KOHIMA SCIENCE COLLEGE

(An Autonomous Government P.G. College)

JOTSOMA, NAGALAND

SYLLABUS
FOR
UNDERGRADUATE PROGRAMME
(ZOOLOGY)

As per National Education Policy, 2020

2024

Structure of the UG Programme

Table: The Semester-wise and Broad Course Category-wise Distribution of credits of the Undergraduate Programme:

Semester	Discipline Specific Courses - Core	Minor	Multi-disciplinary courses	Ability Enhancement courses (language)	Skill Enhancement courses /Internship /Dissertation	Common Value-Added Courses	Total Credits
I	MJ-1 (4 Credits)	MN-1 (4 Credits)	MDC-1 (3 Credits)	AEC-1 (3 Credits)	SEC-1 (3 Credits)	VAC-1 (3 Credits)	20
II	MJ-2 (4 Credits)	MN-2 (4 Credits)	MDC-2 (3 Credits)	AEC-2 (3 Credits)	SEC-2 (3 Credits)	*VAC-2 (3 Credits)	20
	Students exiting the programme after securing 40 credits will be awarded UG Certificate in the relevant Discipline /Subject provided they secure 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.						40
III	MJ-3 MJ-4 (8 Credits)	MN-3 (4 Credits)	MDC-3 (3 Credits)	AEC-3 (2 Credits)	SEC-3 (3 Credits)	-	20
IV	MJ-5 MJ-6 MJ-7 MJ-8 (16 Credits)	MN-4 (4 Credits)	-	-	-	-	20
	Students exiting the programme after securing 80 credits will be awarded UG Diploma in the relevant Discipline /Subject provided they secure additional 4 credits in skill based vocational courses offered during first year or second year summer term.						80
V	MJ-9 MJ-10 MJ-11 (12 Credits)	MN-5 (4 Credits)	-	-	Internship (4 credits)	-	20
VI	MJ-12 MJ-13 MJ-14 MJ-15 (16 Credits)	MN-6 (4 Credits)	-	-	-	-	20
	Students who want to undertake 3-year UG programme will be awarded UG Degree in the relevant Discipline /Subject upon securing 120 credits						120
VII	MJ-16 MJ-17 MJ-18 MJ-19 (16 Credits)	MN-7 (4 Credits)	-	-	-	-	20
VIII	MJ-20 (4 Credits)	MN-8 (4 Credits)	-	-	MJ-21 MJ-22 MJ-23 or [Research Project/ Dissertation](12 credits)		20
	Students will be awarded UG Degree (Honours) with Research in the relevant Discipline /Subject provided they secure 160 credits						160

Course Offered by Department of Zoology

MAJOR COURSE	COURSE NAME	CREDIT
MAJOR 1	Non- chordates 1: Protozoans to Pseudocoelomates	4
MAJOR 2	Non-chordates II: Coelomates	4
MAJOR 3	Diversity of Chordates	4
MAJOR 4	Cell Biology	4
MAJOR 5	Fundamentals of Biochemistry	4
MAJOR 6	Comparative Anatomy of Vertebrates	4
MAJOR 7	Principles of Ecology	4
MAJOR 8	Physiology: Controlling and Coordinating Systems	4
MAJOR 9	Physiology: Life Sustaining Systems	4
MAJOR 10	Biochemistry of Metabolic Processes	4
MAJOR 11	Developmental Biology	4
MAJOR 12	Principles of genetics	4
MAJOR 13	Biosystematics and Evolutionary Biology	4
MAJOR 14	Animal Behaviour and Chronobiology	4
MAJOR 15	Environmental and Public Health	4
MAJOR 16	(A) Fish Biology-I (or) (B) Entomology-I	4
MAJOR 17	Biotechniques and Biostatistics	4
MAJOR 18	Research methodology	4
MAJOR 19	Endocrinology	4
MAJOR 20	(A) Fish biology-II (or) (B) Entomology-II	4
MAJOR 21	Immunology	4
MAJOR 22	Reproductive biology	4
MAJOR 23	Parasitology	4
(In lieu of MAJOR 21, 22 & 23) or Research Project/ Dissertation		*12*

