- Manual of Silkworm Egg Production; M. N. Narasimhanna, CSB, Bangalore 1988.
- Silkworm Rearing; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome 1988.
- A Guide for Bivoltine Sericulture; K. Sengupta, Director, CSR & TI, Mysore 1989.
- Improved Method of Rearing Young age silkworm; S. Krishnaswamy, reprinted CSB,Bangalore, 1986.

ZOO-SE 502: MEDICAL DIAGNOSTICS

Learning objectives:

- The Bachelor degree program in Clinical Laboratory Science at Indian University prepares graduates with the skills and experience needed to work in a clinical laboratory. Upon successful program completion, Clinical Laboratory Science graduates have the training to demonstrate the following entry-level competencies:

Learning outcomes:

- The student will be able to state the significance of nutrition and obesity in health promotion and disease prevention.
- The student will be able to prescribe an exercise program for a sedentary patient.
- The student will be able to recommend timely vaccinations based on age, medical conditions, lifestyle, and environment.

THEORY (Credits 4 & 100 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction and Diagnostics Methods Used for Analysis of Blood
25 marks 15 lectures

Medical Diagnostics and its Importance. Blood composition, Preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's stain, Platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.)

Unit 2: Diagnostic Methods Used for Urine Analysis **10 marks 6 lectures**

Urine Analysis: Physical characteristics; Abnormal constituents

Unit 3:Non-infectious Diseases **20 marks 12 lectures**

Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Testing of blood glucose using Glucometer/Kit

Unit 4: Infectious Diseases **15 marks 9 lectures**

Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis

Unit 5: Tumours **15 marks 9 lectures**

Types (Benign/Malignant), Detection and metastasis; Medical imaging: X-Ray of Bone fracture, PET, MRI and CT Scan (using photographs).

Unit 6:Visit to a diagnostic Lab. and Submission of Project report. **15 marks 9 lectures**

SUGGESTED READINGS

- Park, K. (2007), Preventive and Social Medicine, B.B. Publishers
- Godkar P.B. and Godkar D.P. Textbook of Medical Laboratory Technology, II Edition, Bhalani Publishing House
- Cheesbrough M., A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses
- Guyton A.C. and Hall J.E. Textbook of Medical Physiology, Saunders
- Robbins and Cortan, Pathologic Basis of Disease, VIIIEdition, Saunders
- Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

CORE COURSE V

ZOO-HC 601: DIVERSITY OF CHORDATA

Learning objectives:

- To make the students to identify the diversification of species of chordate world as well as the level of organization in chordate subphylum with evolutionary relationship among them. To understand the basic characters, different behaviours, advancements, adaptations of different types of vertebrates and affinities among different groups of higher vertebrates.

Learning outcomes:

- On completion of the course the student should be able to identify and classify the Chordates, unique characters of protochordates and other vertebrates.
- Also to understand the diversity and ecological role of different groups of chordates.
- Student should be able to recognize life functions of chordates.
- Understand the physiological and anatomical peculiarities through type study and also the ecological role of different groups of chordates.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction, Origin of Chordates, Protochordata 16 marks 10 lectures

General characteristics and outline classification of chordate.

Dipleurula concept and the Echinoderm theory of origin of chordates. Advanced features of vertebrates over Protochordata

General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata

Unit 2: Agnatha, Pisces 12 marks 7 lectures

General characteristics and classification of cyclostomes upto classes.

General characteristics of Chondrichthyes and Osteichthyes, classification up to order. Migration, Osmoregulation and Parental care in fishes.

Unit 3: Amphibia and Reptilia 15 marks 9 lectures

Origin of Tetrapoda (Evolution of terrestrial ectotherms); General characteristics and classification up to order; Parental care in Amphibians.

General characteristics and classification up to order; Affinities of *Sphenodon*; Poison apparatus and Biting mechanism in snakes.

Unit 4: Aves and Mammalia 20 marks 12 lectures

General characteristics and classification up to order. *Archaeopteryx* - a connecting link; Principles and aerodynamics of flight, Flight adaptations and Migration in birds.

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

Unit 5: Zoogeography **12 marks 7 lectures**

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

ZOO-HC 601 P: DIVERSITY OF CHORDATA

PRACTICALS (Credits 2 & 25 marks); 15 lectures

marks

1. Lower Chodates: **8**

(i) Protochordata: *Balanoglossus, Herdmania, Branchiostoma*, Colonial Urochordata. Sections of *Balanoglossus* through proboscis and branchiogenital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions, Permanent slide of *Herdmania* spicules found in the test.

(iii) **Agnatha:** *Petromyzon, Myxine*

(ii) Fishes: *Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas,*

2. Higher Chodates **9**

(i) Amphibia:*Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra.*

(ii) Reptilia:*Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus,* Key for Identification of poisonous and non-poisonous snakes

(iii) Aves: Study of six common birds from different orders. Types of beaks and claws

(iv) Mammalia:*Sorex, Bat* (Insectivorous and Frugivorous), *Funambulus, Slow Loris,* Duck-billed platypus, *Echidna.*

3. Dissection: Mount of weberian ossicles of *Mystus* / Carp, pecten from Fowl head. (Dissections and mounts subject to permission) 5

Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission)

4. Practical Record 3

Classification from Young, J. Z. (2004) to be followed

SUGGESTED READINGS

- Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
- Pough H. Vertebrate life, VIII Edition, Pearson International.
- Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub Co.
- Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

CORE COURSE VI

ZOO-HC 602: ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS

Learning Objectives:

- To enable the students, know about all the physiological processes controlling the human body, functions of hormones and their mechanism of action. To explain the role of nerve cells (neuron) in the transmission of nerve impulses. To analyse the role of some of the endocrine glands in regulating our growth and behaviour.

Learning Outcomes:

- On completion of the course the student should be able to know mechanism of body functions and the basic knowledge of chemistry of biomolecules.
- Students can enlist various sensory receptors in human body and describe the structure and functioning of the sense organs–eye, ear, nose, tongue and skin.
- Students can identify properties of hormones and mention their nature and manner of functioning.
- Know the effects of over functioning (hyperactivity) and hypoactivity (under functioning) of pituitary and thyroid.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Tissues, Bone and Cartilage 16 marks 10 lectures

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue.

Structure and types of bones and cartilages, Ossification, bone growth and resorption.

Unit 2: Nervous System 15 marks 9 lectures

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

Unit 3: Muscle 12 marks 7 lectures

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus.

Unit 4: Reproductive System 12 marks 7 lectures

Histology of testis and ovary; Physiology of male and female reproduction; Puberty, Methods of contraception in male and female.

Unit 5: Endocrine System **20 marks 12 lectures**

Structure of endocrine glands - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them and their mechanism of action; Classification of hormones: steroidal and non-steroidal hormones; Regulation of hormone secretion; Hypothalamus (neuroendocrine gland) - principal nuclei involved in neuroendocrine control of anterior pituitary and endocrine system; Placental hormones

ZOO-HC 602 P: ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Recording of simple muscle twitch with electrical stimulation (or Virtual). Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex) or (Virtual).	3
2. Study of permanent slides of Mammalian skin, Squamous epithelium, Striated muscle fibres and nerve cells, Cartilage, Bone, Spinal cord, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid	8
3. Microtomy: Preparation of permanent slide of any five vertebrate tissues	8
4. Submission of histological slides.	3
5. Practical record	3

(*Subject to UGC guidelines)

SUGGESTED BOOKS

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.

CORE COURSE VII

ZOO-HC 603: FUNDAMENTALS OF BIOCHEMISTRY

Learning objectives:

- Ability to understand basic principles of chemistry to biological systems and molecular biology. To acquaint the students with the structure, chemical properties and biological significance of macromolecules of physiological importance.

Learning outcomes:

- Understand the principles of various fields of chemistry and biology (organic chemistry, analytical chemistry, biochemistry, genetics, metabolism, and molecular biology).
- Apply modern instrumentation theory and practice to biochemical problems.
- On completion of the course the student should be able to know mechanism of body functions and the basic knowledge of chemistry of biomolecule.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Carbohydrates 10 marks 6 lectures

Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates

Unit 2: Lipids 10 marks 6 lectures

Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids

Unit 3: Proteins 20 marks 12 lectures

Amino acids: Structure, Classification and General properties of α-amino acids; Physiological importance of essential and non-essential α-amino acids

Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins

Immunoglobulins: Basic Structure, Classes and Function, Antigenic Determinants.

Unit 4: Nucleic Acids 15 marks 9 lectures

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids Cot Curves: Base pairing, Denaturation and Renaturation of DNA Types of DNA and RNA, Complementarity of DNA, Hpyo, Hyperchromaticity of DNA denaturation.

Unit 5: Enzymes 20 marks 12 lectures

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

ZOO-603 P: FUNDAMENTALS OF BIOCHEMISTRY

PRACTICAL (Credits 2 & 25 marks); **15 lectures**

	marks
1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.	8
2. Paper chromatography of amino acids.	5
3. Effect of pH, temperature and inhibitors on the action of salivary amylase.	5
4. Demonstration of proteins separation by SDS-PAGE.	4
5. Practical Record.	3

SUGGESTED READING

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

GENERIC ELECTIVE COURSES

ZOO-HG 601: ANIMAL DIVERSITY

Learning Objectives:

- To impart knowledge about co-existence of different forms of living organisms ranging from unicellular to multicellular animals with biodiversity. To understand the terminology needed in classification, the possible group of the invertebrate observed in nature and our role as a caretaker and promoter of life.

