UNIVERSITY OF KALYANI

CBCS CURRICULUM FOR THREE YEARS UNDER-GRADUATE COURSE

IN

ZOOLOGY (HONOURS)

COURSES EFFECTIVE FROM THE ACADEMIC SESSION

2018-19

SYLLABUS OF COURSES TO BE OFFERED

Core Courses, Generic Elective Courses, Skill Enhancement Courses & Ability Enhancement Courses

PREAMBLE

The University Grants Commission (UGC) has taken various measures by means of formulating regulations and guidelines and updating them, in order to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions in India. The various steps that the UGC has initiated are all targeted towards bringing equity, efficiency and excellence in the Higher Education System of country. These steps include introduction of innovation and improvements in curriculum structure and content, the teaching-learning process, the examination and evaluation systems, along with governance and other matters. The introduction of Choice Based Credit System is one such attempt towards improvement and bringing in uniformity of system with diversity of courses across all higher education institutes in the country. The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising of core, elective, skill enhancement or ability enhancement courses. The courses shall be evaluated following the grading system, is considered to be better than conventional marks system. This will make it possible for the students to move across institutions within India to begin with and across countries for studying courses of their choice. The uniform grading system shall also prove to be helpful in assessment of the performance of the candidates in the context of employment.

Outline of the Choice Based Credit System being introduced:

1. **Core Course (CC):** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the student's proficiency/skill is termed as an Elective Course.

2.1 **Discipline Specific Elective Course (DSE):** Elective courses that are offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

2.2 **Generic Elective Course (GE):** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

3. **Ability Enhancement Courses/ Skill Enhancement Courses:**

3.1 **Ability Enhancement Compulsory Course (AECC):** Ability enhancement courses are the courses based upon the content that leads to Knowledge enhancement. They
(i) Environmental Science, (ii) English Communication) are mandatory for all disciplines.

3.2 **Skill Enhancement Course (SEC):** These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

A. TOTAL Number of courses in UG-CBCS (B.Sc. ZOOLOGY Honours):

Types of course	Core course (CC)	Elective course		Ability enhancement course		TOTA
		Discipline specific elective course (DSE)	Generic elective course(GE)	Ability Enhancement compulsory course (AECC)	Skill Enhancement course (SEC)	
No. of course	14	4	4	2	2	26
Credit/course	6	6	6	2	2	140

Structure of B.Sc. Honours Zoology under CBCS

Core Courses (CC) – 14 compulsory courses

Semester	Course Name	Course Detail	Credits
I	ZOOL-H-CC-T-01	Non-chordates I: Protista to Pseudocoelomates	4
	ZOOL-H-CC-P-01	Non-chordates I: Protista to Pseudocoelomates Lab	2
	ZOOL-H-CC-T-02	Perspectives in Ecology	4
	ZOOL-H-CC-P-02	Perspectives in Ecology Lab	2
II	ZOOL-H-CC-T-03	Non-chordates II: Coelomates	4
	ZOOL-H-CC-P-03	Non-chordates II: Coelomates Lab	2
	ZOOL-H-CC-T-04	Cell Biology	4
	ZOOL-H-CC-P-04	Cell Biology Lab	2
III	ZOOL-H-CC-T-05	Diversity of Chordates	4
	ZOOL-H-CC-P-05	Diversity of Chordates Lab	2
	ZOOL-H-CC-T-06	Animal Physiology: Controlling and Coordinating Systems	4
	ZOOL-H-CC-P-06	Animal Physiology: Controlling and Coordinating Systems Lab	2
	ZOOL-H-CC-T-07	Fundamentals of Biochemistry	4
	ZOOL-H-CC-P-07	Fundamentals of Biochemistry Lab	2
IV	ZOOL-H-CC-T-08	Comparative Anatomy of Vertebrates	4
	ZOOL-H-CC-P-08	Comparative Anatomy of Vertebrates Lab	2
	ZOOL-H-CC-T-09	Animal Physiology: Life Sustaining Systems	4
	ZOOL-H-CC-P-09	Animal Physiology: Life Sustaining Systems Lab	2
	ZOOL-H-CC-T-10	Immunology	4
	ZOOL-H-CC-P-10	Immunology Lab	2
V	ZOOL-H-CC-T-11	Molecular Biology	4
	ZOOL-H-CC-P-11	Molecular Biology Lab	2
	ZOOL-H-CC-T-12	Principles of Genetics	4