MINOR COURSE	COURSE NAME	CREDIT
MINOR 1	Non- chordates 1: Protozoans to Pseudocoelomates	4
MINOR 2	Non-chordates II: Coelomates	4
MINOR 3	Cell Biology	4
MINOR 4	Physiology: Controlling and Coordinating Systems	4
MINOR 5	Developmental Biology	4
MINOR 6	Environmental and Public Health	4
MINOR 7	Endocrinology	4
MINOR 8	Parasitology	4

MDC	COURSE NAME	CREDIT
MDC 1	(A) Traditional knowledge-I (or) (B) Wildlife Conservation and Management-I	3
MDC 2	(A) Traditional Knowledge-II (or) (B) Wildlife Conservation and Management-II	3
MDC 3	Fundamentals of Life Sciences	3

SEC	COURSE NAME	CREDIT
SEC1	Apiculture (or) Aquarium Fish Keeping	3
SEC 2	Medical Diagnostics (or) Sericulture	3
SEC 3	Vermicomposting Techniques (or) Poultry Management	3

VAC	COURSE NAME	CREDIT
VAC 1	Environmental Studies	3
VAC 2	Food, Nutrition and Health	3

Course Structure (Zoology)

SEMESTER	COURSE	COURSE NAME	CREDIT
I	MAJOR 1	Non- chordates 1: Protozoans to Pseudocoelomates (Theory & Practical)	4
	MINOR 1	Non- chordates 1: Protozoans to Pseudocoelomates (Theory & Practical)	4
	MDC 1	(A) Traditional knowledge-I (Theory & Practical) (or) (B) Wildlife Conservation and Management-I (Theory)	3
	SEC 1	(A) Apiculture (Theory & Practical) (or) (B) Aquarium Fish Keeping (Theory & Practical)	3
	VAC 1	Environmental Studies (Theory)	3
II	MAJOR 2	Non-chordates II: Coelomates (Theory & Practical)	4
	MINOR 2	Non-chordates II: Coelomates (Theory & Practical)	4
	MDC 2	(A) Traditional Knowledge-II (Theory & Practical) (or) (B) Wildlife Conservation and Management-II (Theory)	3
	SEC 2	(A) Medical Diagnostics (Theory & Practical) (or) (B) Sericulture (Theory & Practical)	3
	VAC 2	Food, Nutrition and Health (Theory)	3
III	MAJOR 3	Diversity of Chordates (Theory & Practical)	4
	MAJOR 4	Cell Biology (Theory & Practical)	4
	MINOR 3	Cell Biology (Theory & Practical)	4
	MDC 3	Fundamentals of Life Sciences (Theory)	3
	SEC 3	(A) Vermicomposting techniques (Theory & Practical) (or) (B) Poultry Management (Theory & Practical)	3
IV	MAJOR 5	Fundamentals of Biochemistry (Theory & Practical)	4
	MAJOR 6	Comparative Anatomy of Vertebrates (Theory & Practical)	4
	MAJOR 7	Principles of Ecology (Theory & Practical)	4
	MAJOR 8	Physiology: Controlling and Coordinating Systems (Theory & Practical)	4
	MINOR 4	Physiology: Controlling and Coordinating Systems (Theory & Practical)	4
V	MAJOR 9	Physiology: Life Sustaining Systems (Theory & Practical)	4
	MAJOR 10	Biochemistry of Metabolic Processes (Theory & Practical)	4
	MAJOR 11	Developmental Biology (Theory & Practical)	4
	MINOR 5	Developmental Biology (Theory & Practical)	4

	INTERNSHIP		4
VI	MAJOR 12	Principles of genetics (Theory & Practical)	4
	MAJOR 13	Biosystematics and Evolutionary Biology (Theory & Practical)	4
	MAJOR 14	Animal Behaviour and Chronobiology (Theory & Practical)	4
	MAJOR 15	Environmental and Public Health (Theory & Practical)	4
	MINOR 6	Environmental and Public Health (Theory & Practical)	4
VII	MAJOR 16	(A) Fish Biology-I (Theory & Practical) (or) (B) Entomology-I (Theory & Practical)	4
	MAJOR 17	Biotechniques and Biostatistics (Theory & Practical)	4
	MAJOR 18	Research methodology (Theory & Practical)	4
	MAJOR 19	Endocrinology (Theory & Practical)	4
	MINOR 7	Endocrinology (Theory & Practical)	4
VIII	MAJOR 20	(A) Fish biology-II (Theory & Practical) (or) (B) Entomology-II (Theory & Practical)	4
	MAJOR 21	Immunology (Theory & Practical)	4
	MAJOR 22	Reproductive biology (Theory & Practical)	4
	MAJOR 23	Parasitology (Theory & Practical)	4
	MINOR 8	Parasitology (Theory & Practical)	4
	(In lieu of MAJOR 21, 22 & 23) or Research Project/ Dissertation		*12*

MAJOR COURSE

MAJOR 1
NON-CHORDATES I: PROTOZOANS TO PSEUDOCOELOMATES

Theory Credits: 3

Unit 1: Protozoa

General characteristics and classification up to classes.
Morphological study of *Amoeba*, *Euglena* and *Paramaecium*.
Mode of locomotion and nutrition in *Amoeba* and *Paramecium*.
Mode of reproduction in *Amoeba* and *Euglena*.
Conjugation and Endomixis in P*aramaecium*.

Unit 2: Porifera and Cnidaria

Porifera: General characteristics and classification up to classes; *Sycon* with special reference to structure, reproduction and development; Spicules in sponges; Canal system.
Cnidaria: General characteristics and classification up to classes; Metagenesis in *Obelia*; Polymorphism in Cnidaria; Brief account of corals and coral reefs and their importance.

Unit 3: Ctenophora, Platyhelminthes and Nemathelminthes

General characteristics of Ctenophora.
General characteristics and classification up to classes of Platyhelminthes; Study of *Fasciola hepatica* with reference to structure, reproduction, life cycle and pathogenicity.
General characteristics and classification up to classes of Nemathelminthes; Study of *Ancylostoma duodenali* with special reference to structure, reproduction, life cycle and pathogenicity; Parasitic adaptations in helminthes.

Practical Credits: 1

1. Study of whole mount of *Amoeba*, *Monocystis* and *Trypanosoma*.
2. Binary fission and conjugation in *Paramecium*.
3. Culture of *Paramecium* or *Euglena*.
4. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Spongilla*, *Obelia*, *Physalia*, *Gorgonia*.
5. One specimen/slide of any Ctenophore.
6. Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/microphotographs) .
7. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs).
8. Temporary mounting of Spicules and Gemmules.

Recommended Books and References:

- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science.
- Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.
- Kotpal, R. L. (2005): Modern text book of Zoology Invertebrates (Animal Diversity-I). Rastogi Publications pp 795-831. Rastogi V. B. (2015): Invertebrate Zoology. Publisher- Kedar Nath Ram Nath.
- Verma, P. S. (2015): A Manual of Practical Zoology Invertebrates. S. Chand & Company Pvt. Ltd. Ram Nagar, New Delhi-110055.
- Yadav, V., Yadav, P. Varshney, V. K., Varshney, V. C. (2015): Text Book of Practical Zoology-I. Publisher- Kedar Nath Ram Nath Merrut.

MAJOR 2
NON-CHORDATES II: COELOMATES

Theory Credits: 3

Unit 1: Coelomates and Annelida
Evolution and types of coelom and metamerism; Significance of coelom and metamerism. General characteristics and classification of Annelida up to classes; Locomotion and Reproduction in Annelida.

Unit 2: Onychophora and Arthropoda
General characteristics and Evolutionary significance of Onychophora.
Arthropoda: General characteristics and classification up to classes; Vision and respiration in Arthropoda; Larval forms of crustacean; Metamorphosis in Insects.
Social life in bees and termites.

Unit 3: Mollusca and Echinodermata
Mollusca: General characteristics and classification up to classes; Respiration in Mollusca; Torsion and detorsion in Gastropoda; Pearl formation in bivalves; Evolutionary significance of Trochophore larva.
Echinodermata: General characteristics and classification up to classes; Water-vascular system in Asteroidea; Larval forms in Echinodermata; Affinities with Chordates.

Practical Credits: 1

1. Study of following specimens: Annelids - Aphrodite, *Nereis*, *Heteronereis*, *Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria*.
   Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta*, termites and honeybees
   Onychophora - *Peripatus*
   Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus*.
   Echinodermates - *Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria and Antedon*
2. Dissection/model/video of digestive system, reproductive system, nervous system 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. Temporary mount of Setae of earthworm, Radula of *Pila*. *

(*Subjected to UGC guidelines)

Recommended Books and References:

- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science.
- Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.

MAJOR 3:
DIVERSITY OF CHORDATA

Theory Credit: 3

Unit 1: Chordates, Protochordata and Agnatha
General characteristics and outline classification of chordate; General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates.
Retrogressive metamorphosis in Urochordata; Theories of Chordate Origin.
General characteristics and classification of cyclostomes up to class.

Unit 2: Pisces, Amphibia and Reptilia
General characteristics of Chondrichthyes and Osteichthyes; Classification of Pisces up to order; Migration, Osmoregulation and Parental care in fishes; Origin of *Tetrapoda* (Evolution of terrestrial ectotherms); General characteristics and classification of Amphibia up to order; Parental care in Amphibians; General characteristics and classification of Reptilia up to order.
Poison apparatus and Biting mechanism in snakes.

Unit 3: Aves, Mammals and Zoogeography
General characteristics and classification of Aves up to order; *Archaeopteryx*: a connecting link; Principles and aerodynamics of flight; Flight adaptations and Migration in birds.
General characters and classification of mammals up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages;Distribution of vertebrates in different zoogeographical realms.

Practical Credit: 1

1. Protochordata: *Balanoglossus, Herdmania, Branchiostoma,* Sections of *Amphioxus* throughpharyngeal, intestinal and caudal regions.
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: *Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamandra*
5. Reptilia: *Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus*
6. Key for Identification of poisonous and non-poisonous snakes
7. Aves: Study of six common birds from different orders. Types of beaks and claws
8. Mammalia: *Sorex,* Bat (Insectivorous and Frugivorous), *Funambulus, Loris, Herpestes, Erinaceous.*
9. Dissection/microphotograph/model/video of Frog- Digestive System and spinal nerve.*
10. Dissection/microphotograph/model/video of Afferent and Efferent branchial arteries of Scoliodon.*
11. Temporary mount of placoid, cycloid and Ctenoid Scale of Fish.

(*Subject to UGC guidelines)

Recommended Books and References:

- 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.

MAJOR 4
CELL BIOLOGY

Theory Credit: 3

Unit 1: Overview of cell, Plasma membrane and Endomembrane System
Prokaryotic and Eukaryotic cells; Virus, Viroids, Mycoplasma and Prions.
Plasma Membrane: Various models of plasma membrane structure; Transport across membranes: Active and Passive transport; Cell Junctions: Tight junctions, Desmosomes and Gap junction.
Structure and functions of Endoplasmic Reticulum, Golgi apparatus and Lysosomes; Protein sorting and Transport-system (ER, Golgi apparatus, Lysosome).

Unit 2: Mitochondria, Peroxisomes & Cytoskeleton
Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis, Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis; Peroxisomes; Cytoskeleton: Structure and Functions of Microtubules, Microfilaments and Intermediate filaments.

Unit 3: Nucleus, Cell Division and Cell Signalling
Nucleus: Nuclear envelope, Nuclear pore complex and Nucleolus. Chromatin: Euchromatin and Hetrochromatin and packaging (nucleosome); Lampbrush, polytene and Supernumerary chromosomes; Mitosis, Meiosis, Cell cycle and its regulation; GPCR and Role of second messenger (cAMP).

Practical Credit: 1

1. Preparation of permanent slide to demonstrate:
   i. DNA by Feulgen reaction.
   ii. DNA and RNA by MGP.
   iii. Mucopolysaccharides by PAS reaction.
   iv. Proteins by Mercurobromophenol blue/Fast Green.
2. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
3. Preparation of temporary stained squash on onion root tip to study various stages of mitosis.
4. Study of various stages of meiosis.
5. Preparation of Polythene Chromosome from *Chironomous* Larva.
6. Study of Cell Organelles (slides/ micrograph).

Recommended Books and References:

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

MAJOR 5
FUNDAMENTALS OF BIOCHEMISTRY

Theory Credits: 3

Unit 1: Carbohydrates and Lipids
Carbohydrates: Structure, properties and biological functions of Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates.
Fatty acids: Structure, classification and properties; Tri-acylglycerols, Phospholipids and Steroids.

Unit 2: Proteins and Nucleic Acids
Amino Acids: Structure, classification and properties of α-amino acids; Physiological importance of essential and non-essential α-amino acids.
Proteins: Levels of organization in proteins; Introduction to simple and conjugate proteins.
Nucleic Acids: Structure of Purines and Pyrimidines, Nucleosides, Nucleotides, Nucleic Acids; Base pairing, Denaturation and Renaturation of DNA; Cot curves.

Unit 3: Enzymes
Enzymes: Nomenclature and classification; Co-factors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics (Michealis-Menten equation and Lineweaver-Burk plot); Factors affecting rate of enzyme-catalyzed reactions; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme action.

Practical Credit: 1

1. Qualitative tests of carbohydrates, proteins and lipids by various chemical assays.
2. To separate amino acids by paper chromatography.
3. To study the effect of time on enzyme activity.
4. To study the effect of enzyme concentration on enzyme activity.
5. To study the effect of substrate concentration on enzyme activity and determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk plots.
6. Estimation of free fatty acids.
7. Demonstration of protein separation by SDS-PAGE.

Recommended Books and References:

- 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.

MAJOR 6
COMPARATIVE ANATOMY OF VERTEBRATES

Theory Credit: 3

Unit 1: Integumentary, skeletal and digestive system
Structure, functions and derivatives of integument.
Overview of axial and appendicular skeleton (amphibian, reptiles, aves and mammals).
Alimentary canal and associated glands; Dentition.

Unit 2: Respiratory, Circulatory and Urinogenital System
Skin, gills, lungs and air sacs; Accessory respiratory organs.
General plan of circulation; Evolution of heart and aortic of arches amphibian, reptiles, aves and mammals); Succession of kidney, Evolution of urinogenital ducts.

Unit 3: Nervous System and Sense Organs
Comparative account of brain (amphibian, reptiles, aves and mammals).
Autonomic nervous system, Spinal cord and Cranial nerves in mammals (Human).
Classification of receptors; Gustatory, Olfactory, Photo, Tactile and Audio receptor in man.

Practical Credit: 1

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs.
2. Dis-articulated skeleton of Frog, *Varanus,* Fowl, Rabbit.
3. Mammalian skulls: one herbivorous and one carnivorous animal.
4. Study of arterial and urinogenital system in mice with model/chart.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) from video recording (may be included if dissection not permitted)
6. Video recording/*demonstration of dissection on the Arterial system and Brain of Frog.

(*Subject to UGC guidelines)

Recommended Books and References:

- 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.
- Hilderbr and, M and Gaslow G.E. *Analysis of Vertebrate Structure*, John Wiley and Sons.
- Walter,H.E.and Sayles,L.P;*Biology of Vertebrates*, Khosla Publishing House.

MAJOR 7
PRINCIPLES OF ECOLOGY

Theory Credits: 3

Unit 1: Introduction to Ecology and Population

Concept of Species, sympatric and allopatric species; Liebig's law of minimum and Shelford's law of tolerance; autecology and synecology; Light, Temperature, Rainfall and Humidity as limiting factors.

Unitary and Modular populations; Characteristics of population: density, natality, mortality, survivorship curves, age ratio, sex ratio, dispersal and dispersion; Exponential and logistic growth, r and K strategies.

Unit 2: Community and Ecosystem

Community characteristics, vertical and horizontal stratification; Ecotone and edge effect; Causes and trends of succession; Types of succession, General process of succession; Hydrosere, Lithosere.

Types of ecosystems with one example in detail; Food chain-detritus and grazing food chains; Food web; Energy flow through the ecosystem; Ecological pyramids; Biogeochemical cycle of Nitrogen and Carbon.

Unit 3: Biodiversity and Wildlife Conservation

Definition and types of biodiversity; Measurement of biodiversity; Causes of extinction; Hotspot of Indian biodiversity; Biodiversity conservation strategies; Sanctuaries, National parks and Biosphere reserves of India. Values of wild life-ecological, ethical, scientific, aesthetic and recreational.

Wildlife Protection Act 1972 (India); Anthropogenic impact on environment.

Practical Credits: 1

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, 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.
4. Field Study (report on a visit to zoological park/Mithun reserve forest/river ecosystem).

Recommended Books and References:

- Colin vaux, P.A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
- Krebs, C.J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole.
- Robert Leo Smith. Ecology and field biology Harper and Row publisher.
- Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.
- Sharma, P.D. (2007). Ecology and Environment. Rastogi Publications.

MAJOR 8
ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS

Theory Credit: 3

Unit 1: Tissues, Bone and Cartilage
Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue.
Structure and types of bones and cartilages, Ossification, bone growth and reabsorption.

Unit 2: Nervous System and Muscle
Types of neurons: Myelinated and non-myelinated neurons; Origin of action potential and its propagation across the myelinated and non-myelinated nerve fibers.
Types of synapses; Synaptic transmission and Neuromuscular junction; Reflex action and its types.
Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus.

Unit 3: Endocrine System
Hypothalamus (neuroendocrine gland); neuroendocrine control of anterior pituitary.
Hormones secretion and their mechanism of action: pineal, pituitary, thyroid, parathyroid, pancreas, adrenal, ovary and testis.

Practical Credits 1

1. *Recording of simple muscle twitch with electrical stimulation (or Virtual)
2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
3. Preparation of temporary mounts: Squamous epithelium and Striated muscle fibres
4. Study of permanent slides of Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
5. *Microtomy: Preparation of permanent slide of any five mammalian (Goat/white rat) tissues
6. *Dissection of Endocrine Glands in albino mice.
7. *Dissection of reproduction system in albino mice.

(*Subject to UGC guidelines)

Recommended Books and References:

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

MAJOR 9
ANIMAL PHYSIOLOGY: LIFE SUSTAINING SYSTEMS

Theory Credit: 3

Unit 1: Physiology of Digestion and Respiration
Structure and functions of digestive glands; Digestion and absorption of carbohydrates, fats and proteins. Mechanism of breathing; Transport of oxygen and carbon dioxide in blood; Respiratory pigments; Dissociation curves and the factors influencing it; Control of respiration.

Unit 2: Renal Physiology and Blood
Structure of kidney and its functional unit (Nephron); Mechanism and regulation of urine formation; Regulation of water balance; Regulation of acid-base balance.
Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis; Blood clotting system; Kallikrein-Kinninogen system; Complement system & Fibrinolytic system; Haemopoiesis.

Unit 3: Physiology of Heart
Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers; Origin and conduction of cardiac impulses; Cardiac cycle; Cardiac output and its regulation; Nervous and chemical regulation of heart rate; Electrocardiogram; Blood pressure and its regulation.

Practical Credit: 1

1. Preparation of temporary mount of blood film.
2. Determination of ABO Blood group and Rh factor.
3. Enumeration of red blood cells using haemocytometer.
4. Estimation of haemoglobin using Sahli's haemoglobinometer.
5. Preparation of haemin and haemochromogen crystals.
6. Recording of blood pressure using a sphygmomanometer.
7. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum,rectum liver, trachea, lung, kidney.

Recommended Books and References:

- Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
- 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.
- 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
- 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.

MAJOR 10
BIOCHEMISTRY OF METABOLIC PROCESSES

Theory Credit: 3

Unit 1: Overview of Metabolism
Acids, bases, pH and buffer; Derivation of Henderson and Hasselbach equation; Simple calculations on pH and buffer; Standard reduction potential; ATP as "Energy Currency of cell"; coupled reactions;Use of reducing equivalents and cofactors.

Unit 2: Carbohydrate Metabolism
Catabolism *vs* Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways; Sequence of reactions and regulation of glycolysis, Citric acid cycle, Gluconeogenesis, Glycogenolysis and Glycogenesis; Shuttle systems and membrane transporters; Intermediary metabolism and regulatory mechanisms.

U**nit 3: Protein and Lipid Metabolism**
Catabolism of amino acids, Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.
β-oxidation of saturated fatty acids with even and odd number of carbon atoms; omega –oxidation offatty acids; Biosynthesis of palmitic acid; