CBCS SYLLABUS

FOR

THREE YEARS UNDER-GRADUATE COURSE

IN

Zoology (HONOURS)

(*w.e.f. 2017-18*)

BANKURA UNIVERSITY

BANKURA

WEST BENGAL

PIN 722155

MODEL STRUCTURE IN Zoology (HONOURS)

SEMESTER –I

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
UG/ZOOH / 101/C-1	CT-1: Non-chordates I	4	10	25	50			
	CP-1: Non-chordates I Lab	2		15				
UG/ZOOH / 102/C-2	CT-2: Perspectives In Ecology	4	10	25	50			
	CP-2: Perspectives In Ecology Lab	2		15				
UG/ZOO/ 103/GE-1	GET : Animal Diversity	4	10	25	50			
	GEP: Animal Diversity Lab	2		15				
UG/104/ AECC-1	Environmental Studies	4	10	40	50			
Total in Semester - I		**22**	**40**	**160**	**200**			

SEMESTER –II

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
UG/ZOOH/ 201/C-3	CT-3: Non-chordates II	4	10	25	50			
	CP-3: Non-chordates II Lab	2		15				
UG/ZOOH 202/C-4	CT-4: Cell-Biology	4	10	25	50			
	CP-4: Cell-Biology Lab	2		15				
UG/ZOO 203/GE-2	GET : Aquatic Biology	4	10	25	50			
	GEP: Aquatic Biology Lab	2		15				
UG/204/ AECC-2	English/Hind/MIL	2	10	40	50			
Total in Semester - II		**20**	**40**	**160**	**200**			

SEMESTER –III

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
UG/ZOOH 301/C-5	CT-5: Diversity of Chordata CP-5: Diversity of Chordata Lab	4 2	10	25 15	50			
UG/ZOOH/ 302/ C-6	CT-6: Animal Physiology: Controlling and Co-ordinating systems CP-6: : Animal Physiology: Controlling and Co-ordinating systems Lab	4 2	10	25 15	50			
UG/ZOOH/303/C-7	CT-7: Fundamental of Biochemistry CP-7: Fundamental of Biochemistry Lab	4 2	10	25 15	50			
UG/ZOO/ 304/GE-3	GET : Environment and Public Health GEP : Environment and Public Health Lab	4 2	10	25 15	50			
UG/ZOOH/ 305/SEC-1	SECT: Apiculture	2	10	40	50			
Total in Semester - III		**26**	**50**	**200**	**250**			

SEMESTER –IV

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
UG/ZOOH /401/C-8	CT-8: Comparative Anatomy of Vertebrates	4	10	25	50			

	CP-8: Comparative Anatomy of Vertebrates Lab	2		15				
UG/ZOOH /402/C-9	CT-9: Animal Physiology: Life Sustaining System CP-9: Animal Physiology: Life Sustaining System Lab	4 2	10	25 15	50			
UG/ZOOH /403/C-10	CT-10: Immunology CP-10: Immunology Lab	4 2	10	25 15	50			
UG/ZOO/ 404/GE-4	GET : Insect Vectors and Diseases GEP : Insect Vectors and Diseases Lab	4 2	10	25 15	50			
UG/ZOOH/ 405/SEC-2	SECT: Aquarium Fish Keeping Or SECT: Sericulture	2	10	40	50			
Total in Semester - IV		**26**	**50**	**200**	**250**			

SEMESTER – V

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total			
UG/ZOOH / 501/C-11	CT-11: Molecular Biology CP-11: Molecular Biology Lab	4 2	10	25 15	50			
UG/ZOOH / 502/C-12	CT-12: Principles of Genetics CP-12: Principles of Genetics Lab	4 2	10	25 15	50			
UG/ZOOH / 503/DSE-1	DSET: Animal Behavior & Chronobiology DSEP: Animal Behavior & Chronobiology Lab	4 2	10	25 15	50			
UG/ZOOH / 504/DSE-2	DSET: Animal Bio Technology DSEP: Animal Bio Technology Lab	4 2	10	25 15	50			
Total in Semester – V		**24**	**40**	**160**	**200**			

SEMESTER – VI

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
UG/ZOOH/ 601/C-13	CT-13: Developmental Biology CP-13: Developmental Biology Lab	4 2	10	25 15	50			
UG/SC/ 602/C-14	CT-14: Evolutionary Biology CP-14: Evolutionary Biology Lab	4 2	10	25 15	50			
UG/ZOOH/ 603/DSE-3	DSET: Biology of Insecta DSEP: Biology of Insecta Lab Or DSET: Fish & Fisheries DSEP: Fish & Fisheries Lab Or DSET: Parasitology DSEP: Parasitology Lab	4 2	10	25 15	50			
UG/ZOOH/ 604/DSE-4	DSET: Endocrinology DSEP: Endocrinology Lab	4 2	10	25 15	50			
Total in Semester – VI		**24**	**40**	**160**	**200**			

SC = Subject Code, C= Core Course, AECC= Ability Enhancement Compulsory Course, SEC= Skill Enhancement Course, GE= Generic Elective, DSE= Discipline Specific Elective IA= Internal Assessment, ESE= End-Semester Examination, Lec.=Lecture, Tu.= Tutorial, and Prc.=Practical

Syllabus Zoology (Hons)

1. Introduction

The syllabus for Zoology at undergraduate level using the Choice Based Credit system has been framed in compliance with model syllabus given by UGC. While framing the syllabus as per the UGC guideline, the topics have been kept as generic as possible in order to provide enough freedom to the individual Universities to detail out their own syllabus as per their own infrastructure, expertise and strength.

The main objective of framing this new syllabus is to give the students a holistic understanding of the subject giving substantial weightage to both the core content and techniques used in Zoology.

Keeping in mind and in tune with the changing nature of the subject, adequate emphasis has been given on new techniques and understanding of the subject.

The syllabus has also been framed in such a way that the basic skills of subject are taught to the students, and everyone might not need to go for higher studies and the scope of securing a job after graduation will increase.

There is wide deviation in the infrastructure, be it physical or in human resource, in the form of teachers' expertise and ability and aspiration of the students. Hence, University is free to choose the Electives as per their infrastructural strengths and offer at least 6 to 7 electives

While the syllabus is in compliance with UGC model curriculum, it is necessary that Zoology students should learn "Immunology" as one of the core courses rather than as elective while. Also, an important elective on "Microbiology" has been added.

Project Work may be introduced instead of the 4th Elective with a credit of 6 split into 2+4, where 2 credits will be for continuous evaluation and 4 credits reserved for the merit of the dissertation.

2. Scheme for CBCS Curriculum

2.1 Credit Distribution across Courses

		Credits	
Course Type	**Total Papers**	**Theory + Practical**	**Theory***
Core Courses	14	14*4=56 14*2 =28	14*5 =70 14*1=14
Discipline Specific	4	4*4=16	4*5=20
Electives		4*2=8	4*1=4
Generic Electives	4	4*4=16 4*2=8	4*5=20 4*1=4
Ability Enhancement Language Courses	2	2*2=4	2*2=4
Skill Enhancement Courses	2	2*2=4	2*2=4
Total	26	140	140

"Tutorials of 1 Credit will be conducted in case there is no practical component

Scheme for CBCS Curriculum

Semester	Course Name	Course Details	Credits
I	**Ability Enhancement Compulsory Course - I**	English communication / Environmental Science	2
	Core course -1	Non-chordates I: Protista to Pseudocoelomates	4
	Core course -1 Practical	Non-chordates I: Protista to Pseudocoelomates Lab	2
	Core course – II	Perspectives in Ecology	4
	Core course - II Practical	Perspectives in Ecology Lab	2
	Generic Elective – 1	TBD	4
	Generic Elective - 1 Practical	TBD	2
II	**Ability Enhancement Compulsory Course - II**	English communication / Environmental Science	2
	Core course – III	Non-chordates II: Coelomates	4
	Core course - III Practical	Non-chordates II: Coelomates Lab	2
	Core course - IV	Cell Biology	4
	Core course - IV Practical	Cell Biology Lab	2
	Generic Elective - 2	TBD	4
	Generic Elective - 2 Practical	TBD	2
III	Core course – V	Diversity of Chordates	6
	Core course - V Practical	Diversity of Chordates Lab	-
	Core course – VI	Animal Physiology: Controlling and Coordinating Systems	6
	Core course - VI Practical	Animal Physiology: Controlling and Coordinating Systems Lab	-
	Core course - VII	Fundamentals of Biochemistry	4
	Core course - VII Practical	Fundamentals of Biochemistry Lab	2
	Skill Enhancement Course – 1	TBD	2
	Generic Elective - 3	TBD	4
	Generic Elective - 3 Practical	TBD	2

IV	Core course – VII	Comparative Anatomy of Vertebrates	4
	Core course - VII Practical	Comparative Anatomy of Vertebrates Lab	2
	Core Course IX	Animal Physiology : Life Sustaining Systems	4
	Core Course IX Practical	Animal Physiology : Life Sustaining Systems Lab	4
	Core Course X	Immunology	4
	Core Course X Practical	Immunology Lab	2
	Skill Enhancement Course – 2	TBD	2
	Generic Elective - 3	TBD	4
	Generic Elective - 3 Practical	TBD	2
V	Core Course-XI	Molecular Biology	4
	Core Course-XI Practical	Molecular Biology	4
	Core Course-XII	Principles of Genetics	4
	Core Course-XII Practical	Principles of Genetics Lab	4
	Discipline Specific Elective - 1	TBD	4
	Discipline Specific Elective - 1 Practical	TBD	2
	Discipline Specific Elective - 2	TBD	4
	Discipline Specific Elective - 2 Practical	TBD	2
VI	Core Course-XIII	Developmental Biology	4
	Core Course-XIII Practical	Developmental Biology lab	4
	Core Course-XIV	Evolutionary Biology	4
	Core Course-XIV Practical	Evolutionary Biology Lab	4
	Discipline Specific Elective - 1	TBD	4
	Discipline Specific Elective - 1 Practical	TBD	2
	Discipline Specific Elective - 3	TBD	4
	Discipline Specific Elective - 3 Practical	TBD	2

Discipline Specific Elective - 4	TBD	4
Discipline Specific Elective - 4 Practical	TBD	2

2.3 Choices for Discipline Specific Electives

Discipline Specific Elective - 1 to 4			
Animal Behavior & Chronobiology	Animal Biotechnology	Biology of Insecta	Endocrinology
Fish and Fisheries	Microbiology	Parasitology	Wild Life Conservation & Management
Reproductive Biology			

2.4 Choices for Skill Enhancement Courses

Skill Enhancement Course-1 & Skill Enhancement Course-2			
Apiculture	Aquarium Fish Keeping	Medical Diagnostics Techniques	Sericulture

3. Core Subjects Syllabus

3.1 Core T1 - Non-chordates I: Protista to Pseudocoelomates

Non-Chordates I: Protists to Pseudocoelomates

4 Credits

Unit 1: Basics of Animal Classification

1. Definitions: Classification, Systematics and Taxonomy: Taxonomic Hierarchy, Taxonomic types

2. Codes of Zoological Nomenclature; Principle of priority; Synonymy and Homonymy; Six kingdom concept of classification (Carl Woese)

Unit 2: Protista and Metazoa

1.Protozoa

a. General characteristics and Classification up to phylum (according to Levine et. al., 1981) Locomotion in *Euglena, Paramoecium* and *Amoeba*; Conjugation in *Paramoecium.*

B.Life cycle and pathogenicity of *Plasmodium vivax* and *Entamoeba histolytica*

2. Metazoa

a. Evolution of symmetry and segmentation of Metazoa

Unit 3: Porifera

General characteristics and Classification up to classes (Hyman); Canal system and spicules in sponges

Unit 4: Cnidaria

1. General characteristics and Classification up to classes

2. Metagenesis in Obelia & Aurelia

3. Polymorphism in Cnidaria

4. Corals and coral reef diversity, function & conservation

Unit 5: Ctenophora

General characteristics

Unit 6: Platyhelminthes

1. General characteristics and Classification up to classes

2. Life cycle and pathogenicity and control measures of *Fasciola hepatica* and *Taenia solium*

Unit 7: Nematoda

1. General characteristics and Classification up to classes

2. Life cycle, and pathogenicity and control measures of *Ascaris lumbricoides* and *Wuchereria bancrofti*

3. Parasitic adaptations in helminthes

Reference Books

Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.

Invertebrates by Brusca&Brusca. Second edition, 2002.

Classification for metazoans to be followed from: Rupert and Barnes, 1994, 6th Edition.

3.2 Core PI - Non-Chordates I Lab

Non-Chordates I: Protists to Pseudocoelomates	2 credits

List of Practical

1. Study of whole mount of *Euglena, Amoeba* and *Paramoecium*

2. Identification with reasons of *Amoeba, Euglena, Entamoeba, Opalina, Paramecium, Plasmodium vivax* and *Plasmodium falciparum* (from the prepared slides)

3.Identification with reasons of *Sycon*, Neptune's Cup, *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Aicyonium, Gorgonia*, *Metridium, Pennatula, Fungia, Meandrina, Madrepora*

4. Identification and significance of adult *Fasciola hepatica, Taenia solium* and *Ascaris lumbricoides*

5. Staining/mounting of any protozoa/helminth from gut of cockroach

6. Preparation of Laboratory Note Book

3.3 Core T2 - Perspectives in Ecology 4 Credits

Perspectives in Ecology

Unit 1: Introduction to Ecology

History of ecology, Autecology and synecology, Levels of organization, Laws of limiting factors, Study of Physical factors, The Biosphere.