Semester	Course Name	Course Detail	Credits
V	ZOOL-H-CC-P-12	Principles of Genetics Lab	2
VI	ZOOL-H-CC-T-13	Developmental Biology	4
	ZOOL-H-CC-P-13	Developmental Biology Lab	2
	ZOOL-H-CC-T-14	Evolutionary Biology	4
	ZOOL-H-CC-P-14	Evolutionary Biology Lab	2

Discipline Specific Elective Courses (DSE) – Four courses offered, to be opted for in Semesters V and VI

Semester V		Semester VI	
ZOOL-H-DSE – 1	**ZOOL-H-DSE – 2**	**ZOOL-H-DSE – 3**	**ZOOL-H-DSE – 4**
Fish and Fisheries	Microbiology	Parasitology	Endocrinology
Provided that a candidate will, in Sem 5, be able to opt for a Dissertation *in lieu* of a DSE paper, on a topic to be chosen from the paper that was opted out of.			

Generic Elective Courses (GEC) – Courses offered to students of other Departments

Semester I	Semester II	Semester III	Semester IV
ZOOL-H-GE-T-01	**ZOOL-H-GE-T-02**	**ZOOL--GE-T-03**	**ZOOL-H-GE-T-04**
Aquarium Fish Keeping	Human Physiology	Environment and Public Health	Insect Vectors and diseases

Ability Enhancement Compulsory Courses (AECC) – Two compulsory courses in Semesters I & II

1. English Communication
2. Environmental Science

Skill Enhancement Courses (SEC): Two courses in Semesters III and IV

ZOOL-H-SEC – 1	ZOOL-H-SEC – 2
Aquarium Fish Keeping	Sericulture

TABLE-1. DETAILS OF COURSES & CREDIT OF B.SC. ZOOLOGY (HONOURS) UNDER CBCS

S. No.	**Particulars of Course**	**Credit Point**
1.	**Core Course: 14 Papers**	**Theory + Practical**
1.A.	Core Course: Theory (14 papers)	14x4 = 56
1.B.	Core Course (Practical/Tutorial) *(14 papers)	14x2 = 28
2.	**Elective Courses: (8 papers)**	
2.A.	A. Discipline specific Elective (DSE)(4 papers)	4x4 = 16
2.B.	DSE (Practical)* (4 papers)	4x2 =8
2C.	General Elective (GE) (Interdisciplinary) (4 papers)	4x4 = 16
2.D.	GE (Practical)* (4 papers)	4x2 =8
# Optional Dissertation/ Project Work in place of* one *DSE paper (6 credits) in 6th semester		
3. Ability Enhancement Courses		
A.	AECC (2 papers of 2 credits each) ENVS, English Communication/ MIL	2x2 = 4
B.	Skill Enhancement Course(SEC) (2 papers of 2 credits each)	2x2 = 4
Total Credit:		**140**

TABLE-2: SEMESTER-WISE DISTRIBUTION OF COURSE & CREDITS IN B.SC. ZOOLOGY HONOURS

Courses/ (Credits)	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Sem-V**	**Sem-VI**	**Total No. of Courses**	**Total**
CC (6)	2	2	3	3	2	2	14	84
DSE (6)	--	--	--	--	2	2	04	24
GE (6)	1	1	1	1	--	--	04	24
AECC (2)	1	1	--	--	--	--	02	04
SEC (2)	--	--	1	1	--	--	02	04
Total No. of Course/ Sem.	4	4	5	5	4	4	26	--
Total Credit/ Semester	**20**	**20**	**26**	**26**	**24**	**24**	--	**140**

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Course Structure: UG (Zoology Honours) CBCS Curriculum

Semester I			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-CC-T-01	Non-chordates I: Protista to Pseudocoelomates	Core (60L)	4
ZOOL-H-CC-P-01	Non-chordates I: Protista to Pseudocoelomates Lab	Core (30P)	2
ZOOL-H-CC-T-02	Perspectives in Ecology	Core (60L)	4
ZOOL-H-CC-P-02	Perspectives in Ecology Lab	Core (30P)	2
ZOOL-H -GE-T-01	Aquarium fish keeping	General Elective (60L)	4
ZOOL-H -GE-P-01	Aquarium Fish keeping Lab	General Elective (30P)	2
ZOOL-H-AECC-01	English Communication/ Environmental Science	Ability Enhancement Compulsory (30L)	2
TOTAL FOUR (4) COURSES			**20**
Semester II			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-CC-T-03	Non-chordates II: Coelomates	Core (60L)	4
ZOOL-H-CC-P-03	Non-chordates II: Coelomates Lab	Core (30P)	2
ZOOL-H-CC-T-04	Cell Biology	Core (60L)	4
ZOOL-H-CC-P-04	Cell Biology Lab	Core (30P)	2
ZOOL-H -GE-T-02	Human Physiology	General Elective (60L)	4
ZOOL-H -GE-P-02	Human Physiology Lab	General Elective (30P)	2
UG-H-AECC-02	Environmental Science/ English Communication	Ability Enhancement Compulsory (30L)	2
TOTAL FOUR (4) COURSES			**20**
Semester III			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-CC-T-05	Diversity of Chordates	Core (60L)	4
ZOOL-H-CC-P-05	Diversity of Chordates Lab	Core (30P)	2