Learning outcomes:

- The student will be able to understand classify and identify the diversity of animals.
- The student understands the importance of classification of animals and classifies them effectively using the six levels of classification.
- The student knows his role in nature as a protector, preserver and promoter of life which he has achieved by learning, observing and understanding life.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1. Protista, Porifera, Radiata **15 marks 9 lectures**

General characters of Protozoa; Life cycle of Plasmodium; General characters and canal system in Porifera; General characters of Cnidarians and polymorphism

Unit 2. Aceolomates, Pseudocoelomates, Coelomate Protostomes **15 marks 9 lectures**

General characters of Platyhelminthes; Life cycle of Taenia solium; General characters of Nemathehelminthes; Parasitic adaptations; General characters of Annelida ; Metamerism.

Unit 3. Arthropoda, Mollusca, Coelomate Deuterostomes. **15 marks 9 lectures**

General characters. Social life in insects; General characters of mollusca; Pearl Formation; General characters of Echinodermata, Water Vascular system in Starfish.

Unit 4. Protochordata, Pisces. **10 marks 6 lectures**

Salient features of Protochordata; Osmoregulation in fishes, Migration of Fishes

Unit 5. Amphibia, Amniotes, Aves, Mammalia **20 marks 12 lectures**

General characters, Adaptations for terrestrial life, Parental care in Amphibia; Origin of reptiles. Terrestrial adaptations in reptiles; The origin of birds, Flight adaptations; Early evolution of mammals; Primates; Dentition in mammals.

ZOO-HG 601 P: ANIMAL DIVERSITY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

marks

1. Study of following specimens:

Non Chordates: *Euglena, Noctiluca, Paramecium, Sycon, , Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, , Hermitcrab, Daphnia, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias, and Antedon.*

Chordates: *Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx,* any three common birds-(Crow, duck, Owl), Squirrel and Bat. 8

2. Study of following Permanent Slides: Cross section of Sycon, Ascaris (male and female). T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva. 3
3. Temporary mounts of Septal & pharyngeal nephridia of earthworm. Unstained mounts of Placoid, cycloid and ctenoid scales. 4
4. Dissections of Digestive and nervous system of Cockroach. Urinogenital system of Rat. 7
5. Practical record. 3

SUGGESTED BOOKS

- Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
- Ruppert, Fox and Barnes (2006) Invertebrate Zoology. A functional Evolutionary Approach 7th Edition, Thomson Books/Cole
- Campbell & Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
- Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.
- Raven, P. H. and Johnson, G. B. (2004). Biology, 6th edition, Tata McGraw Hill Publications. New Delhi.

CORE COURSEVIII

ZOO-HC 604: COMPARATIVE ANATOMY OF VERTEBRATES

Learning Objectives:

- Study relationships between the structural and functional anatomy of the different vertebrate groups and their environment are examined. The comparative study of the body structures of different species of animals in order to understand the adaptive changes they have undergone in the course of evolution from common ancestors. To understand the compare of homologous structures of different species specially forelimbs.

Learning Outcomes:

- The students should be able to understand the characteristics of vertebrates and what makes both chordates and vertebrates unique among animals.
- They can also understand of the evolutionary history of vertebrates and the evolutionary relationships among different groups of vertebrates.
- It also assists in classifying the organisms based on similar characteristics of their anatomical structures.
- Homologies of the forelimb among vertebrates give the evidence for evolution.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Integumentary System **7 marks 4 lectures**

Structure, functions and derivatives of integument

Unit 2: Skeletal System **10 marks 6 lectures**

Overview of axial and appendicular skeleton, Jaw suspensorium, Visceral arches

Unit 3: Digestive System and Respiratory System **20 marks 12 lectures**

Alimentary canal and associated glands, dentition; Respiration through Skin, gills, lungs and air sacs; Accessory respiratory organs

Unit 4: Circulatory System and Urinogenital System **20 marks 12 lectures**

General plan of circulation, evolution of heart and aortic arches; Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri

Unit 5: Nervous System and Sense Organs **18 marks 11 lectures**

Comparative account of brain, Autonomic nervous system, Spinal cord, Cranial nerves in mammals. Classification of receptors Brief account of visual and auditory receptors in man

ZOO-HC 604 P: COMPARATIVE ANATOMY OF VERTEBRATES

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Study of placoid, cycloid and ctenoid scales through permanent slides/ photographs	4
2. Study of bones: Mammalian skulls: One herbivorous and one carnivorous animal. Disarticulated skeleton of Frog, Varanus / Calotes, Fowl, Rabbit	10
3. Carapace and plastron of turtle /tortoise	3
4. Dissection of rat to study arterial and urinogenital system(subject to permission) Study of structure of any two organs (heart, lung, kidney, eye and ear) from model / video recording (may be included if dissection not permitted)	5
5. Practical record.	3

Project on skeletal modifications in vertebrates (may be included if dissection not permitted)

SUGGESTED READINGS

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

CORE COURSE IX

ZOO-HC 605: ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS

Learning Objectives:

- To understand the proper animal physiology and evaluating underlying biological processes, behavioural states and animal response to different biological, and environmental stimuli. It will provide a thorough understanding of normal body function, enabling more effective treatment of abnormal or disease states.

Learning Outcomes:

- On completion of the course, students should be able to know mechanism of body functions and the basic knowledge of chemistry of biomolecules.
- This course provides the study of life sustaining in mammals, principally human.
- It investigates the biological processes that occur for animal life to exist. These processes can be studied at various levels of organization from membranes through to organelles, cells, organs, organ systems, and to the whole animal.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Physiology of Digestion 16 marks 10 lectures

Structure and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

Unit 2: Physiology of Respiration 16 marks 9 lectures

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration

Unit 3: Renal Physiology: 10 marks 6 lectures

Structure of kidney and its functional unit; Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance.

Unit 4: Blood: 15 marks 9 lectures

Components of blood and their functions; Structure and functions of haemoglobin Haemostasis: Blood clotting system, Kallikrein-Kinninogen system, Complement system & Fibrinolytic system, Haemopoiesis Blood groups: Rh factor, ABO and MN.

Unit 5: Physiology of Heart 18 marks 11 lectures

Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation.

ZOO-HC 605 P: ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Determination of ABO Blood group.	3
2. Enumeration of red blood cells and white blood cells using haemocytometer Estimation of haemoglobin using Sahli's haemoglobinometer, Preparation of haemin and haemochromogen crystals	8
3. Recording of frog's heart beat under in situ and perfused conditions	4
4. Recording of blood pressure using a sphygmomanometer	3
5. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney	4
6. Practical record.	3

(*Subject to UGC guidelines)

SUGGESTED READINGS

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.
- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills

CORE COURSE X

ZOO-HC 606: BIOCHEMISTRY OF METABOLIC PROCESSES

Learning Objectives:

- To describe, in quantitative terms, the chemical changes catalyzed by the component enzymes of the route in mammalian body. To describe the various intracellular controls that govern the rate at which the pathway functions. To understand the various biomolecules in body and the functions of biomolecules in body secretion. To understand the structural chemistry of proteins, carbohydrates, fats.

Learning Outcomes:

- The student should be able to understand intricacies of Biochemistry and Its role in metabolic processes.
- Students are able to understand the physiology at cellular and system levels.
- Students are able to describe the role and functions of different biomolecules.
- Biochemical studies have yielded such benefits as treatments for many metabolic diseases, antibiotics to combat bacteria and methods to boost industrial and agricultural productivity.
- Students are able to understand how mammalian body get nutrition from different biomolecule.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Overview of Metabolism 18 marks 12 lectures

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

Unit 2: Carbohydrate Metabolism 15 marks 9 lectures

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis

Unit 3: Lipid Metabolism 14 marks 8 lectures

β-oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis.

Unit 4: Protein Metabolism 14 marks 8 lectures

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids

Unit 5: Oxidative Phosphorylation 14 marks 8 lectures

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

ZOO-HC 606 P: BIOCHEMISTRY OF METABOLIC PROCESS

PRACTICALS (Credits 2 & 25 marks); 15 lectures

1. Determination of Total carbohydrate by Anthrone Method. 4
2. Estimation of total protein in given solutions by Lowry's method. 6
3. Determination of free fatty acids. 4
4. Detection of serum glutamic-oxaloacetic transaminase (SGOT) and Serum Glutamic Pyruvic Transaminase (SGPT) or Glucose screening tests (GST) and Glutathione (GSH) in serum/ tissue 4
5. To study the enzymatic activity of Trypsin and Lipase. / Study of biological oxidation (SDH) [any mammal] / To perform the Acid and Alkaline phosphatase assay from serum / tissue. 4
6. Practical record. 3

SUGGESTED READINGS

- Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
- Jain, J. L., Sunjay Jain, and Jain Nitin (2016) Fundamentals of biochemistry, S. Chand and Company limited, New Delhi.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.

GENERIC ELECTIVE COURSES

ZOO-HG 602: HUMAN PHYSIOLOGY

Learning objectives:

- The primary objective of the human Physiology course is to ensure that students understand how the body works. State the functions of each organ system of the body. Explain the mechanisms by which each function relates the anatomy and histology of each organ system.