Unit 2: Population

Unitary and Modular populations

Population: Characteristics, growth forms, and regulation of population density

Geometric, exponential and logistic growth, equation and patterns, 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.

Unit 3: Community

Community characteristics: species diversity, abundance,, dominance, richness,

Concept of community stratification, Ecotone and edge effect. Ecological succession with one example

Unit 4: Ecosystem

Types of ecosystem with an example, 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

Biogeochemical cycle with an example of Nitrogen cycle

Human modified forest ecosystem

Unit 5: Applied Ecology

Wildlife Conservation (in-situ and ex-situ conservation)

Management strategies for tiger conservation; Wild life protection act (1972)

Reference Books

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

Ecology: Theories & Application (2001). 4th Edition by Peter Stilling.

Ecology by Cain, Bowman & Hacker. 3rd edition. Sinauer associates

3.4 Core P2 - Perspectives in Ecology Lab **2 Credits**

Perspectives in Ecology

List of Practical

1. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community

2. 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 CO_2

3. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

3.5 Core T3 - Non-Chordates II

Non-Chordates II: Coelomates	4 Credits

Unit 1: Introduction

Evolution of coelom and metamerism

Unit 2: Annelida

1. General characteristics and Classification up to classes

2. Excretion in Annelida through nephridia.

3. Metamerism in Annelida.

Unit 3: Arthropoda

1. General characteristics and Classification up to classes

2. Respiration in Arthropoda (Gills in prawn and trachea in cockroach)

3. Metamorphosis in Lepidopteran Insects.

4. Social life in termite

5. Compound eye in insects

Unit 4: Onychophora

General characteristics and Evolutionary significance

Unit 5: Mollusca

1. General characteristics and Classification up to classes

2. Nervous system and torsion in Gastropoda

3. Feeding and respiration in *Pila* sp

Unit 6: Echinodermata

1. General characteristics and Classification up to classes

2. Water-vascular system in Asteroidea

3. Larval forms in Echinodermata

4. Affinities with Chordates

Unit 7: Hemichordata

1. General characteristics of phylum Hemichordata.

2. Relationship with non-chordates and chordates

Reference Books

Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition

The Invertebrates: A New Synthesis, III Edition, Blackwell Science

Note: Classification to be followed from Rupert and Barnes, 1994, 6th Edition.

3.6 Core P3 - Non-Chordates II

Non-Chordates II: Coelomates	**2 Credits**

List of Practical

1. Study of following specimens:

Annelids - *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria*

Arthropods - *Carcinoscorpius, Palamnaeus, Paiaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta, Apis*

Onychophora - *Peripatus*

Molluscs - *Chiton, Dentalium, Pila, Doris, Unio, Pinctada, Sepia, Octopus, Nautilus*

Echinodermates - *Asterias, Ophiura, Echinus, Cucumaria and Antedon*

2. Study of digestive system, septal nephridia of earthworm

3. Study of T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm

4. Mount of mouth parts and dissection of digestive system and nervous system of Periplaneta*

5. To submit a Project Report on any insect larval forms

3.7 Core T4 - Cell Biology

Cell Biology	4 Credits

Unit 1: Overview of Cells

Basic structure of Prokaryotic and Eukaryotic cell

Unit 2: Plasma Membrane

1. Ultra structure and composition of Plasma membrane: Fluid mosaic model

2. Transport across membrane: Active and Passive transport, Facilitated transport

3. Cell junctions: Tight junctions, Gap junctions, Desmosomes

Unit 3: Cytoplasmic organelles I

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

2. Protein sorting and mechanisms of vesicular transport

Unit 4: Cytoplasmic organelles II

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

2. Peroxisomes: Structure and Functions

3. Centrosome: Structure and Functions

Unit 5: Nucleus

1.Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus

2. Chromatin: Euchromatin and Hetrochromatin and packaging (nucleosome)

Unit 6: Cell Division

1. Cytoskeletal structures,

2. Centrosome structure and function

3. Accessory proteins of microfilament & microtubule

4. A brief idea about molecular motors

5. Mitosis and Meiosis: Basic process and their significance

Unit 7: Cell cycle and cancer

1. Cell cycle and its regulation

2. Cancer (Concept of oncogenes and tumor suppressor genes with special reference to p53, Retinoblastoma and Ras and APC.

Unit 8: Cell Signaling

1. Cell signalling transduction pathways; Types of signaling molecules and receptors

2. GPCR and Role of second messenger (cAMP)

3. Extra cellular matrix-Cell interactions

4. Apoptosis

Reference Books

Lewin's Cells - 3rd Edition - Cassimeris/Lingappa/Plopper - Johns & Bartlett Publishers

Biology of Cancer by Robert. A. Weinberg. 2nd edition.

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

Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

3.8 Core P4 - Cell Biology Lab

Cell Biology	2 Credits

List of Practical

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis

2. Study of various stages of meiosis from grasshopper testis

3. Staining: DNA by Feulgen reaction/ ethidium bromide

3.9 Core T5 - Diversity of Chordata

Diversity of Chordata **4 Credits**

Unit 1: Introduction to Chordates

Concept of Phylum Chordata

Unit 2: Protochordata

1. General characteristics and classification of sub-phylum Urochordata and Cephalochordata up to Classes.

2. Retrogressive metamorphosis in *Ascidia*.

3. Chordate Features and Feeding in *Branchiostoma*

Unit 3: Origin of Chordata

1. Dipleurula concept and the Echinoderm theory of origin of chordates

2. Advanced features of vertebrates over Protochordata

Unit 4: Agnatha

General characteristics and classification of cyclostomes up to order

Unit 5: Pisces

1. General characteristics and classification of Chondrichthyes and Osteichthyes up to Subclasses

2. Accessory respiratory organ, migration and parental care in fishes

3. Swim bladder in fishes.

Unit 6: Amphibia

1. General characteristics and classification up to living Orders.

2. Metamorphosis and parental care in Amphibia

Unit 7: Reptilia

1. General characteristics and classification up to living Orders.

2. Poison apparatus and Biting mechanism in Snake

Unit 8: Aves

1. General characteristics and classification up to Sub-Classes

2. Exoskeleton and migration in Birds

3. Principles and aerodynamics of flight

Unit 9: Mammals

1. General characters and classification up to living orders

2. Affinities of Monotremata

3. Exoskeleton derivatives of mammals

4. Adaptive radiation in mammals with reference to locomotory appendages

5. Echolocation in Micro chiropterans and Cetaceans

Unit 10: Zoogeography

Zoogeographical realms, Plate tectonic and Continental drift theory, distribution of birds and mammals in different realms

Reference Books

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.