Semester III			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-CC-T-06	Animal Physiology: Controlling and Coordinating Systems	Core (60L)	4
ZOOL-H-CC-P-06	Animal Physiology: Controlling and Coordinating Systems Lab	Core (30P)	2
ZOOL-H-CC-T-07	Fundamentals of Biochemistry	Core (60L)	4
ZOOL-H-CC-P-07	Fundamentals of Biochemistry Lab	Core (30P)	2
ZOOL-H-SEC-T-01	Sericulture	Skill Enhancement (30L)	2
ZOOL-H -GE-T-03	Environment and Public Health	General Elective (60L)	4
ZOOL-H -GE-P-03	Environment and Public Health Lab	General Elective (30P)	2
TOTAL FIVE (5) COURSES			**26**
Semester IV			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-CC-T-08	Comparative Anatomy of Vertebrates	Core (60L)	4
ZOOL-H-CC-P-08	Comparative Anatomy of Vertebrates Lab	Core (30P)	2
ZOOL-H-CC-T-09	Animal Physiology: Life Sustaining Systems	Core (60L)	4
ZOOL-H-CC-P-09	Animal Physiology: Life Sustaining Systems Lab	Core (30P)	2
ZOOL-H-CC-T-10	Immunology	Skill Enhancement (30L)	4
ZOOL-H-CC-P-10	Immunology Lab	General Elective (60L)	2
ZOOL-H-SEC-T-02	Sericulture	General Elective (30P)	2
ZOOL-H -GE-T-04	Insect Vectors and diseases	Core (60L)	4
ZOOL-H -GE-P-04	Insect Vectors and diseases Lab	Core (30P)	2
TOTAL FIVE (5) COURSES			**26**
Semester V			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-CC-T-11	Molecular Biology	Core (60L)	4
ZOOL-H-CC-P-11	Molecular Biology Lab	Core (30P)	2
ZOOL-H-CC-T-12	Principles of Genetics	Core (60L)	4
ZOOL-H-CC-P-12	Principles of Genetics Lab	Core (30P)	2
ZOOL-H-DSE-T-1	Fish and Fisheries	DSE (60L)	4

Semester V			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-DSE-P-1	Fish and Fisheries Lab	DSE (30P)	2
ZOOL-H-DSE-T-2	Microbiology	DSE (60L)	4
ZOOL-H-DSE-P-2	Microbiology Lab	DSE (30P)	2
TOTAL FOUR (4) COURSES			**24**

Semester V			
Course Name	**Course Detail**	**Course wise Class**	**Credits**
ZOOL-H-CC-T-13	Developmental Biology		4
ZOOL-H-CC-P-13	Developmental Biology Lab		2
ZOOL-H-CC-T-14	Evolutionary Biology		4
ZOOL-H-CC-P-14	Evolutionary Biology Lab		2
ZOOL-H-DSE-T-3	Parasitology		4
ZOOL-H-DSE-P-3	Parasitology Lab		2
ZOOL-H-DSE-T-4	Endocrinology		4
ZOOL-H-DSE-P-4	Endocrinology Lab		2
TOTAL FOUR (4) COURSES			**24**

ZOOL-H-CC-T-01 – 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.

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; Canal system in sponges.

Unit 4: Cnidaria

1. General characteristics and Classification up to classes
2. Metagenesis in *Obelia*
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.*

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 helminths

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.

ZOOL-H-CC-P-01– Non-Chordates I Lab

Non-Chordates I: Protists to Pseudocoelomates. 2 credits

List of Practical

1. Identification of Amoeba, Euglena, Entamoeba, *Opalina, Paramecium, Plasmodium vivax* and *Plasmodium falciparum* (from the prepared slides)
2. Identification of *Sycon*, Neptune's Cup, *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora*
3. Identification and significance of adult *Fasciola hepatica*, *Taenia solium* and *Ascaris lumbricoides*
4. Staining/mounting of any protozoa/helminth from gut of cockroach

1 - 3: Identification upto subclass, with characters, with drawing and labeling.
4: Mounting.