Learning outcomes:

- At the end of the course students should have an enhanced knowledge and appreciation of mammalian physiology.
- understand the functions of important physiological systems including the cardio-respiratory, renal, reproductive and metabolic systems.
- understand how these separate systems interact to yield integrated physiological responses to challenges such as exercise, fasting and ascent to high altitude & how they can sometimes fail.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Digestion and Absorption of Food 12 marks 7 lectures

Structure and function of digestive glands; Digestion and absorption of carbohydrates, fats and proteins; Nervous and hormonal control of digestion (*in brief*)

Unit 2: Functioning of Excitable Tissue (Nerve and Muscle) 13 marks 8 lectures

Structure of neuron, Propagation of nerve impulse (myelinated and non-myelinated nerve fibre); Structure of skeletal muscle, Mechanism of muscle contraction (Sliding filament theory), Neuromuscular junction

Unit 3: Respiratory and Cardiovascular Physiology 20 marks 12 lectures

Ventilation, External and internal Respiration, Transport of oxygen and carbon dioxide in blood, Factors affecting transport of gases.

Structure of heart, Coordination of heartbeat, Cardiac cycle, ECG.

Unit 4: Renal Physiology 10 marks 6 lectures

Functional anatomy of kidney, Mechanism and regulation of urine formation,

Unit 5: Endocrine and Reproductive Physiology 20 marks 12 lectures

Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes), Brief account of spermatogenesis and oogenesis, Menstrual cycle.

ZOO-HG 602 P: HUMAN PHYSIOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Preparation of temporary mounts: Neurons and Blood film.	5
2. Preparation of haemin and haemochromogen crystals. Estimation of haemoglobin using Sahli's haemoglobinometer.	7
3. Examination of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney, thyroid, pancreas, adrenal, testis, ovary.	10
4. Practical record.	3

SUGGESTED READINGS

- Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley and Sons, Inc.
- Widmaier, E.P., Raff, H. and Strang, K.T. (2008). Vander's Human Physiology, XI Edition, McGraw Hill.
- Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
- Marieb, E. (1998). Human Anatomy and Physiology, IV Edition, Addison-Wesley.
- Kesar, S. and Vashisht, N. (2007). Experimental Physiology, Heritage Publishers.
- Prakash, G. (2012). Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Company Ltd.

CORE COURSE XI

ZOO-HC 701: MOLECULAR BIOLOGY

Learning Objectives:

- To understand the principles of inheritance from molecular mechanisms and evolution as the central unifying concept in biological sciences. To make the students understand the organization of the genetic material and its evolution, genetic code and the basic principles of genetics.

Learning Outcomes:

- The student should be able to appreciate and know the genes and molecular biology in terms of evolution of the major groups of organisms.
- Get well versed in recombinant DNA technology which holds application in biomedical & genomic science,

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Nucleic Acids and DNA Replication 18 marks 11 lectures

Salient features of DNA and RNA Watson and Crick model of DNA; DNA Replication in prokaryotes and eukaryotes, mechanism of DNA replication, Semi-conservative, bidirectional and semi-discontinuous replication, RNA priming, Replication of circular and linear ds-DNA, replication of telomeres

Unit 2: Transcription and Post Transcriptional Modifications and Processing of Eukaryotic RNA 20 marks 12 lectures

RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors; Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of tRNA

Unit 3: Translation 15 marks 9 lectures

Genetic code, Degeneracy of the genetic code and Wobble Hypothesis; Process of protein synthesis in prokaryotes: Ribosome structure and assembly in prokaryotes, fidelity of protein synthesis, aminoacyltRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation

Unit 4: Gene Regulation 12 marks 7 lectures

Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from lac operon and trp operon; Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing, Genetic imprinting.

Unit 5: DNA Repair Mechanisms and Regulatory RNAs 10 marks 6 lectures

Pyrimidine dimerization and mismatch repair; Ribo-switches, RNA interference, miRNA, siRNA.

ZOO-HC 701 P: MOLECULAR BIOLOGY

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Study of Polythene chromosomes from Chironomous / Drosophila larvae	4
2. Preparation of liquid culture medium (LB) and raise culture of E. coli	4
3. Estimation of the growth kinetics of E. coli by turbidity method	4
4. Quantitative estimation of salmon sperm / ox / pig /calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement)	4
5. Study and interpretation of electron micrographs/ photograph showing (a) DNA replication (b) Transcription (c) Split genes	6
5. Practical record	3

SUGGESTED READINGS

- Arora, M. P. (2000) Organic Evolution. 2nd Ed. Himalaya Publishing House, Mumbai.
- Becker, W. M., Kleinsmith, L. J., Hardin. J. and G. P., Bertoni, (2009) The World of the Cell. 7th Ed. Pearson Benjamin Cummings Publishing, San Francisco.
- De Robertis, E. D. P. and E. M. F. De Robertis, (2006) Cell and Molecular Biology.8th Ed. Lippincott Williams and Wilkins, Philadelphia.
- Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th Ed. John Wiley and Sons.Inc.
- McLennan A., Bates A., Turner, P and M. White, (2015) Molecular Biology. 4th Ed. GS, Taylor and Francis Group, New York and London.
- Rastogi, V. B., (1998) Organic Evolution. 11th Ed. KedarNath Ram Nath, Meerut.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: Molecular Biology of the Cell, IV Edition.
- Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
- Lewin B. (2008). Gene XI, Jones and Bartlett

CORE COURSE XII

ZOO-HC 702: PRINCIPLES OF GENETICS

Learning Objectives:

- This course covers genetics, the science of heredity from its basic principles to the mostrecent advances in the field. Imparts basic knowledge of classical (transmission) andmolecular genetics.

Learning Outcomes:

- Comprehensive, detailed understanding of the chemical basis of heredity.
- Comprehensive and detailed understanding of genetic methodology and how quantification of heritable traits in families and populations provides insight into cellular and molecular mechanisms.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Mendelian Genetics and its Extension 10 marks 6 lectures

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

Unit 2: Linkage, Crossing Over and Chromosomal Mapping 14 marks 8 lectures

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

Unit 3: Mutations and Sex Determination 17 marks 11 lectures

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method, attached X method.

Chromosomal mechanisms of sex determination in Drosophila and Man

Unit 4: Extra-chromosomal Inheritance and Polygenic Inheritance 14 marks 8 lectures

Criteria for extra-chromosomal inheritance, Antibiotic resistance in Chlamydomonas, Mitochondrial mutations in Saccharomyces,

Infective heredity in *Paramecium* and Maternal effects Polygenic inheritance with suitable examples; simple numericals based on it.

Unit 5: Recombination in Bacteria and Viruses and Transposable Genetic Elements 20 marks 12 lectures

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage

Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans.

ZOO-HC 702 P: PRINCIPLES OF GENETICS

PRACTICALS (Credits 2 & 25 marks); 15 lectures

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

SUGGESTED READINGS

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

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)

ZOO-HE 701: FISH AND FISHERIES

Learning objectives:

- To provide students the morphology and physiology of fishes with theoretical and practical understanding of fisheries and Problems and Prospects in Fisheries.

Learning Outcomes:

- The student should be able to understand structure, function and behaviour of fishes as well as physiology of fishes.
- Have the idea of fisheries with laws and regulations in improving human welfare.
- The student should be able to understand a knowledge about aquaculture.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

UNIT 1: Introduction and Classification: 8 marks 5 lectures

General description of fish; Account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction.

UNIT 2: Morphology and Physiology: 20 marks 12 lectures

Types of fins and their modifications; Locomotion in fishes; Hydrodynamics; Types of Scales, Use of scales in Classification and determination of age of fish; Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy; Osmoregulation in Elasmobranchs; Reproductive strategies (special reference to Indian fishes); Electric organs; Bioluminiscience; Mechanoreceptors; Schooling; Parental care; Migration

UNIT 3: Fisheries 15 marks 9 lectures

Inland Fisheries; Marine Fisheries; Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal; Fishing crafts and Gears; Depletion of fisheries resources; Application of remote sensing and GIS (geographic information system) in fisheries; Fisheries law and regulations

Unit 4: Aquaculture 20 marks 12 lectures

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish; Management of finfish hatcheries; Preparation and maintenance of fish aquarium; Preparation of compound diets for fish; Role of water quality in aquaculture;

UNIT 5: Problems and Prospects in Fisheries 12 marks 7 lectures

Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products. Transgenic fish, Zebra fish as a model organism in research.

ZOO-HE 701 P: FISH AND FISHERIES

PRACTICAL (Credits 2 & 25 marks); 15 lectures

		marks
1.	Morphometric and meristic characters of fishes.	5
2.	Study of *Petromyzon, Myxine, Pristis, Chimaera, Exocoetus, Hippocampus, Gambusia, Labeo, Heteropneustes, Anabas.*	4
3.	Study of different types of scales (through permanent slides/ photographs).	2
4.	Dissection: Accessory respiratory organ in *Channa / Anabas / Clarias*.	3
5.	Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids.	3
6.	Demonstration of induced breeding in Fishes (video). Demonstration of parental care in fishes (video).	
7.	Practical record.	3
8.	Field Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.	5

SUGGESTED READINGS

- Q Bone and R Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.
- D. H. Evans and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor.The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
- C.B.L. Srivastava, Fish Biology, Narendra Publishing House
- J.R. Norman, A history of Fishes, Hill and Wang Publishers
- S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra• Publishing House

ZOO-HE 701: BIOLOGY OF INSECTA

Learning Objectives:

- To understand different types of insects and what conditions affect the growth and decline of their populations. To study of insects serves as the basis for developments in biological and chemical pest control, food production and storage, pharmaceuticals epidemiology, biological diversity, and a variety of other fields of science. Insect is crucial to our understanding of human disease, agriculture, evolution, ecology and biodiversity.