Parker, T. J. &Haswell, W. (1972). Text Book of Zoology , Volume II: Marshall and Wiliam (Eds.) 7th Ed. Macmillan Press,London.

Kardong, K. V. (2002). Vertebrates: Comparative anatomy, function evolution. Tata McGraw Hill.

Kent, G. C. & Carr, R. K. (2001). Comparative anatomy of the Vertebrates. 9th Ed. McGraw Hill.

Nelson, J.S., (2006): Fishes of the World, 4th Edn., Wiley.

Romer, A. S. & Parsons, T. S. (1986). The vertebrate body. 6th Ed. Saunders College Publishing.

Jordan, E.L. &Verma, P.S. (2003). Chordate Zoology. S. Chand & Company Ltd. New Delhi.

Sinha, K. S., Adhikari, S., Ganguly, B. B. &BharatiGoswami, B. D. (2001). Biology of Animals. Vol. II. New Central Book Agency (p) Ltd.

Futuyama, D. (1997). Evolutionary Biology. 3rd Ed. Sinauer Associates, INC.

Note: Classifications for Protochordata, Agnatha, Reptilia, Aves and Mammalia to be followed from Young (1981), for Pisces to be followed from Nelson (1994), for Amphibia to be followed from Nobel.

3.10 Core P5 - Diversity of Chordata Lab

Diversity of Chordata	2 Credits

List of Practical

1. Protochordata: Balanoglossus, Herdmania, Branchiostoma

2. Agnatha : Petromyzon, Myxine

3. Fishes: Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/ Diodon, Anabas, Flat fish

4. Amphibia: Necturus, Bufo, Hyla, Alytes, Axolotl, Tylototriton

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

6. Mammalia: Bat (Insectivorous and Frugivorous), Funambulus

7. Pecten from Fowl head

8. Dissection of brain and pituitary of Tilapia

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

3.11 Core T6 - Animal Physiology: Controlling & Coordinating Systems

Animal Physiology: Controlling & Coordinating Systems **4 Credits**

Unit 1: Tissues

Classification, structure and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue

Unit 2: Bone and Cartilage

Structure and types of bones and cartilages

Unit 3: Nervous System

Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse. Synaptic transmission and Neuromuscular junction

Unit 4: Muscular system

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle fibre

Unit 5: Reproductive System

Histology of testis and ovary Physiology of Reproduction

Unit 6: Endocrine System

1. Histology and function of pituitary, thyroid, pancreas and adrenal

2. Classification of hormones; Mechanism of Hormone action

3. Signal transduction pathways for Steroidal and Non steroidal hormones in brief

4. Placental hormones

Reference Books

Histology: A Text and Atlas. Sixth Edition. Ross &Pawlina. Lippincott Williams & Wilkins. Eckert Animal Physiology by David Randall and Warren Burggren. 4th edition. W.H.Freeman.

3.12 Core P6 - Animal Physiology: Controlling & Coordinating Systems Lab

Animal Physiology: Controlling & Coordinating Systems	**2 Credits**

List of Practical

1. Recording of computer aided simple muscle twitch with electrical stimulation (or Virtual)

2. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres and nerve cells

3. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid

4. Microtomy: Preparation of permanent slide of any five mammalian (Goat/white rat) tissues

3.13 Core T7 - Fundamentals of Biochemistry

Fundamentals of Biochemistry	**4 Credits**

Unit 1: Carbohydrates

1. Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides: Derivatives of Monosachharides

2. Carbohydrate metabolism: Glycolysis, Citric acid cycle, Pentose phosphate pathway, Gluconeogenesis

Unit 2: Lipids

1. Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Sphingolipid, Glycolipids, Steroids, Eicosanoidsand terpinoids.

2. Lipid metabolism: p-oxidation of fatty acids

Unit 3: Proteins

1. Amino acids: Structure, Classification, General and Electro chemical properties of a-amino acids; Physiological importance of essential and non-essential amino acids

Proteins: Bonds stabilizing protein structure; Levels of organization

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

Unit 4: Nucleic Acids

1. Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids

2. Types of DNA and RNA, Complementarity of DNA, Hpyo- Hyperchromaticity of DNA

3. Basic concept of nucleotide metabolism

Unit 5: Enzymes

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

Unit 5: Oxidative Phosphorylation in mitochondrial matrix

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

Reference Books

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.

3.14 Core P7 -Fundamentals of Biochemistry Lab

Fundamentals of Biochemistry Lab	2 Credits

List of Practical

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

2. Quantitative estimation of Lowry Method

3. To study the enzymatic activity of Trypsin and Lipase.

4. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.

3.15 Core T8 - Comparative Anatomy of Vertebrates

Comparative Anatomy of Vertebrates	**4 Credits**

Unit 1: Integumentary System

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

Unit 2: Skeletal System

General idea of axial and appendicular skeleton; Basic idea of jaw suspension and visceral arches.

Unit 3: Digestive System

Ruminating stomach; dentition in mammals

Unit 4: Respiratory System

Respiratory organs in fish, amphibian, and birds

Unit 5: Circulatory System

Comparative account of heart and aortic arches

Unit 6: Urinogenital System

Archinephros, Pronephros, Mesonephros and Metanephros

Evolution of urinogenital ducts, Types of mammalian uteri

Unit 7: Nervous System

Comparative account of brain, Cranial nerves in mammals

Unit 8: Sense Organs

Classification of receptors

Reference Books

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

Saxena, R.K. &Saxena, S.C.(2008): Comparative Anatomy of Vertebrates, Viva Books Pvt. Ltd.