ZOOL-H-CC-T-02– Perspectives in Ecology. 4 Credits.

Unit 1: Introduction to Ecology

Autecology and synecology, Levels of organization, Laws of limiting factors.

Unit 2: Population

1. Unique and group attributes of population: Demographic factors, life tables, fecundity tables, survivorship curves, dispersal.
2. Geometric, exponential and logistic growth, equation, r and K strategies Population regulation - density-dependent and independent factors.
3. Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition, predator-prey cycling.

Unit 3: Community

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

Unit 4: Ecosystem

1. Pond ecosystem 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
2. Nitrogen cycle

Unit 5: Applied Ecology

1. Wildlife Conservation (in-situ and ex-situ conservation).
2. 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

ZOOL-H-CC-P-02– Perspectives in Ecology Lab. 2 Credits

List of Practical

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO_2
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

1, 2: Theoretical, dry-lab.
4: Major excursion.

ZOOL-H-CC-T-03- 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 Excretion in Annelida through nephridia.
2. Metamerism in Annelida.

Unit 3:Arthropoda

1. General characteristics and Classification up to classes.
2. Respiration in Arthropoda
3. Metamorphosis in Lepidopteran Insects.
4. Social life in termite

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

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

General characteristics of phylum Hemichordata. 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.

ZOOL-H-CC-P-03– Non-Chordates II

Non-Chordates II: Coelomates. 2 Credits.

List of Practical

1. Study of following specimens:
    a. Annelids - *Aphrodite, Nereis, Sabella, Chaetopterus, Pheretima, Hirudinaria*
    b. Arthropods – *Limulus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx*, *Periplaneta*, termites and honey bees *Onychophora – Peripatus*
    c. Molluscs - *Chiton, Pila, Unio, Sepia, Octopus*
    d. Echinodermates - *Asterias*, *Echinus, Cucumaria* and *Antedon*
2. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm
3. 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 related topic to larval forms (crustacean, mollusc and echinoderm)

1, a – e, 2, 3: Identification upto subclass, with characters, with drawing and labelling.

ZOOL-H-CC-T-04- Cell Biology. 4 Credits

Unit 1: Overview of Cells

Basic structure of Prokaryotic and Eukaryotic cells, Viruses

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, Golgi Apparatus, Lysosomes
2. Protein sorting and mechanisms of vesicular transport

Unit 4: Cytoplasmic organelles II

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

Unit 5: Cytoskeleton

Type, structure and functions of cytoskeleton

Unit 6: Nucleus

Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome)

Unit 7: Cell Division

Cell cycle and its regulation, 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. Apoptosis and Necrosis

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.

ZOOL-H-CC-P-04 – Cell Biology Lab. 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.
3. Preparation of permanent slide to demonstrate:
    a. DNA by Feulgen reaction
    b. Cell viability study by Trypan Blue staining

Either 3a or 3b.

Lab note book, with drawing and labelling; methods where applicable.

ZOOL-H-CC-T-05- Diversity of Chordata. 4 Credits.

Unit 1: Introduction to Chordates

General characteristics and outline classification of Phylum Chordata

Unit 2: Protochordata

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

Unit 3: Origin of Chordata

Dipleurula concept and the Echinoderm theory of origin of chordates

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. Migration in Birds
3. Principles and aerodynamics of flight

Unit 9: Mammals

1. General characters and classification up to living orders
2. Affinities of Prototheria
3. Echolocation in Micro chiropterans.

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 Willam (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 Romer (1959), for Amphibia to be followed from Duellman and Trueb (1986).

ZOOL-H-CC-P-05– Diversity of Chordata Lab. 2 Credits

List of Practical

1. Protochordata: *Balanoglossus*, *Branchiostoma*
2. Agnatha: *Petromyzon* or *Myxine*
3. Fishes: *Scoliodon, Sphyrna*, *Torpedo, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis*, *Anguilla*, *Hippocampus, Tetrodon/ Diodon, Anabas,* Flat fish
4. Amphibia: *Bufo, Hyla, Axolotl, Tylototriton*
5. Reptilia: *Chelone*, *Trionyx, Hemidactylus, Varanus, Chamaeleon, Ophiosaurus, Draco, Vipera*, *Naja, Crocodylus*.

   Key for Identification of poisonous and non-poisonous snakes
6. Mammalia: Bat (Insectivorous and Frugivorous)
7. Pecten from Fowl head
8. Dissection of brain and pituitary of Rohu/Catla/Mrigal
9. Power point presentation on study of any two animals from two different classes by students (may be included if dissections not given permission)

1 – 6: Identification, upto Order, with labeled diagrams and characters

Students can opt for only 9, in place of 7 and 8

ZOOL-H-CC-T-06- Animal Physiology: Controlling & Coordinating Systems. 4 Credits.