Learning Outcomes:

- It gives a solid foundation in insect biology, including general entomology, basic systematics, morphology, physiology, and biodiversity.
- Understand evolution and biodiversity generation through macro- and micro-evolutionary processes, including how these processes have formed and diversified insects.
- Gain appreciation of insects in society and human affairs and as model systems in insect biology and insect vectors.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction and Insect Taxonomy 12 marks 7 lectures

General Features of Insects. Distribution and Success of Insects on the Earth

Basis of insect classification; Classification of insects up to orders

Unit 2: General Morphology of Insects 10 marks 6 lectures

External Features; Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits

Thorax: Wings and wing articulation, Types of Legs adapted to diverse habitat

Abdominal appendages and genitalia

Unit 3: Physiology of Insects 30 marks 18 lectures

Structure and physiology of Insect body systems - Integumentary, digestive, excretory, circulatory, respiratory, endocrine, reproductive, and nervous system. Sensory receptors

Growth and metamorphosis

Unit 4: Insect Society 8 marks 5 lectures

Group of social insects and their social life

Social organization and social behaviour (w.r.t. any one example)

Unit 5: Insect Plant Interaction and Insects as Vectors 15 marks 9 lectures

Theory of co-evolution, role of allelochemicals in host plant mediation

Host-plant selection by phytophagous insects, Insects as plant pests

Insects as mechanical and Biological vectors, Brief discussion on houseflies and mosquitoes as important insect vectors.

ZOO-HE 701 P: BIOLOGY OF INSECTA

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Study of one specimen from each insect order.	4
2. Study of different kinds of antennae, legs, wings and their venation, spiracles and mouth parts of insects. Study of head and sclerites of any one insect.	3
3. Methodology of collection, preservation and identification of insects.	3
4. Morphological studies of various castes of Apis, Camponotus and Odontotermes.	3
5. Study of any three insect pests and any three beneficial insects	4
6. Practical record.	3
7. Field study of insects and submission of a report on the insect diversity	5

SUGGESTED READINGS

- A general text book of entomology, Imms , A. D., Chapman & Hall, UK
- The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK
- Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
- Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F., M Saunders College Publication, USA
- The Insect Societies, Wilson, E. O., Harward Univ. Press, UK
- Physiological system in Insects, Klowden, M. J., Academic Press, USA
- Tambre: Entomology

ZOO-HE 701: MICROBIOLOGY

Learning Objectives:

- The course provides an insight into the immense importance of the microbes around us. Their uses and benefits outweigh their harmful aspects. It focuses on the role of microbes in waste management and environmental restoration.

Learning outcomes:

- After successfully completing this course, the students will be able to develop understanding on the microbiology diversity, processes and applications in the environment.
- Analyse the contribution of microbiology area of science in water treatment, solid waste management, bioremediation and phytoremediation.
- Apply the skills for environmental protection

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1 : Introduction to Microbiology: 10 marks 6 lectures

History of microbiology; Application of microbiology: Food and industry, microbes in genetic engineering and biotechnology, microbes in medical microbiology, microbes in Agriculture, microbes in bioterrorism,

Unit 2: Classification of Microrganisms: 10 marks 6 lectures

Concept of microbial species; Different types of Classification: (Five kingdom system, Eight kingdom system, Three domain system), Classification and identification of Bacteria.

Unit 3: Methods in microbiology: 15 marks 9 lectures

Culture of microorganism: mixed culture – physical, chemical and biological methods; Isolation: Methods of isolation, maintenance of pure culture- use of micromanipulator, isolation by exposure to air, isolation by streaking or streak plate technique, isolation by using selective or enrichment media.

Unit 4: Culture characteristics 10 marks 6 lectures

Colony appearance, colony forms, colony elevation, colony margin, optical density, colour, colony order, colony consistency.

Unit 4: Microbial ecology 15 marks 9 lectures

Ecological group of organism; Extremophiles; Soil, water and air microbiology.

Unit 5: Environmental Microbiology 15 marks 9 lectures

Organic compost; Biogas production; sewage treatment; Biodegradation.

ZOO-HE 701 P: MICROBIOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Preparation of culture and selective media for studying bacterial growth .	5
2. Isolation of microbs by exposure to air	4
3. Isolation by streaking or streak plate technique.	4
4. Process of cleaning and disinfecting of the glassware/ plastic ware.	4
5. Practical record.	3
6. Field study tour at any microbiological lab.	5

Recommended readings

- Sharma, P. D. (2005). Environmental Microbiology. Alpha Science International Ltd. ISBN. 1842652761
- Bertrand, J. C., Caumetter, P., Laboron, R., Matheron, R., Normand, P., SIme-Nganda. (2015). Environmental Microbiology: Fundamental and Applications of Microbial Ecology. Editor: Springer
- Pepper, I.; Gerba, C. and Gentry, T. (2014). Environmental Microbiology Academic Press.
- Pradipta, K. and Mohapatra, I. K. (2008). Text book of Environmental Microbiology.

GENERIC ELECTIVE COURSES

ZOO-HG 701: ENVIRONMENT AND PUBLIC HEALTH

Learning Objectives:

- Environmental education is a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment. As a result, individuals develop a deeper understanding of environmental issues and have the skills to make informed and responsible decisions

Learning outcomes:

- After the completion of the course, students will be able to understand environmental pollution, global warming, climate change and its effects.
- Students will be able to understand interrelationships between a multitude of factors that can impact on a public health problem, including scientific, medical, environmental factors.
- Have understanding different types of diseases.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

UNIT 1: Introduction **13 marks 8 lectures**

Sources of Environmental hazards, hazard identification and accounting, fate of toxic and persistent substances in the environment, dose Response Evaluation, exposure Assessment.

UNIT 2: Climate Change **12 marks 7 lecturers**

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, Effect of climate change on public health

Unit 3: Pollution **10 marks 6 lectures**

Air, water, noise pollution sources and effects, Pollution control

Unit 4: Waste Management Technologies **25 marks 15 lectures**

Sources of waste, types and characteristics, Sewage disposal and its management,
Solid waste disposal, Biomedical waste handling and disposal, Nuclear waste handling and disposal, Waste from thermal power plants, Case histories on Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident and their aftermath.

Unit 5: Diseases **15 marks 9 lectures**

Causes, symptoms and control of tuberculosis, Asthma, Cholera, Minamata disease, typhoid

ZOO-HG 701 P: ENVIRONMENT AND PUBLIC HEALTH

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. To determine the pH of the given soil and water samples from different locations.	5
2. To determine the Free Cl of the given soil and water sample from different locations.	5
3. To determine the Free SO_4 of the given soil and water sample from different locations.	6
4. To determine the Free NO_3 of the given soil and water sample from different locations.	6
5. Practical record.	3

SUGGESTED BOOKS

- Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt.Ltd., New Delhi, 1999.
- Kolluru Rao, Bartell Steven, Pitblado R and Stricoff "Risk Assessmentand Management Handbook", McGraw Hill Inc., New York,1996.
- Kofi Asante Duah "Risk Assessment in Environmental management",John Wiley and sons, Singapore, 1998.
- Kasperson, J.X. and Kasperson, R.E. and Kasperson,R.E., GlobalEnvironmental Risks, V.N.University Press, New York, 2003.
- Joseph F Louvar and B Diane Louver Health and Environmental RiskAnalysis fundamentals with applications, Prentice Hall, New Jersey 1997.

CORE COURSE XIII

ZOO-HC 703: DEVELOPMENTAL BIOLOGY

Learning Objectives:

- To enable the students understand the processes of development in various animals and the phenomena associated with them. It also aims to make students understand the genetic involvement and the role of maternal environment on fetal development.

Learning Objectives:

- It aims to understand how a single cell becomes an organized grouping of cells that is then programmed at specific times to become specialized for certain tasks.
- It helps to understand the molecular, genetic, cellular, and integrative aspects of building an organism. Knowledge of normal developmental processes can aid in the understanding of developmental abnormalities and other conditions such as cancer.
- Concept of in vitro fertilization.

THEORY(Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction **10 marks 6 lectures**

Historical review and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants.

Unit 2: Early Embryonic Development **30 marks 18 lectures**

Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula;

Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers

Unit 3: Late Embryonic Development **10 marks 6 lectures**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta)

Unit 4: Post Embryonic Development **15 marks 9 lectures**

Metamorphosis: Changes of organisation in Amphibia, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories

Unit 5: Implications of Developmental Biology **10 marks 6 lectures**

Teratogenesis: Teratogenic agents and their effects on embryonic development; In vitro fertilization, Stem cell (ESC), Amniocentesis.

ZOO-HC 703 P: DEVELOPMENTAL BIOLOGY

PRACTICALS (Credits 2 & 25 marks); 15 lectures

		marks
1.	Study of whole mounts and sections of developmental stages of frog through	
2.	permanent slides: Cleavage stages, blastula, gastrula, neurula. Study of whole mounts tail-bud stage, tadpole (external and internal gill stages	7
3.	Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)	7
4.	Study of the developmental stages and life cycle of Drosophila from stock culture.	5
5.	Study of different sections of placenta (photomicropgraph/ slides)	3
6.	Practical record.	3

Project report on Drosophila culture/chick embryo development

SUGGESTED READINGS

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

CORE COURSE XIV

ZOO-HC 704: EVOLUTIONARY BIOLOGY

Learning Objectives:

- To enable the students understand the mechanism and process of origin and evolution of life on earth. It also aims to educate the students about population genetics and its phylogeny.

Learning Outcomes:

- Evolutionary biology provides the key to understanding the principles governing the origin and extinction of species.
- It provides causal explanations, based on history and on processes of genetic change and adaptation, for the full sweep of biological phenomena ranging from the molecular to the ecological.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Life's Beginnings and Historical review of evolutionary concept

14 marks 9 lectures

Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes

Lamarckism, Darwinism, Neo-Darwinism

Unit 2: Evidences of Evolution and Sources of variations 22 marks 13 lectures

Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse,

Molecular (universality of genetic code and protein synthesising machinery, three domains of life, neutral theory of molecular evolution, example of globin gene family, rRNA/cyt c.

Heritable variations and their role in evolution

Unit 3: Population genetics: 15 marks 9 lectures

Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working; types of selection: kin selection, sexual selection. density-dependent selection, heterozygous superiority, adaptive resemblances, Genetic Drift (mechanism, founder's effect, bottledneck phenomenon; Role of Migration and Mutation in changing allele frequencies

Unit 4: Product of evolution and Extinctions 12 marks 7 lectures

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation-allopatric, sympatric; Adaptive radiation / macroevolution exemplified by Galapagos finches**.**

Back ground and mass extinctions (causes and effects), detailed example of K-T extinction.

Unit 5: Origin, evolution and Phylogenetic trees 12 marks 7 lectures

Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from Dryopithecus leading to Homo sapiens, molecular analysis of human origin;

Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees.

ZOO-HC 704 P:EVOLUTIONARY BIOLOGY

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Study of fossils from models/ pictures	3
2. Study of homology and analogy from suitable specimens	4
3. Study and verification of Hardy-Weinberg Law by chi square analysis	5
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies.	4
6. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.	6
6. Practical record.	3

SUGGESTED READINGS

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

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)

ZOO-HE 702: PARASITOLOGY

Learning Objectives:

- Study of three major groups of animals: parasitic protozoa, parasitic helminths (worms) and those arthropods that directly cause disease or act as vectors of various pathogens. Insect parasites such as fleas and lice are at best, annoyances to humans and as vectors of diseases that have been responsible for a great deal of human mortality.

Learning Outcomes:

- Upon successful completion, students will have the knowledge and skills to identify, describe and contrast unicellular parasites and parasitic worms. Describe specific human and non-human parasitic diseases.
- Evaluate the complexity of the parasite/host relationship (parasite evasion mechanisms vs host defensive mechanisms)

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit I: Introduction to Parasitology 5 marks 3 lectures

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector) Host parasite relationship

Unit II: Parasitic Protists 18 marks 11 lectures

Study of Morphology, Life Cycle, Abundance, Epidemiology, Pathogenicity, Prophylaxis (preventive measure) and Treatment of *Entamoeba histolytica, Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani, Plasmodium vivax*

Unit III: Parasitic Platyhelminthes 18 marks 11 lectures

Study of Morphology, Life Cycle, Abundance, Epidemiology, Pathogenicity, Prophylaxis and Treatment of *Fasciola hepatica, Schistosoma haematobium* and *Taenia solium*

Unit IV: Parasitic Nematodes 18 marks 11 lectures

Study of Morphology, Life Cycle, Abundance, Epidemiology, Pathogenicity, Prophylaxis and Treatment of *Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti* and *Trichinella spiralis.*

Unit V: Parasitic Arthropoda and Vector Biology 16 marks 9 lectures

Biology, importance and control of ticks, mites, *Pediculus humanus* (head and body louse), *Xenopsylla cheopis* and *Cimex lectularius.*

Arthropods as a vector of parasitic diseases. Elementary knowledge/ideas Zoonocis and Mysis.

ZOO-HE 702 P: PARASITOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

marks

1. Study of Permanent slides of *Entamoeba histolytica, Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani and Plasmodium vivax* through permanent slides/micro photographs. 3

2. Study of adult and life stages of *Fasciolopsisbuski/ Schistosomahaematobium, Taeniasolium/ Hymenolepis nana, Ascarislumbricoide/, Ancylostomaduodenale, Wuchereriabancrofti/ Trichinellaspiralis* through permanent slides/micro photographs. 10

3. Study of *Pediculushumanus* (Head louse and Body louse), *Xenopsyllacheopis* and *Cimexlectularius* through permanent slides/ photographs. 4

4. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry]. 5

5. Practical record. 3

Collection and submission of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a by product] /
Submission of a brief report on parasites of vertebrates.

SUGGESTED READINGS

- Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors.
- E.R. Noble and G.A. Noble (1982) Parasitology: The biology of animal parasites. V Edition, Lea &Febiger
- Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group.
- Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi.
- Rattan LalIchhpujani and Rajesh Bhatia. Medical Parasitology, III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
- Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers.
- K. D. Chatterjee (2009). Parasitology: Protozoology and Helminthology. XIII- Edition, CBS Publishers & Distributors (P) Ltd.

ZOO-HE 702: REPRODUCTIVE BIOLOGY

Learning Objectives:

- Reproduction (both natural and artificial)gives the concepts of making a copy, a likeness and thereby providing for the continued existence of species. Effective reproduction depends upon knowledge of the structure (anatomy) and function (physiology) of the male and female reproductive systems.

Learning Outcomes:

- Knowledge of the physiology of human reproduction will give better understanding among young students and will lead to correct attitudes and responsible reproductive health behaviour.
- Reproductive health imparted the ability to produce offspring having better survival rates. It also helps in maintaining the population size and avoiding unwanted pregnancies.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Reproductive Endocrinology 20 marks 12 lectures

Reproductive System: Development and differentiation of gonads, genital ducts.
Gonadal hormones and mechanism of hormone action, steroids, Types of hormone.Control and Regulation of gonadotrophin secretion of male and female, hypothalamo–hypophyseal–gonadal axis.

Unit 2: Functional anatomy of male reproduction 18 marks 11 lectures

Anatomy of male reproductive system in higher mammal; Testis: Histology, Cellular functions, germ cell, system cell renewal; Spermatogenesis: Formation of spermatozoon and hormonal regulation; Androgen secretion and function; Epididymal function and sperm maturation; functions of Accessory organs.

Unit 3: Functional anatomy of female reproduction 22 marks 13 lectures

Anatomy of female reproductive system in higher mammal; Ovary: Histology, folliculogenesis, ovulation, corpus luteum formation and regression; Secretion of ovarian hormones; Reproductive cycles (higher mammal) and their regulation, changes in the female tract; Ovum transport in the fallopian tubes; Sperm transport in the female tract, fertilization; Hormonal control of implantation; Hormonal regulation of gestation, pregnancy diagnosis, foeto – maternal relationship; Mechanism of parturition and its hormonal regulation; Lactation and its regulation

Unit 4: Reproductive Health and techniques 15 marks 9 lectures

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: sex selection, sperm banks, frozen embryos, in vitro fertilization, ET (embryo transfer), EFT (endometrial function test), IUT (intra uterine transfusion), ZIFT (zygote intra fallopian transfer), GIFT (gamete intra fallopian transfer), ICSI (intra cytoplasmic sperm injection), PROST (pronuclear stage tubal transfer);

ZOO-HE 702 P: REPRODUCTIVE BIOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectorny, castration and vasectomy in higher vertebrates/video recording.	6
2. Examination of histological sections from photomicrographs/ permanent slides of mammal: testis, epididymis and accessory glands of male reproductive systems;	8
3. Examination of histological sections from photomicrographs/ permanent slides of mammal: ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.	8
4. Practical record.	3

Study of animal house: set up and maintenance of animal house / cages, care of normal and experimental animals.

SUGGESTED READINGS

- Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
- Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
- Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
- Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.

ZOO-HE 702: BIOTECHNIQUES

Learning Objectives:

- This is the only laboratory course taught independently of lecture courses. It has full hands on approach to expose the students to modern techniques and methodologies. The diverse techniques from microscopy to spectroscopy, calorimetry, chromatography ELISA, tissue culture to cloning etc. are included to make the student well versed with these protocols and methods.

Learning outcomes:

- After successfully completing this course, the students will be able to understand the purpose of the technique, its proper use and possible modifications/ improvement.
- Learn the theoretical basis of technique, its principle of working and its correct application.
- Learn the maintenance laboratory equipments / tools, safety hazards and precautions.
- Understand the technique of cell and tissue culture. Learn the preparation of solution of given percentage and molarity.
- Understand the process of preparation of buffer. Learn the techniques of separation of amino acids, proteins and nucleic acids.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

UNIT I : Microscopy and Microtomy 15 marks 9 lectures

Microscopy: Introduction to Microscopy. Definitions-Resolving Power, Limit of Resolution and Magnification, Numerical Aperture. Types of microscopes, bright field, dark-field, phase contrast. Basic principles of Light, Electron, Fluorescence and Confocal Microscopy. Measurements, Drawings and photomicrography. Microtomy: Tissue preparation, fixation, block preparation, sectioning, staining, dehydration and mounting.

UNIT II : Tools and techniques in Biochemistry and Physiology 20 marks 12 lectures

Biochemistry and Physiology: Physiological Salines, Buffers and the use of pH meter. Extraction of Tissue Glycogen, Proteins, Lipids and Nucleic Acids. Subcellular Fractionation by Differential Centrifugation. Basic Principle and Application of Colorimetry and Spectrophotometry, Beer-Lambert's Law. Principle and applications of Electrophoresis: Separation of Biomolecules by Native PAGE, 2D PAGE. Agarose gel electrophoresis. Principle and Applications of Paper chromatography, Thin layer chromatography, Gel-filtration chromatography.