3.16 Core P8 - Comparative Anatomy of Vertebrates

Core P8 - Comparative Anatomy of Vertebrates	2 Credits

List of Practical

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs

2. Study of disarticulated skeleton of Toad, Pigeon and Guineapig (Skull, Vertebrae, Pectoral girdle, Pelvic girdle)

3. Demonstration of Carapace and plastron of turtle

4. Identification of mammalian skulls: One herbivorous (Guineapig) and one carnivorous (Dog) animal

5. Dissection of carp: Circulatory system, Brain, pituitary, urinogenital system

3.17 Core T9 - Animal Physiology: Life Sustaining Systems

Animal Physiology: Life Sustaining Systems	4 Credits

Unit 1: Physiology of Digestion

Structural organisation and functions of Gastrointestinal tract and Associated glands: Mechanical and chemical digestion of food, absorption of Carbohydrates, Lipids, Proteins and Nucleic Acids; Digestive enzymes

Unit 2: Physiology of Respiration

Mechanism of Respiration, transport of Oxygen and Carbon dioxide in blood, Dissociation curves and the factors influencing it, Carbon monoxide poisoning

Unit 3: Physiology of Circulation

1. Components of Blood and their functions; Structure and functions of haemoglobin

2. Haemostasis; Blood clotting system

3. Haemopoiesis; Basic steps and its regulation

4. Blood groups; ABO and Rh factor

Unit 4: Physiology of Heart

1. Structure of mammalian heart, Coronary Circulation, Structure and working of conducting myocardial fibres, Origin and conduction of cardiac impulses

2. Cardiac Cycle and cardiac output

3. Blood pressure and its regulation

Unit 5: Thermoregulation & Osmoregulation

1. Physiological classification based on thermal biology.

2. Osmoregulation in aquatic vertebrates

3. Extrarenal osmoregulatory organs in vertebrates

Unit 6: Renal Physiology

Structure of Kidney and its functional unit, Mechanism of urine formation, Regulation of acid-base balance

Reference 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,

Eckert Animal Physiology: Mechanisms and adaptations Randall, Burggren and FrenchVander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills

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

3.18 Core P9 - Animal Physiology: Life Sustaining Systems Lab

Animal Physiology: Life Sustaining Systems Lab	2 Credits

List of Practical

1. Determination of ABO Blood group

2. Enumeration of red blood cells and white blood cells using haemocytometer

3. Estimation of haemoglobin using Sahli's haemoglobinometer

4. Preparation of haemin and haemochromogen crystals

5. Recording of blood pressure using a sphygmomanometer

3.19 Core T 10 Immunology

Immunology	4 Credits

Unit 1: Overview of Immune System

Basic concepts of health and diseases, Historical perspective of Immunology, Cells and organs of the Immune system

Unit 2: Innate and Adaptive Immunity

Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral).

Unit 3: Antigens

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

Unit 4: Immunoglobulins

Structure and functions of different classes of immunoglobulins, Antigen- antibody interactions, Immunoassays (ELISA and RIA), Hybridoma technology, concept of monoclonal antibody

Unit 5: Major Histocompatibility Complex

Structure and functions of MHC molecules.

Structure of T cell Receptor and its signalling

Unit 6: Cytokines

Types, properties and functions of cytokines.

Unit 7: Complement System

Components and pathways of complement activation.

Unit 8: Hypersensitivity

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

Unit 9: Immunology of diseases

Malaria, Filariasis, and Tuberculosis

Unit 10: Vaccines

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

Reference Books

Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.

Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication.

3.20 Immunology

Immunology	2 Credits

List of Practical

1.Demonstration of lymphoid organs.

2. Histological study of spleen, thymus and lymph nodes through slides/ photographs

3. Preparation of stained blood film to study various types of blood cells.

4. ABO blood group determination.

The experiments can be performed depending upon usage of animals in UG courses.

3.21 Core T11 - Molecular Biology

Molecular Biology	4 Credits

Unit 1: Nucleic Acids

Salient features of DNA and RNA Watson and Crick Model of DNA

Unit 2: DNA Replication

Mechanism of DNA Replication in Prokaryotes, Semi-conservative, bidirectional and discontinuous Replication, RNA priming, Replication of telomeres

Unit 3: Transcription

Mechanism of Transcription in prokaryotes and eukaryotes, Transcription factors, Difference between prokaryotic and eukaryotic transcription.

Unit 4: Translation

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

Unit 5: Post Transcriptional Modifications and Processing of Eukaryotic RNA

Capping and Poly A tail formation in mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, and RNA editing

Unit 6: Gene Regulation

Regulation of Transcription in prokaryotes: lac operon and trp operon;

Regulation of Transcription in eukaryotes: Activators, enhancers, silencer, repressors, miRNA mediated gene silencing, Genetic imprinting

Unit 7: DNA Repair Mechanisms

Types of DNA repair mechanisms, RecBCD model in prokaryotes, nucleotide and base excision repair, SOS repair

Unit 8: Molecular Techniques

Basic concept of PCR, Western and Southern blot, Northern Blot

Reference Books

Molecular Cell Biology by Harvey Lodish. 7th Edition. W.H. Freeman.

Molecular Biology Of The Gene by Watson. 7th Edition. Pearson.

iGenetics: A Molecular Approach by Peter. J. Russell. 3rd edition. Pearson Benjamin ummings.

3.22 Core PII - Molecular Biology Lab

Molecular Biology Lab	2 Credits

List of Practical

1. Demonstration of polytene and lampbrush chromosome from photograph/ slide

2. Isolation and quantification of genomic DNA using spectrophotometer (A260 measurement)

3.23 Core T 12 Principles of Genetics

Principles of Genetics	4 Credits

Unit 1: Mendelian Genetics and its Extension

Principles of inheritance, Incomplete dominance and co-dominance, Epistasis Multiple alleles, Lethal alleles, Pleiotropy,

Sex-linked, sex- influenced and sex-limited inheritance, Polygenic Inheritance.

Unit 2: Linkage, Crossing Over and Chromosomal Mapping

Linkage and Crossing Over, molecular basis of crossing over, Measuring Recombination frequency and linkage intensity using three factor crosses, Interference and coincidence

Unit 3: Mutations

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

Unit 4: Sex Determination

1. Mechanisms of sex determination in Drosophila

2. Sex determination in mammals

3. Dosage compensation in Drosophila & Human

Unit 5: Extra-chromosomal Inheritance

1. Criteria for extra chromosomal inheritance, Antibiotic resistance in Chlamyadomonas,

2. Kappa particle in Paramoecium

3. Shell spiralling in snail

Unit 6: Recombination in Bacteria and Viruses

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage

Unit 7: Transposable Genetic Elements

Transposons in bacteria, Ac-Ds elements in maize , LINE, SINE, Alu elements in humans

Reference Books

Developmental biology by Scott.F.Gilbert, 9th edition.