Unit 1: Tissues

Structure, location, classification and functions of epithelial tissue.

Unit 2: Bone and Cartilage

Structure and types of bones and cartilages, Ossification

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; Reflex action and its types

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. Hypothalamus (neuroendocrine gland) - principal nuclei involved in neuroendocrine control of anterior pituitary and endocrine system.

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.

ZOOL-H-CC-P-06– Animal Physiology: Controlling & Coordinating Systems Lab. 2 Credits.

List of Practical

1. Preparation of temporary mounts: Squamous epithelium or Striated muscle fibres or nerve cells
2. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
3. Microtomy: Preparation of permanent slide of any five mammalian (Goat/white rat) tissues

Lab note book, with drawing and labelling; methods to be mentioned wherever applicable.

ZOOL-H-CC-T-07- Fundamentals of Biochemistry. 4 Credits.

Unit 1: Carbohydrates

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

Unit 2: Lipids

Lipid metabolism: β-oxidation of fatty acids; Fatty acid biosynthesis

Unit 3: Proteins

1. Amino acids

   Structure, Classification, General and Electro chemical properties of α-amino acids; Physiological importance of essential and non-essential amino acids
2. 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- and 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; Derivation of Michaelis-Menten equation, Lineweaver-Burk plot; Factors affecting rate of enzyme-catalyzed reactions; Enzyme inhibition; Allosteric enzymes and their kinetics.

Unit 5: Oxidative Phosphorylation

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.

ZOOL-H-CC-P-07–Fundamentals of Biochemistry Lab. 2 Credits

List of Practical

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Demonstration/Virtual lab/Dry lab of paper chromatography of amino acids.
3. Quantitative estimation of Lowry Method
4. Demonstration/Virtual lab/Dry lab of proteins separation by SDS-PAGE.
5. Wet lab: to study the enzymatic activity of Trypsin or Lipase.
6. Wet lab: To perform the Acid and Alkaline phosphatase assay from serum/ tissue/soil.

Either 2 or 4.
Lab note book, with methods where applicable.

ZOOL-H-CC-T-08 - Comparative Anatomy of Vertebrates. 4 Credits

Unit 1: Integumentary System

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

Unit 2: Skeletal System

Jaw suspension; structure of branchial and visceral arches.

Unit 3: Digestive System

Types of jaws and suspensions; Teeth.

Unit 4: Circulatory System

Comparative account of heart and aortic arches

Unit 5: Urinogenital System

Succession of kidney, Types of mammalian uteri.

Unit 6: Nervous System

Cranial nerves in mammals.

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.

ZOOL-H-CC-P-08– 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
3. Demonstration of Carapace and plastron of turtle OR
4. Identification of mammalian skulls: One herbivorous (Guineapig) and one carnivorous (Dog) animal
5. Dissection of Tilapia: Circulatory system, Brain, pituitary, urinogenital system

Either 3 or 4.
Lab note book, with labelled diagrams and identifications, with reason.

ZOOL-H-CC-T-09- 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

Unit 2: Physiology of Respiration

Mechanism of Respiration, Respiratory volumes and capacities, transport of Oxygen and Carbon dioxide in blood, Dissociation curves and the factors influencing it, respiratory pigments; Carbon monoxide poisoning

Unit 3: Physiology of Circulation

1. Components of Blood and their functions; Structure and functions of haemoglobin
2. Haemostasis; Blood clotting system, Fibrinolytic 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, 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. Thermal biology of endotherms
3. Osmoregulation in aquatic vertebrates
4. 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. Harcourt 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 French.
- 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

ZOOL-H-CC-P-09– 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 from mammal/fish blood.
5. Recording of blood pressure using a sphygmomanometer

Lab note book with methods and results.

Core T10 – Immunology. 4 Credits

Unit 1: Overview of Immune System

Basic concepts of health and diseases, 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

Unit 4: Immunoglobulins

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

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, Dengue ~~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.

Core P10 – Immunology Lab. 2 Credits

List of Practical

1. Demonstration/virtual lab/dry lab 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.
5. Demonstration/virtual lab/dry lab of ELISA.

The experiments can be performed depending upon usage of animals in UG courses.
Lab notebook with labelled drawings and results. Methods to be mentioned where applicable.

Core T11 - Molecular Biology. 4 Credits

Unit 1: Nucleic Acids

Salient features of DNA and DNA 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, Ribosome structure and assembly 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.