. **UNIT III : Tools and Techniques in Endocrinology and immunology 20 marks 12 lectures**

Immunology and Endocrinology: Introduction to Antigens, Antibodies, Adjuvants. Raising Polyclonal and Monoclonal Antibodies. Antigen-Antibody Interactions- Immunodiffusion, Western Blotting, ELISA, RIA. Principle & Working of ELISA, Reader, Hormones assay methods. Application of Immunological techniques in disease diagnosis.

UNIT IV: Cell culture, maintenance of Laboratory animals 20 marks 12 lectures

Cell Culture and Laboratory Animals: Cell culture and its basic requirements. Culture media- Nutrient and Non-nutrient, commonly used media for human cell lines. Sterilization of culture wares and Media, laminar flow. Types of animal cell culture, cell viability testing. cryopreservation. Lymphocyte culture. Cell harvesting and Storage Methods. In Vitro culture of *Entamoeba histolytica*, Coenorhabditis elegans. Bioethics.

ZOO-HE 702 P: BIOTECHNIQUES

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Preparation of buffer and determination of pH.	3
2. Identification of amino acids in the mixture using paper chromatography.	5
3. Tissue fixation, paraffin block preparation, sectioning.	7
4. Preparation of permanent slides of microscopic organisms/ small insects.	4
5. Demonstration of bright field, phase contrast, fluorescence, confocal, electron microscopes and spectophotometry.	3
6. Practical record.	3

Recommended readings

- Boyer, R. (2000) Modern Experimental Biochemistry (3rd edition) Benjamin-Cummings.
- Pearse, A.G.E. (1980-1993) Histochemistry - Theoretical and applied, Volume I-III, Churchill-Livingstones.
- Plummer, D. (2017) An Introduction to Practical Biochemistry (3rd edition) McGraw Hill.
- Wilson, K. and Walker, J. (2010) Experimental Biochemistry, Cambridge.

GENERIC ELECTIVE COURSES

ZOO-HG 702: INSECT VECTORS AND DISEASES

Learning Objectives:

- To understand the students the morphology of an insect and difference among insects. The overall idea of diseases carried by insects through capacity building the health security in human, health threats and bio-safety risks at national and regional levels.

Learning Outcomes:

- Students can understand about the insects and vectors after the completion of the course.
- Students able to know that Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans. Many of these vectors are bloodsucking insects, which ingest disease-producing microorganisms during a blood meal from an infected host (human or animal) and later transmit it into a new host, after the pathogen has replicated.
- Often, once a vector becomes infectious, they are capable of transmitting the pathogen for the rest of their life during each subsequent bite/blood meal.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction to Insects and Concept of Vectors 20 marks 12 lectures

General Features of Insects, Morphological features, Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits

Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity

Unit 2: Insects as Vectors 10 marks 6 lectures

Classification of insects up to orders, detailed features of orders with insects as vectors – Diptera, Siphonaptera, Siphunculata, Hemiptera

Unit 3: Dipteran as Disease Vectors 15 marks 9 lectures

Dipterans as important insect vectors – Mosquitoes, Sand fly, Houseflies; Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Control of mosquitoes Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sand fly Study of house fly as important mechanical vector, Myiasis, Control of house fly

Unit 4: Siphonaptera as Disease Vectors 10 marks 6 lectures

Fleas as important insect vectors; Host-specificity, Study of Flea-borne diseases –Plague, Typhus fever; Control of fleas

Unit 5: Siphunculata and Hempitera as Disease Vectors 20 marks 12 lectures

Human louse (Head, Body and Pubic louse) as important insect vectors; Study of louse-borne diseases –Typhus fever, Relapsing fever, Trench fever, Vagabond's disease, Phthiriasis; Control of human louse

Bugs as insect vectors; Blood-sucking bugs; Chagas disease, Bed bugs as mechanical vectors, Control and prevention measures

ZOO-HE 702 P: INSECT VECTORS AND DISEASES

PRACTICAL (Credits 2 & 25 marks); 15 lectures

1. Study of different kinds of mouth parts of insects. 7
2. Study of following insect vectors through permanent slides/ photographs:
Aedes, Culex, Anopheles, Pediculus humanus, Phithirus pubis, Xenopsylla cheopis, Cimex lectularius, Phlebotomus argentipes, Musca domestica, through permanent slides/ photographs. 10
3. Study of different diseases transmitted by above insect vectors chart/microphotograph. 5
4. Practical record. 3

Submission of a project report on any one of the insect vectors and disease transmitted

SUGGESTED READINGS

- Imms, A.D. (1977). A General Text Book of Entomology. Chapman & Hall, UK
- Chapman, R.F. (1998). The Insects: Structure and Function. IV Edition, Cambridge University Press, UK
- Pedigo L.P. (2002). Entomology and Pest Management. Prentice Hall Publication
- Mathews, G. (2011). Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases. Wiley-Blackwell

CORE COURSE XV

ZOO-HC 801: ANIMAL BIOTECHNOLOGY

Learning Objectives:

- Illustrate the techniques, procedure and growth patterns of animal cell culture. Construct the techniques in production of cloned animal and its applications. Apply the applications of Gene therapy for the treatment of various diseases.

Learning Outcomes:

- To understand principles of animal culture, media preparation .
- To get insight in applications or recombinant DNA technology,Gene manipulation, production of therapeutic proteins.
- To understand Genetically Modified Organisms.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1. Introduction, Molecular Techniques in Gene manipulation 30 marks 18 lectures

Concept and scope of biotechnology

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics). Restriction enzymes: Nomenclature, detailed study of Type II.

DNA sequencing: Sanger method. Polymerase Chain Reaction, DNA Finger Printing and DNA micro array.

Transformation techniques: Calcium chloride method and electroporation. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization Southern, Northern and Western blotting.

Unit 2. Molecular markers and their Techniques 12 marks 7 lectures

Different types of Molecular markers: RFLP, RAPDs, VNTRs, SSRs, AFLP. Construction of physical maps of plants and animals.

Unit 3. Genetically Modified Organism 20 marks 12 lectures

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

Production of transgenic plants: Agrobacterium mediated transformation. Applications of transgenic plants: insect and herbicide resistant plants.

Unit 4. Culture Techniques and Applications 13 marks 8 lectures

Animal cell culture, Expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia). Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

ZOO-HC 801 P: ANIMAL BIOTECHNOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Genomic DNA isolation from E.coli.	3
2. Plasmid DNA isolation (pUC 18/19) from E.coli.	3
3. Restriction digestion of plasmid DNA.	3
4. Construction of circular and linear restriction map from the data provided.	5
5. Calculation of transformation efficiency from the data provided.	5
6. To study following techniques through photographs	6
a. Southern Blotting	
b. Northern Blotting	
c. Western Blotting	
d. DNA Sequencing (Sanger'sMethod)	
e. PCR	
f. DNA fingerprinting	

SUGGESTED READINGS

- Brown, T.A. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
- Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, AS M press, Washington, USA.
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M.(2009). An Introduction to Genetic Analysis. IX Edition. Free man and Co., N.Y USA.
- Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. V Edition, John Wiley and Son Inc.
- Watson, J.D., Myers, R.M.,Caudy,A. and Witkowski, J.K. (2007). Recombinant DNA- Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y.,USA.
- Beauchamp, T.I. and Childress, J.F. (2008). Principles of Biomedical Ethics.VI Edition, Oxford University Press

CORE COURSE XVI

ZOO-HC 802: IMMUNOLOGY

Learning Objectives:

- The students will be able to identify the cellular and molecular basis of immune responsiveness and to describe the roles of the immune system in both maintaining health and contributing to disease. They will be able to transfer knowledge of immunology into clinical decision-making through case studies presented in class.

Learning Outcomes:

- Illustrate various mechanisms that regulate immune responses likeallergy, hypersensitivity, autoimmunity and maintain tolerance.
- Understand basic techniques for identifying antigenantibody interactions.
- Reasons for immunization and aware of different vaccination

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Overview of Immune System and Antigens **15 marks 9 lectures**

Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system.

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes

Unit 2: Innate and Adaptive Immunity **18 marks 11 lectures**

Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity, Immune dysfunctions (brief account of autoimmunity with reference to Rheumatoid Arthritis and tolerance, AIDS).

Unit 3: Immunoglobulins **15 marks 9 lectures**

Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA and RIA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis

Unit 4: Major Histocompatibility Complex and Cytokines **12 marks 7 lectures**

Structure and functions of MHC molecules.Endogenous and exogenous pathways of antigen processing and presentation.

Four properties and functions of cytokines, Therapeutics Cytokines

Unit 5: Complement System and Hypersensitivity **10 marks 6 lectures**

Components and pathways of complement activation.

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

Unit 6: Vaccines: Various types of vaccines. **5 marks 3 lectures**

ZOO-HC 802 P: IMMUNOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

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

SUGGESTED READINGS

- Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
- David, M., Jonathan, B., David, R. B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.
- Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)

ZOO-HE 801: ENDOCRINOLOGY

Learning objectives:

- The course envisages information on endocrine system with emphasis on the structure of hypothalamus and anterior pituitary. The associated hormones and the related disorders will be explained.

Learning outcomes:

- On completion of the course, the students will know the internal methods on integrating the functions of different internal systems to maintain homeostasis through hormonal regulation.
- Understand neurohormones and neurosecretions. Learn about hypothalamo and hypapophysial axis.
- Understand about different endocrine glands and their disorders.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction to Endocrinology **17 marks 10 lectures**

History of endocrinology, Classification, Characteristic and Transport of Hormones (Endocrine, paracrine and autocrine modes of hormone delivery), Feedback mechanism.

Neurosecretions and Neurohormones

Unit 2: Epiphysis, Hypothalamo-hypophysial Axis **25 marks 15 lectures**

Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction.

Structure of hypothalamus, Hypothalamic nuclei and their functions, Regulation of neuroendocrine glands, Feedback mechanisms

Structure of pituitary gland, Hormones and their functions, Hypothalamohypophysial portal system, Disorders of pituitary gland.

Unit 3: Peripheral Endocrine Glands **18 marks 11 lectures**

Structure, Hormones, Functions and Regulation of Thyroid gland, Parathyroid, Adrenal, Pancreas, Ovary and Testis

Hormones in homeostasis, Disorders of endocrine glands

Unit 4: Regulation of Hormone Action **15 marks 9 lectures**

Hormone action at Cellular level: Hormone receptors, transduction and regulation

Hormone action at Molecular level: Molecular mediators, Genetic control of hormone action.

ZOO-HE 801 P: ENDOCRINOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

		marks
1.	Dissect and display of Endocrine glands in laboratory bred rat.	5
2.	Study of the permanent slides of all the endocrine glands.	5
3.	Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat.	5
4.	Demonstration of Castration/ ovariectomy in laboratory bred rat.	5
5.	Estimation of plasma level of any hormone using ELISA.	5

SUGGESTED READINGS

- Turner, C. D. (1971) General Endocrinology, Pub- Saunders Toppan.
- Nussey, S.S.; and Whitehead, S.A. (2001) Endocrinology: An Integrated Approach, Oxford: BIOS Scientific Publishers.
- Hadley, M.E. and Levine J.E. (2007) Endocrinology (6th edition) Pearson Prentice-Hall, New Jersey.
- David, O.N. (2013) Vertebrate Endocrinology.

ZOO-HE 801: WILD LIFE CONSERVATION AND MANAGEMENT

Learning Objectives:

- The course is an introduction to wildlife management. Topics covered are to equip students with adequate knowledge of various biodiversity monitoring methodologies, conservation and management issues of vertebrate pests, wildlife conflict and over abundant species, wildlife health and diseases.

Learning Outcomes:

- On completion of the course the student should be able to know the current status and conservation strategies for wildlife conservation and management.
- Develop the ability to work collaboratively on team-based projects.
- Gain an appreciation for the modern scope of scientific inquiry in the field of wildlife conservation management.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction to Wild Life **12 marks 7 lectures**

Values of wild life - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies.

Unit 2: Evaluation and management of wild life **15 marks 9 lectures**

Habitat analysis, Physical parameters: Topography, Geology, Soil and water;
Biological Parameters: food, cover, forage, browse and cover estimation;
Standard evaluation procedures: remote sensing and GIS.

Unit 3: Management of habitats **13 marks 8 lectures**

Setting back succession; Grazing logging; Mechanical treatment; Advancing the successional process; Cover construction; Preservation of general genetic diversity;
Restoration of degraded habitats

Unit 4: Population estimation **15 marks 9 lectures**

Population density, Natality, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Pug marks and census method.
Common diseases of wild animals.

Unit 5: Protected areas and Management planning of wild life in protected areas.

20 marks 12 lectures

National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve.
Estimation of carrying capacity; Eco tourism / wild life tourism in forests; Concept of climax persistence; Ecology of perturbence.

ZOO-HE 801 P: WILD LIFE CONSERVATION AND MANAGEMENT

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna.	5
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).	5
3. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, nest, antlers etc.	5
4. PCQ, Ten tree method, Circular, Square & rectangular plots, Parker's 2 Step and other methods for ground cover assessment, Tree canopy cover assessment, Shrub cover assessment.	5
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).	5

SUGGESTED READINGS

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

ZOO-HE 801: Research Methodology

Learning Objectives:

- The aim of the course is to familiarize students with basics of research and the research process; provide an introduction to research methods and report writing; give insight into various kinds research design and sampling.

Learning outcomes:

- Understand the concept of research and different types of research in the context of biology.
- Have basic knowledge on qualitative research techniques and also acquainted with practical knowledge of research work. Develop laboratory experiment related skills.
- Develop competence on data collection, data analysis, hypothesis testing procedures and process of scientific documentation. Evaluate the different methods of scientific writing and reporting.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit-1: Foundations of Research 17 marks 10 lectures

Meaning, objectives, motivation: types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit 2: Research Design 15 marks 9 lectures

Need for research design: features of good design, important concepts related to good design-Observation and Facts, Prediction and Explanation, Development of Models. Developing a research plan: Problem identification, Formulating hypotheses, Experimentation, Determining experimental and sample designs.

Unit-3: Data Collection and Documentation of Observations 12 marks 7 lectures

Maintaining laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit-4: Overview of Biological Problems 13 marks 8 lectures

History; Key biology research areas, Model organisms in biology (A brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.

Unit-5: Ethics and Art of Scientific Writing 18 marks 11 lectures

Authors, acknowledgements, reproducibility, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references: Power-point presentation. Poster presentation. Scientific writing and ethics, preparation of tables and bibliography. Introduction to copyright-academic misconduct/plagiarism.

ZOO-HE 801: Research Methodology

PRACTICALS (Credits 2 & 25 marks); 15 lectures

	marks
1. Sketching a research proposal.	4
2. Designing an experimental work (field / Lab.)	4
3. Performing a study in related field (aquatic / aerial / land) for taxonomic study.	4
4. Report preparation of field experiment or lab experiment.	4
5. Presentation of report in class seminar on related topic through power-point presentation.	5
6. Analysis of references and citation for at least 10 documents (books, journals, reports, thesis etc.)	4

Recommended readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.

2. M. L. Singh (1998). Understanding Research Methodology.

3. F. N. Kerlinger (2000). Foundations of Behavioural Research. Surjeet Publication, New-Delhi.

4. Walliman, N. (2011) Research Methods: The Basics. Taylor and Francis, London, New York ISBN No- 9780415489942

5. Wadhera, B. L (2002) Law Relating to Patents, Trademarks, Copyright Designs and Geographical Indications, Universal Law Publishing ISBN No- 9789350350300

6. Kothari, C. R (2009) Research Methodology, New Age International, New Delhi ISBN No- 9788122415223

7. Ruzin, S. E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

GENERIC ELECTIVE COURSES

ZOO-HG 801: AQUATIC BIOLOGY

Learning Objectives:

- The program of study aims to provide students with a broad-based foundation in science together with extensive subject knowledge in the discipline of aquatic biology. It also aims to develop a range of transferable research, analytical and communication skills.

Learning outcomes:

- Understand and apply relevant scientific principles in the area of aquatic biology.
- Appreciate the multidisciplinary nature of the study of aquatic biology and engage positively with people and ideas beyond their own discipline.
- Explore some of the unique environmental problems dealing with aquatic environments.
- Develop employable skills in freshwater biological water quality analysis.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

UNIT 1: Aquatic Biomes **15 marks 9 lectures**

Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.

UNIT 2: Freshwater Biology **35 marks 21 lectures**

Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous.

Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.

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UNIT 3: Marine Biology **10 marks 6 lectures**

Physico-chemical environment: Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms like Corals, Sea weeds.

UNIT 4: Management of Aquatic Resources **15 marks 9 lectures**

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment Water quality assessment- BOD and COD.

ZOO-HG 801 P: AQUATIC BIOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. Determine the area of a lake using graphimetric and gravimetric method.	5
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.	5
3. Determine the amount of Turbidity/transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collectedfrom a nearby lake/water body.	5
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.	5
5. A Project Report on a visit to a Sewage treatment plant/Marine bioreserve/Fisheries Institutes.	5

SUGGESTED READINGS

- Anathakrishnan : Bioresources Ecology 3rd Edition.
- Goldman : Limnology, 2nd Edition.
- Odum and Barrett : Fundamentals of Ecology, 5th Edition.
- Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1stEdition.
- Wetzel : Limnology, 3rd edition.
- Trivedi and Goyal : Chemical and biological methods for water pollution studies.
- Welch : Limnology Vols. I-II

CORE COURSE XVII

ZOO-HC 803: ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

Learning Objectives:

- The course aims to explain the natural behaviour patterns, how the behaviour varies among individuals and species (wild, domestic, and captive), how current and past environments and ecology influence not only behaviour, but also the underlying gene-environment interactions that shape it.

Learning Outcomes:

- On completion of the course the student should be able to understand stereotyped and social behaviors of animals and know about the biological rhythms governing the behaviour of animals.
- Understand and be able to objectively evaluate the role of behaviour in the protection and conservation of animals in the wild.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

Unit 1: Introduction to Animal Behaviour **12 marks 7 lectures**

Origin and history of Ethology; Brief profiles of Karl Von Frish, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, Proximate and ultimate causes of behaviour, Methods and recording of a behaviour

Unit 2: Patterns of Behaviour **12 marks 7 lectures**

Stereotyped Behaviours (Orientation, Reflexes); Individual Behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting.

Unit 3: Social and Sexual Behaviour **16 marks 10 lectures**

Social Behaviour: Concept of Society; Communication and the senses;

Altruism; Insects' society with Honey bee as example; Foraging in honey bee and advantages of the waggle dance.

Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Sexual conflict in parental care.

Unit 4: Introduction to Chronobiology **10 marks 6 lectures**

Historical developments in chronobiology; Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks

Unit 5: Biological Rhythm and Clocks **25 marks 15 lectures**

Types and characteristics of biological rhythms: Short- and Long- term rhythms;

Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin.

Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy.

ZOO-HC 803 P: ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

	marks
1. To study nests and nesting habits of the birds and social insects.	5
2. To study the behavioural responses of wood lice to dry and humid conditions.	3
3. To study geotaxis behaviour in earthworm.	3
4. To study the phototaxis behaviour in insect larvae.	3
5. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.	5
6. Study and actogram construction of locomotor activity of suitable animal models.	3
7. Study of circadian functions in humans (daily eating, sleep and temperature patterns).	3

SUGGESTED READINGS

- David McFarland, Animal Behaviour, Pitman Publishing Limited,London, UK.
- Manning, A. and Dawkins, M. S, An Introduction to AnimalBehaviour, Cambridge, University Press, UK.
- John Alcock, Animal Behaviour, Sinauer Associate Inc., USA.
- Paul W. Sherman and John Alcock, Exploring Animal Behaviour,Sinauer Associate Inc., Massachusetts, USA.
- Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J.Loros, Patricia J. DeCoursey (ed). 2004, Sinauer Associates, Inc.Publishers, Sunderland, MA, USA
- Insect Clocks D.S. Saunders, C.G.H. Steel, X., Afopoulou (ed.)R.D.Lewis. (3rdEd) 2002 Barens and Noble Inc. New York, USA
- Biological Rhythms: Vinod Kumar (2002) Narosa Publishing House,Delhi/ Springer-Verlag, Germany.

CORE COURSE XVIII

ZOO-HC 804: BIOSTATISTICS AND BIOINFORMATICS

Learning Objectives:

- The course is aimed at introducing the application of bioinformatics and statistics in biology and methods used in bioinformatics. It provides foundation on statistical methods to enable students to compute and interpret basic statistical parameters. As an interdisciplinary field it integrates biology, computer science, chemistry and statistics together sequence analysis structure analysis and functional analysis of biological data.

Learning outcomes:

- After successfully completing this course, the students will be able to know the theory behind fundamental bioinformatics analysis methods.
- Know basic statistical methods and probability distributions relevant for molecular biology data.
- Know the applications and limitations of different bioinformatics and statistical methods.
- Acquire knowledge of various databases of proteins, nucleic acids. Primary, secondary and composite databases.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

UNIT I: Data collection, distribution, presentation, authentication and analysis

15 marks 9 lectures

Collection and classification of data. Graphical representation of data: Pie chart, Bar diagram, Histogram, Frequency polygon. Cumulative frequency curve (Ogive), Box plot. Probability theory: Binomial distribution, Poisson distributions. Measures of central tendency: Arithmetic Mean, Median, Mode; Measures of dispersion: Variance, Standard deviation and Standard error, Concept of Coefficient of variation.

UNIT II: Correlation, regression, analysis of variance etc. 15 marks 9 lectures

Correlation: Types of correlation, Calculation of correlation in continuous data and ordinal data. Regression: Linear regression, regression coefficient. Analysis of variance (ANOVA): One way, post-hoc tests. Hypothesis testing: Parametric tests (Paired and unpaired t-test, z-test, F-test) & Non Parametric tests (Chi-square test, Mann-Whitney U-test)

UNIT III: Basics of IT; Data archiving systems etc. 20 marks 12 lectures

Introduction and scope of bioinformatics: concept of digital laboratory. Basics of information technology, computer, operating systems, network. Concept of internet protocol (TCP/IP), hypertext, home-page, web-page and uniform resource locators (URL). Introduction to data archiving systems (FASTA format, Accession, and GI-Number).

UNIT IV: Data base management: software, packages and tools 25 marks 15 lectures

Basic features and management systems of following: Nucleic acid sequences databases, Genome databases, Protein sequence, structures and interacting proteins databases, Literature databases, Introduction to data retrieval systems, Search engines, Entrez, sequence retrieval system (SRS) and protein identification resource (PIR). Introduction to molecular sequence analysis software packages and tools, Prediction of motifs, folds and domains, Sequence alignments (BLAST and Clustal W) and phylogenetic trees (PHYLIP).

ZOO-HC 804 P: BIOSTATISTICS AND BIOINFORMATICS

PRACTICAL (Credits 2 & 25 marks); 15 lectures

		marks
1.	Calculation of mean, standard deviation and standard error.	5
2.	Calculation of correlation coefficient values and finding out the probability.	4
3.	Calculation of 'F' value and finding out the probability value for the F value.	4
4.	Student's t-test: Independent and dependent. Hand calculation or calculation using MS Excel.	4
5.	ANOVA and Tukey's HSD: Hand calculation or calculation using MS Excel.	4
6.	Pair-wise alignment of sequences (BLAST) and interpretation of the output.	4

SUGGESTED READINGS

- Daniel, W.W. (2012) Biostatistics: A Foundation for Analysis in Health Sciences (10th edition) John Wiley.
- Milton, J.S. & Tsokos, J.O. (1992) Statistical Methods in the Biological and Health Sciences (2nd edition) McGraw Hill. 3. Zar, J.H. (2013) Biostatistical Analysis (5th edition) Pearson.
- Barnes, M.R. and Gray, I.C. (2003) Bioinformatics for geneticists, Wiley.
- Mount, D.W. (2006) Bioinformatics (2nd edition) CBS.

GENERIC ELECTIVE COURSES

ZOO-HG 802: ANIMAL CELL BIOTECHNOLOGY

Learning objectives:

- Identification and characterization of animal breeds. Developing DNA - based diagnostics and genetically engineered vaccines for animals. Studying animal genomics and its varied applications. Developing embryo - transfer technology, cloning, transgenic animals

Learning outcomes:

- Be able to describe the structure of animal genes and genomes and also to describe basic principles and techniques in genetic manipulation and genetic engineering.
- Be able the technique for animal cell culture and organ culture as well as cell lines.
- Be able to describe techniques and problems both technical and ethical in animal cloning.
- Be able to describe different applications in Health.

THEORY (Credits 4 & 75 marks) (One lecture is equivalent to one hour duration)

UNIT 1: Introduction and Techniques in Gene manipulation 25 **marks 15 lectures**

Concept and Scope of Biotechnology

Outline process of genetic engineering and recombinant DNA technology, Isolation of genes, Concept of restriction and modification: Restriction endonucleases, DNA modifying enzymes

Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids, BAC, YAC, HAC.Shuttle and Expression Vectors. Construction of Genomic libraries and cDNA libraries

Transformation techniques: microbial, plants and animals: Cloning in mammalian cells, Integration of DNA into mammalian genome- Electroporation and Calcium Phosphate Precipitation method.

UNIT 2: Animal cell Culture 15 marks 9 lectures

Basic techniques in animal cell culture and organ culture, Primary Culture and Cell lines, Culture media- Natural and Synthetic, Stem cells, Cryopreservation of cultures.

Agarose and Polyacrylamide Gel Electrophoresis, Southern, Northern and Western blotting, DNA sequencing: Sanger method, Polymerase chain reaction, DNA Fingerprinting and DNA microarrays.

UNIT 3: Fermentation 10 marks 6 lectures

Different types of Fermentation: Submerged & Solid state; batch, Fed batch &Continuous; Stirred tank, Air Lift, Fixed Bed and Fluidized.

Downstream Processing: Filtration, centrifugation, extraction, chromatography, spray drying and lyophilization.

UNIT 4: Transgenic Animal Technology 10 marks 6 lectures

Production of transgenic animals: nuclear transplantation, Retroviral method, DNA microinjection method, Dolly and Polly.

UNIT6: Application in Health and Biosafety: 15 marks 9 lectures

Development of recombinant Vaccines, Hybridoma technology, Gene Therapy.

Production of recombinant Proteins: Insulin and growth hormones.

Bio safety Physical and Biological containment.

ZOO-HG 802 P: ANIMAL CELL BIOTECHNOLOGY

PRACTICAL (Credits 2 & 25 marks); 15 lectures

		marks
1.	Packing and sterilization of glass and plastic wares for cell culture.	3
2.	Preparation of culture media.	3
3.	Preparation of genomic DNA from E. coli/animals/ human.	3
4.	Plasmid DNA isolation (pUC 18/19) and DNA quantitation using agarose gel electrophoresis (by using lambda DNA as standard).	5
5.	Restriction digestion of lambda (!) DNA using EcoRi and Hind III.	3
6.	Preparation of competent cells and Transformation of E. coli with plasmid DNA using CaCl2, Selection of transformants on X-gal and IPTG (Optional).	3
7.	To study following techniques through photographs a. Southern Blotting b. Northern Blotting c. Western Blotting d. DNA Sequencing (Sanger'sMethod) e. PCR f. DNA fingerprinting	5

SUGGESTED READINGS

- Animal Cells Culture and Media, D.C. Darling and S.J. Morgan, 1994. BIOS Scientific Publishers Limited.
- Methods in Cell Biology, Volume 57, Jennie P. Mathur and David Barnes, 1998. Animal Cell Culture Methods Academic Press.
- P.K. Gupta: Biotechnology and Genomics, Rastogi publishers (2003).
- B.D. Singh: Biotechnology, Kalyani publishers, 1998 (Reprint 2001).
- T.A. Brown: Gene cloning and DNA analysis: An Introduction, Blackwell Science (2001).
- Bernard R. Click & Jack J. Pasternak: Molecular Biotechnology, ASM Press, Washington (1998).
- W. Wu, M.J. Welsh, P.B. Kaufman & H.H. Zhang, 1997, Methods in Gene Biotechnology, CRC Press, New York.