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. Principles of Genetics

3.24 Core P12- Principles of Genetics Lab

Principles of Genetics Lab	2 Credits

List of Practical

1.Chi-square analyses

2.Linkage maps based on conjugation

3. Identification of chromosomal aberration in Drosophila and man from photograph

4. Pedigree analysis of some human inherited traits

3.25 Developmental Biology

Developmental Biology	4 Credits

Unit 1: Introduction

Basic concepts: Phases of Development, Cell cell interaction, Differentiation and growth, Differential gene expression

Unit 2: Early Embryonic Development

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

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

Development of brain and Eye in Vertebrate

Brief idea of regeneration

Unit 5: Implications of Developmental Biology

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

Reference Books

Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA Slack JMW , Essential Developmental Biology

3.26 Core P13 Developmental Biology

Developmental Biology	2 Credits

List of Practical

1. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 24, 28,48,72, and 96 hours of incubation (Hamilton and Hamburger stages)

2. Study of the developmental stages and life cycle of Drosophila from stock culture

3. Study of different sections of placenta (photomicropgraph/ slides)

4. Project report on Drosophila culture/chick embryo development

3.27 Core T 14 Evolutionary Biology

Evolutionary Biology	4 Credits

Unit 1

Basic concept of origin of life , Evolution of eukaryotes

Unit 2

Historical review of Evolutionary concepts, Lamarkism, Darwinism and Neo Darwinism

Unit 3

1. Geological time scale, Fossil records of Hominids (from Australopithacus to Homo sapiens), evolution of horse

2. Neutral theory of molecular evolution, Molecular clock

Unit 4

Sources of variations: Heritable variations and their role in evolution

Unit 5

1. Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to biallelic Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, types of selection, selection coefficient, mode of selection heterozygous superiority).

2. Genetic Drift mechanism (founder's effect, bottleneck phenomenon)

3. Role of Migration and Mutation in changing allele frequencies.

Unit 6

Species concept, Isolating mechanisms, modes of speciation

Adaptive radiation/macroevolution (exemplified by Galapagos finches)

Unit 7

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

Unit 8

Origin and Evolution of Man, Unique Hominin characteristics contrasted with primate characteristic

Unit 9

Phylogenetic trees, Convergent & Divergent evolution.

Reference Books

Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.

Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.

iGeneics: A Molecular Approach. 3rd edition. Peter.J.Russell.

3.28 Core P 14 Evolutionary Biology

Evolutionary Biology	2 Credits

List of Practical

1.Study of fossils from models/ pictures

2. Study of homology and analogy from suitable specimens

3. Study and verification of Hardy-Weinberg Law by chi square analysis

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

4. Department Specific Electives Subjects Syllabus

4.1 DSE T1 - Animal Behaviour and Chronobiology

Animal Behaviour and Chronobiology	**4 Credits**

Unit 1: Introduction to Animal Behaviour

Origin and history of Ethology, Proximate and ultimate causes of behaviour, Methods and recording of a behaviour

Unit 2: Patterns of Behaviour

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

Social Behaviour: Concept of Society; various modes of animal communication

Altruism; Insects' society with Honey bee as example; Foraging in honey bee and 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

Biological oscillation

Adaptive significance of biological clocks

Unit 5: Biological Rhythm

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 of seasonal reproduction of vertebrates; Role of melatonin.

Reference Books

Animal Behaviour by Drickamar.

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.

4.2 DSE PI - Animal Behaviour and Chronobiology Lab

Animal Behaviour and Chronobiology Lab	2 Credits

List of Practical

1. To study nests and nesting habits of the birds and social insects.

2. To study the behavioural responses of wood lice to dry and humid conditions.

3. To study geotaxis behaviour in earthworm.

4. To study the phototaxis behaviour in insect larvae.

5. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.

6. Study and actogram construction of locomotor activity of suitable animal models.

7. Study of circadian functions in humans (daily eating, sleep and temperature patterns).

4.3 DSE T2 - Animal Biotechnology

Animal Biotechnology	**4 Credits**

Unit 1: Introduction

Organization of prokaryotic and eukaryotic genome, Concept of genomics

Unit 2: Molecular Techniques in Gene manipulation

1. Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics).Restriction enzymes: Nomenclature, detailed study of Type II. Transformation techniques: Calcium chloride method and electroporation. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization

2. Southern, Northern and Western blotting

3. Polymerase Chain Reaction, DNA Finger Printing and DNA micro array

Unit 3: Genetically Modified Organisms

1. Concept of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection.

2. Applications of transgenic animals in production of pharmaceuticals, and production of donor organs, knock out mice.

Unit 4: Culture Techniques and Applications

Animal cell culture, Expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia)

Reference Books

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, ASM press, Washington, USA.

Weaver. Molecular Biology of Gene. 5th edition.

Primrose & Twyman. Principles of Gene Manipulation and Genomics. 7th edition.

4.4 DSE P2 - Animal Biotechnology Lab

Animal Biotechnology Lab	**2 Credits**

List of Practical

1. Genomic DNA isolation from E. coli

2. Plasmid DNA isolation (pUC 18/19) from E. coli

3. Construction of circular and linear restriction map from the data provided.

4. To study following techniques through photographs

a. Southern Blotting

b. Northern Blotting

c. Western Blotting

d. PCR

e. DNA fingerprinting

5. Visit to reputed molecular biology labProject report on animal cell culture

4.5 DSE T3 Biology of Insecta

Biology of Insecta	4 Credits

Unit 1: Introduction

General Features of Insects

Success of Insects on the Earth

Unit 2: Insect Taxonomy

Basis of insect classification; Classification of insects up to orders (according to Ruppert and Barnes)

Unit 3: General Morphology of Insects

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

2. Thorax: Wings and wing articulation, Types of Legs adapted to diverse habitat Abdominal appendages and genitalia

Unit 4: Physiology of Insects

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

2. Photoreceptors: Types, Structure and Function

3. Metamorphosis: Types and Neuroendocrine control of metamorphosis

Unit 5: Insect Society

1. Social insects with special reference to termites

2. Trophallaxis in social insects such as ants

Unit 6: Insect Plant Interaction

Theory of co-evolution, role of allelochemicals in host plant mediation Host-plant selection by phytophagous insects

Unit 7: Insects as Vectors

Insects as mechanical and biological vectors, Brief discussion on houseflies and mosquitoes as important vectors

Reference Books

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. 0., Harward Univ. Press, UK

Host Selection by Phytophagous insects, Bernays, E. A., and Chapman, R. F., Chapman and Hall, New York, USA

Physiological system in Insects, Klowden, M. J., Academic Press, USA

The Insects, An outline of Entomology, Gullan, P. J., and Cranston, P. S., Wiley Blackwell,UK

Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA Mosquito, Chandra G (2000), Sribhumi Pub. Co.

Medical Entomology, Hati A. K., Allied Book Agency, 2010

Note: Classification to be followed from IMMS A. D. (1938)

4.6 DSE P3 Biology of Insecta

Biology of Insecta	2 Credits

List of Practical

1. Study of life cycle of Mosquito

2. Study of different kinds of antennae, legs and mouth parts of insects

3. Mounting of insect wings, spiracles and genitalia of any insects

4. Methodology of collection, preservation and identification of insects.

5. Morphological studies of various castes of Apis, Camponotus Odontotermes

6. Study of major insect pests of paddy and their damages

7. Study of Mulberry silk moth

4.7 DSE T4 – Endocrinology

Endocrinology	**4 Credits**

Unit 1: Introduction to Endocrinology

General idea of Endocrine systems, Classification, Characteristic and Transport of Hormones, Neurosecretions and Neurohormones

Unit 2: Epiphysis, Hypothalamo-hypophysial Axis

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

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

3. Structure of pituitary gland, Hormones and their functions, Hypothalamo-hypophysial portal system, Disorders of pituitary gland.

Unit 3: Peripheral Endocrine Glands

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

2. Hormones in homeostasis, Disorders of endocrine glands

Unit 4: Regulation of Hormone Action

1. Mechanism of action of steroidal, non-steroidal hormones with receptors

2. Bioassays of hormones using RIA & ELISA

3. Estrous cycle in rat and menstrual cycle in human

4. Role of Vasopressin & Oxytocin. Hormonal regulation of parturition.

Reference Books

Guyton and Hall. Textbook of Medical Physiology. 13th Edition

Histology: A Text and Atlas. Sixth Edition. Ross & Pawlina. Lippincott Williams & Wilkins.

Vertebrate Endocrinology by David 0. Norris,

4.8 DSE P4 Endocrinology Lab

Endocrinology Lab	**2 Credits**

List of Practical

1. Dissect and display of Endocrine glands in laboratory bred rat.

2. Study of the permanent slides of all the endocrine glands

3. Tissue fixation, embedding in paraffin, microtomy and slide preparation of any endocrine gland

4. Designing of primers of any hormone

4.9 DSE T5 - Fish and Fisheries

Fish and Fisheries	4 Credits

Unit 1: Introduction and Classification

1. General description of fish

2. Feeding habit, habitat and manner of reproduction

Unit 2: Morphology and Physiology

Types of fins and their modifications; Locomotion in fish; 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 fish); Electric organ, Bioluminescence

Unit 3: Fisheries

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 in fisheries

Unit 4: Aquaculture

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; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products

Unit 5: Fish in research

Transgenic fish

Zebrafish as a model organism in research

Reference Books

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

Note: Classification to be followed from: Romar A. S. (1959)

4.10 DSE P5 - Fish and Fisheries Lab

Fish and Fisheries Lab	2 Credits

List of Practical

1.Morphometric and meristic characters of fishes

2.Study of Petromyzon, Myxine, Pristis, Chimaera, Exocoetus, Hippocampus, Gambusia, Labeo, Heteropneustes, Anabas

3.Study of different types of scales (through permanent slides/ photographs).

4.Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids

5.Study of air breathing organs in Channa, Heteropneustes, Anabas and Clarias

6.Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.

4.11 DSE T6 Parasitology

Parasitology	**4 Credits**

Unit 1: Introduction to Parasitology

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

Unit 2: Parasitic Protists

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of Giardia Intestinalis, Trypanosoma gambiense, Leishmania donovani

Unit 3: Parasitic Platyhelminthes

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of Schistosoma haematobium, Taenia sajinata

Unit 4: Parasitic Nematodes

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

Unit 5: Parasitic Arthropods

Biology, importance and control of ticks (Soft tick Ornithodoros, Hard tick Ixodes), mites (Sarcoptes), Lice (.Pediculus), Flea (Xenopsylla) and Bug (Cimex)

Unit 5: Parasite Vertebrates

Brief account of Hood Mocking bird, Vampire bat

Reference Books

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 Lai Ichhpujani 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.

4.12 DSE P6 Parasitology Lab

DSE P6 Parasitology Lab	2 Credits

List of Practicals

1.Study of life stages of Giardia intestinalis. Trypanosoma gambiense, Leishmania donovani through permanent slides/micro photographs

2. Study of adult and life stages of Schistosoma haematobium, through permanent slides/micro photographs

3. Study of adult and life stages of Ancylostoma duodenale, through permanent slides/micro photographs

4.Study of plant parasitic root knot nematode, Meloidogyne from the soil sample

5.Study of Pediculus humanus, and Cimex lectularius through permanent slides/ photographs

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

7.Study of nematode/cestode parasites from the intestines of Poultry [Intestine can be procured from poultry/market as a by-product

8. Submission of a brief report on parasitic vertebrates

5. Skill Enhancement Course

5.1 SEC T1 – Apiculture

Apiculture	**2 Credits**

Unit 1: Biology of Bees

History, Classification and Biology of Honey Bees

Social Organization of Bee Colony

Unit 2: Rearing of Bees

Artificial Bee rearing (Apiary), Beehives - Newton and Langstroth

Bee Pasturage

Selection of Bee Species for Apiculture

Bee Keeping Equipment

Methods of Extraction of Honey (Indigenous and Modern)

Unit 3: Diseases and Enemies

Bee Diseases and Enemies

Control and Preventive measures

Unit 4: Bee Economy

Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis), Pollen etc

Unit 5: Entrepreneurship in Apiculture

Bee Keeping Industry - Recent Efforts, Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens

Reference Books

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.

5.2 SEC T2 Aquarium Fish Keeping

Aquarium Fish Keeping	**2 Credits**

Unit 1: Introduction to Aquarium Fish Keeping

The potential scope of Aquarium Fish Industry as a Cottage Industry, Exotic and Endemic species of Aquarium Fishes

Unit 2: Biology of Aquarium Fishes

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 and Butterfly fish

Unit 3: Food and feeding of Aquarium fishes

Use of live fish feed organisms. Preparation and composition of formulated fish feeds, Aquarium fish as larval predator

Unit 4: Fish Transportation

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

Unit 5: Maintenance of Aquarium

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

5.3 SEC T4 Sericulture

Sericulture	2 Credits

Unit 1: Introduction

Sericulture: Definition, history and present status: Silk route

Types of silkworms, Distribution and Races

Exotic and indigenous races

Mulberry and non-mulberry Sericulture

Unit 2: Biology of Silkworm

Life cycle of Bombyxmori

Structure of silk gland and secretion of silk

Unit 3: Rearing of Silkworms

Selection of mulberry variety and establishment of mulberry garden

Rearing house and rearing appliances.

Disinfectants: Formalin, bleaching powder, RKO

Silkworm rearing technology: Early age and Late age rearing

Types of mountages

Spinning, harvesting and storage of cocoons

Unit 4: Pests and Diseases

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates

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

Control and prevention of pests and diseases

Unit 5: Entrepreneurship in Sericulture

Prospectus of Sericulture in India: Sericulture industry in different states, employment, potential in mulberry and non-mulberry sericulture

Visit to various sericulture centres.

Reference Books

Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi Solar energy - M P Agarwal - S Chand and Co. Ltd.

Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.

Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.

Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009 J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA). http://en.wikipedia.org/wiki/Renewable_energy

6. Generic Elective

6.1 GE T2- Animal Diversity

Animal Diversity	**4 Credits**

Unit 1: Protista

Protozoa

General characters of Protozoa; Life cycle of Plasmodium

Unit 2: Porifera

General characters and canal system in Porifera

Unit 3: Radiata

General characters of Cnidarians and polymorphism

Unit 4: Aceolomates

General characters of Helminthes

Unit 5: Pseudocoelomates

General characters of Nematoda

Parasitic adaptations

Unit 6: Annelida

General characters of Annelida

Metamerism

Unit 7: Arthropoda

General characters

Social life in insects.

Unit 8: Mollusca

General characters of mollusc

Pearl Formation

Unit 9: Echinodermata

General characters of Echinodermata

Water Vascular system in Starfish

Unit 10: Protochordata

Salient features

Unit 11: Pisces

General Characters

Osmoregulation, Migration of Fish

Unit 12: Amphibia

General characters, Adaptations for terrestrial life, Parental care

Unit 13: Reptilia

General Characters

Amniotes; Origin of reptiles. Terrestrial adaptations in reptiles.

Unit 14: Aves

General Characters

The origin of birds; Flight adaptations

Unit 15: Mammalia

General Characters

Early evolution of mammals; Primates; Dentition in mammals.

Reference 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.

6.2 GE P2 - Animal Diversity Lab

Animal Diversity Lab	**2 Credits**

List of Practical

1.Study of following specimens:

a.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*.

b.Chordates: *Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/Uraeotyphlus, Salamander, Rhacophorus, Draco, Uromastix, Naja,* Viper, Crow, duck, Owl, Squirrel and Bat.

2.Study of following Permanent Slides:

Cross section of Ascaris (male and female). T. S. of Earthworm passing through typhlosolar intestine. Bipinnaria and Pluteus larva.

3.Temporary mounts of:

Septal & pharyngeal nephridia of earthworm.

Unstained mounts of Placoid, cycloid and ctenoid scales.

4. Dissections of:

Digestive and nervous system of Cockroach

Urinogenital system of Rat

6.3 GE T3 - Aquatic Biology

Aquatic Biology	**4 Credits**

Unit 1: Aquatic Biomes

Brief introduction to 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

Lakes: 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.

Unit 3: Marine Biology

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.

Unit 4: Management of Aquatic Resources

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

Reference Books

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, 1st Edition Wetzel: Limnology, 3rd edition

Trivedi and Goyal: Chemical and biological methods for water pollution studies Welch: Limnology Vols. I-II

6.4 GE P3 - Aquatic Biology Lab

Aquatic Biology Lab	2 Credits

List of Practical

1. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.

2. Determine the amount of Turbidity/transparency, Dissolved Oxygen, and Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a nearby lake / water body.

3. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.

4. A Project Report on a visit to a Sewage treatment plant/Marine bio- reserve/Fisheries Institute.

6.5 GE T4 Environment and Public Health

Environment and Public Health	**4 Credits**

Unit 1: Introduction

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

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

Unit 3: Pollution

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

Unit 4: Waste Management Technologies

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.

Unit 5: Diseases

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

Reference 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 Assessment and 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., Global Environmental Risks, V.N.University Press, New York, 2003.

Joseph F Louvar and B Diane Louver Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey 1997.

6.6 GE P4 - Environment and Public Health Lab

Environment and Public Health Lab	2 Credits

List of Practical

To determine pH, Cl, S04, N03 in soil and water samples from different locations.

6.7 GE T5 - Insect Vectors and Diseases

Insect Vectors and Diseases	4 Credits

Unit 1: Introduction to Insects

General Features of Insects, Morphological features, Head - Eyes, Types of antennae, Mouth parts

Unit 2: Concept of Vectors

Brief introduction to Vectors (mechanical and biological vectors),Reservoirs, Host-vector relationship, Adaptations as vectors, Host specificity

Unit 3: Insects as Vectors

Detailed features of orders with insects as vectors - Diptera, Siphonaptera, Siphunculata, Hemiptera

Unit 4: Dipteran as Disease Vectors

1.Dipterans as important insect vectors - Mosquitoes, Sand fly, Houseflies

2. Study of mosquito-borne diseases - Malaria, Dengue, Chikungunya, Filariasis

3.Control of mosquitoes

4.Study of sand fly-borne diseases -Leishmaniasis,; Control of Sand fly

5.Study of house fly as important mechanical vector, Myiasis, Control of house fly

Unit 5: Siphonaptera as Disease Vectors

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

Unit 6: Siphunculata as Disease Vectors

Human louse (Head, Body and Pubic louse) as important insect vectors; Control of human louse

Unit 7: Hempitera as Disease Vectors

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

Reference Books

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 Mosquito (2000) Chandra G, Sribhumi Publication Co. Kolkata Medical Entomology, Hati A. K Allied Book Agency, Kolkata

6.8 GE P5 - Insect Vectors and Diseases Lab

Insect Vectors and Diseases Lab	2 Credits

List of Practical

1. Study of different kinds of mouth parts of insects

2. Study of following insect vectors through permanent slides/ photographs: *Aedes, Culex, Anopheles, Pediculus humanus capitis, Pediculus humanus corporis, Phithirus pubis*, *Cimex lectularius, Phlebotomus argentipes, Musca domestica* through permanent slides/ photographs

3. Study of different diseases transmitted by above insect vectors

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

7.Appendix I - Scheme for CBCS Curriculum for Pass Course

Credit Distribution across Courses

'Tutorials of 1 Credit will be conducted in case there is no practical component

All Pass courses will have 3 subjects/disciplines of interest. Student will select 4 core courses each from discipline of choice including Zoology as one of the disciplines. The details for core courses available in Zoology have been detailed in Section 3 of this document

Student will select 2 core courses each from discipline of choice including Zoology as one of the disciplines. The details for elective courses available in Zoology have been detailed in Section 4 and 6 of this document

Student may also choose Skill Enhancement courses in Zoology. The details for skill enhancement courses available in Zoology have been detailed in Section 5 of this document

Scheme for CBCS Curriculum