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

PCR, Western and Southern blot, Northern Blot, Sanger DNA sequencing

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 Cummings.

Core P11 – Molecular Biology Lab. 2 Credits

List of Practical

1. Demonstration of polytene and lampbrush chromosome from photograph
2. Isolation and quantification of genomic DNA usingspectrophotometer (A260 measurement) either by Instrument or by demonstration/virtual lab/dry lab.
3. Agarose gel electrophoresis for DNA either by Instrument or by demonstration/virtual lab/dry lab.

Lab notebook with labelled diagrams, methods and results.

Core T12 - Principles of Genetics. 4 Credits

Unit 1: Mendelian Genetics and its Extension

1. Principles of inheritance, Incomplete dominance and co-dominance, Epistasis Multiple alleles, Lethal alleles, Pleiotropy,
2. 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
2. Kappa particle in *Paramoecium*

Unit 6: Recombination in Bacteria and Viruses

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage

Unit 7: Transposable Genetic Elements

Transposons in bacteria, P elements in *Drosophila*, 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.

Core P12 – 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

Lab notebook with labelled diagrams, methods (wherever applicable) and results.

Core T13 - Developmental Biology. 4 Credits.

Unit 1: Early Embryonic Development

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); Embryonic induction and organizers

Unit 2: 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 3: Post Embryonic Development

Development of brain and Eye in Vertebrate
Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each)

Unit 4: Implications of Developmental Biology

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

Reference Books

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

Core P13 – Developmental Biology Lab. 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, 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 (photomicrograph/ slides)
4. Project report on *Drosophila* culture/aspects of chick embryo development under normal or stressed condition

Either 1 or 2.
Lab notebook with labelled diagrams, methods (wherever applicable) and results.

Core T14 – Evolutionary Biology. 4 Credits

Unit 1

1. Geological time scale; evolution of horse
2. Neutral theory of molecular evolution, Molecular clock

Unit 2

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)

Unit 3

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

Unit 4

Origin and Evolution of Man (from *Sahelanthropus* to *Homo sapiens*), Unique Hominid characteristics contrasted with primate characteristics.

Unit 5

Phylogenetic trees, Construction & interpretation of Phylogenetic tree using parsimony, distance methods, 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.

Core P14 – Evolutionary Biology Lab. 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 20 humans in relation to their age and sex.

   Lab notebook with labelled diagrams, methods and results.

Department Specific Electives Subjects Syllabus

DSE T1 – Endocrinology. 4 Credits

Unit 1: Introduction to Endocrinology

General idea of Endocrine systems, Classification, Characteristic and Transport of Hormones.

Unit 2: Epiphysis, Hypothalamo-hypophysial Axis

1. Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction.
2. 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, Pancreas, Ovary and Testis
2. Hormones in homeostasis, Disorders of endocrine glands

Unit 4: Regulation of Hormone Action

1. Bioassays of hormones using RIA & ELISA
2. Estrous cycle in rat and menstrual cycle in human
3. Multifaceted role of Vasopressin & Oxytocin.

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 O. Norris.

DSE P1 – 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. Estimation of plasma level of any hormone using ELISA (either on Instrument or by demonstration).
5. Designing of primers of any hormone.

Lab notebook with labelled diagrams, methods (wherever applicable) and results.

DSE T2 - Fish and Fisheries. 4 Credits

Unit 1: Introduction and Classification

1. Feeding habit, habitat and manner of reproduction
2. Classification of fish (up to Subclasses)

Unit 2: Morphology and Physiology

Types of fins and their modifications; 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.

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.

Unit 4: Aquaculture

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Induced breeding of fish; Management of finfish hatcheries; 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: Romer A. S. (1959)

DSE P2 – 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*, *Echeneis*, exotic carps – Identification with characters.
3. Study of different types of scales (through permanent slides/ photographs).
4. Study of crafts and gears used in Fisheries (Pictures/models). Characters.
5. Water quality criteria for Aquaculture: Assessment of pH, DO, free CO_2, productivity, alkalinity, hardness, chloride (by titration/refractometer).
6. Study of air breathing organs in *Channa*, *Heteropneustes*, *Anabas* and *Clarias.* Drawing with characters.
7. Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.

Lab notebook with labelled diagrams, methods and results.

DSE T3 – 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 *Trypanosoma gambiense, Leishmania donovani*

Unit 3: Parasitic Platyhelminthes

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

Unit 4: Parasitic Nematodes

Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti.*

Unit 5: Parasitic Arthropods

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

Unit 5: Parasite Vertebrates

Brief account of 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 Lal 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.

DSE P3 – Parasitology Lab. 2 Credits

List of Practicals

1. Study of life stages of any one: *Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani* through permanent slides/micro photographs
2. Study of adult and life stages of any one: *Schistosoma haematobium*, *Taenia saginata* through permanent slides/micro photographs
3. Study of adult and life stages of any one: *Ancylostoma duodenale*, *Brugia malayi* and *Trichinella spiralis* through permanent slides/micro photographs
4. Study of plant parasitic root knot nematode, Meloidogyne from the soil sample through permanent slides/micro photographs
5. Study of any one: *Pediculus humanus*, *Xenopsylla cheopis* 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 bird [Intestine can be procured from poultry/market as a by-product

Submission of a brief report on parasitic vertebrates

6 and 7: Wet lab.

Lab notebook with labelled diagrams, methods and results.

DSE T4- Microbiology. 4 Credits

Unit 1: Morphology of Bacteria and Virus

Cell wall (Structure of peptidoglycan), Cell envelope (Cell membrane, Differences between gram- positive and gram-negative species, External capsule and glycocalyx, Plasmids and episomes. Nuclear material, Bacterial Chromosome (Fundamental differences with eukaryotic chromosome). Reserve materials (carbon and phosphate reserve, cyanophycin), Cytoplasmic inclusions (Chlorosome, magnetosome, carboxysome, gas vesicles, ribosome).

Unit 2: Normal flora

Distribution of normal flora in the-intestinal tract and urino-genital tract, Beneficial functions of normal flora. Harmful effects of normal flora.

Unit 3: Pathogenicity of Microorganisms

Bacterial pathogenesis: Entry to the host, Adherence to host cells, Invasiveness, Bacterial toxins: Exotoxins, Endotoxins, Cellular level (Cell death, Transformation, Cell fusion, Cytopathic effect). Initial infections: Routes of entry and dissemination to secondary sites, Typical secondary sites of localization.

Unit 4: Infection of pathogens to human populations

Communicable, Non-communicable, Endemic, Epidemic, Pandemic and Sporadic

Unit 7: Diagnostic Microbiology and Bacteria culture

Koch's postulates, Sensitivity and specificity of test results, Principles and applications: Simple staining, Gram-staining, Acid-fast staining, Collection of specimens, Growth requirements and Growth factors, Oxygen requirement. Culture Media: Simple media, Complex media, Selective media and Enriched media

Unit 8: Genetic recombination in bacteria

Transformation, Conjugation- F+, F-, Hfr & F' strain, Transduction, Generalised & specialized types.

Unit 9: Microbial Diseases

Name of pathogen, symptoms, pathogenesis, mode of action & preventive measures of following diseases: Typhoid, Staphylococcal Food Poisoning, AIDS

Reference Books

- Alexander, M. (1977). Introduction to Soil Microbiology. John Wiley and Sons, New York.
- Atlas, R. M. and Bartha, R. (1997). Microbial Ecology: Fundamentals and Applications, 4th ed., Benjamin/ Cummings.
- Black, J. G. (2011). Microbiology: Principles and Explorations. 8th ed. John Wiley and Sons, New York.
- Campbell, R. (1983). Microbial Ecology. 2nd ed. Oxford, Blackwell.
- Pinehuk, G. (2003). Schaum's outline Series: Theory and Problems of Immunology. McGrawHill.

- Presscott, L. M., Harley, J. P. and Klein, D. A. (2011). Microbiology, 8th ed. McGrawHill, New York.
- Schlegel, H. G. (1993). General Microbiology. 7th ed. Cambridge University Press.
- Slonczeweski, J.L. and Foster, J.W. (2009). Microbiology- An Evolving Science. Norton.
- Stanier, R. Y., Adelberg, E. A. and Ingraham, J. L. (1986). General Microbiology. 5th ed. Macmillan.
- Talaro, K. and Talaro, A. (1999). Foundations in Microbiology. 3rd ed. Dubuque, McGraw Hill.
- Tortora, G. J., Funke, B. R., and Case. C. L. (2008). Microbiology. An Introduction. 9th ed. Benjamin/Cummings Publishing. Menlo Park Calif.
- Voyleys, B. A. (2002). The biology of viruses, 2nd ed. McGraw-Hill.

DSE P5 – Microbiology Lab. 2 Credits

List of Practical

1. Simple staining and Gram's staining of bacteria.
2. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria.

Demonstration, with pictures/slides/virtual lab of (with write-up in lab note book):

3. Preparation of slant and stab.
4. Pure culture techniques: Spread plate, Pour plate and Streak plate
5. Biochemical test for characterization:

   Catalase, Nitrate-reduction, Indole production, Methyl Red and Voges-Proskauer Test.
6. Microbiological examination of milk (Methylene blue reductase test).
7. Sugar fermentation test.

Lab notebook with labelled diagrams, methods and results.

Skill Enhancement Course

SEC T1 - Aquarium Fish Keeping. 2 Credits

Unit 1: Introduction to Aquarium Fish Keeping

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, 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,

Unit 4: Fish Transportation

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

SEC T2 – Sericulture. 2 Credits

Unit 1: Introduction

1. Types of silkworms, Distribution and Races
2. Exotic and indigenous races
3. Mulberry and non-mulberry Sericulture

Unit 2: Biology of Silkworm

1. Life cycle of *Bombyx mori*
2. Structure of silk gland and secretion of silk

Unit 3: Rearing of Silkworms

1. Rearing house and rearing appliances.
2. Disinfectants: Formalin, bleaching powder, ~~RKO~~
3. Silkworm rearing technology: Early age and Late age rearing
4. Types of mountages
5. Spinning, harvesting and storage of cocoons

Unit 4: Pests and Diseases

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

Unit 5: Entrepreneurship in Sericulture

Report on a visit to various sericulture centre.

GE 1SemTh - 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

GE 1SemPr – Environment and Public Health Lab 2 Credits

List of Practical

To determine pH, Cl^-, SO_4^{3-}, NO_3^- in soil and water samples from different locations.

Lab notebook with methods and results.

GE 2SemTh - 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, Viral encephalitis, 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

GE 2SemPr – 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*, *Xenopsylla cheopis*, *Cimex lectularius*, *Phlebotomus argentipes*, *Musca domestica* through permanent slides/ photographs
3. Study of different diseases transmitted by above insect vectors

Submission of a project report on any one of the insect vectors and disease transmitted
Lab notebook with labelled diagrams.

GE 3SemTh - Human Physiology. 4 Credits.

Unit 1: Digestion and Absorption of Food

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)

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 Physiology

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

Unit 4: Renal Physiology

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

Unit 5: Cardiovascular Physiology

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

Unit 6: Endocrine and Reproductive Physiology

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

Reference Books

- 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.

GE 3SemPr – Human Physiology Lab. 2 Credits

List of Practical

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

   Lab notebook with labelled diagrams, methods and results.

GE 4SemTh - Animal Cell Biotechnology. 4 Credits

Unit 1: Techniques in Gene manipulation

1. Recombinant DNA technology, Isolation of genes, Concept of restriction and modification: Restriction endonucleases, DNA modifying enzymes
2. Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids, Shuttle and Expression Vectors.
3. Construction of Genomic libraries and cDNA libraries

Unit 2: Animal cell Culture

1. Basic techniques in animal cell culture and organ culture, Primary Culture and Cell lines, Culture media- Natural and Synthetic, Stem cells, Cryopreservation of cultures.
2. Agarose and Polyacrylamide Gel Electrophoresis, Southern, Northern and Western blotting, DNA sequencing: Sanger method, Polymerase chain reaction, DNA Fingerprinting.

Unit 3: Fermentation

1. Different types of Fermentation: Submerged & Solid state; batch, Fed batch & Continuous; Stirred tank.
2. Downstream Processing: Filtration, centrifugation, extraction, chromatography, spray drying-and lyophilization.

Unit 4: Transgenic Animal Technology

Production of transgenic animals: nuclear transplantation, DNA microinjection method, Dolly

Unit 5: Application in Health

Development of recombinant Vaccines, Hybridoma technology, Gene Therapy.
Production of recombinant Proteins: Insulin and growth hormones.

Reference Books

- 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).
- Methods in Gene Biotechnology, W. Wu, M.J. Welsh, P.B. Kaufman & H.H. Zhang, 1997, CRC Press, New York
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart,
- W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA

GE 4SemPr – Animal Cell Biotechnology Lab. 2 Credits

List of Practical

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation of culture media.

Demonstration/Virtual lab/Dry lab of (with write-up in lab note book):

3. Preparation of genomic DNA from E. coli/animals/ human.
4. Plasmid DNA isolation (pUC 18/19) and DNA quantitation using agarose gel electrophoresis (by using lambda DNA as standard).
5. Restriction digestion of lambda (λ) DNA using EcoR1 and Hind III.
6. Preparation of competent cells and Transformation of E. coli with plasmid DNA using CaCl2, Selection of transformants on X-gal and IPTG (Optional).
7. Techniques: Western Blot, Southern Hybridization, DNA Fingerprinting, PCR, DNA Microarrays

Lab notebook with diagrams, methods and results.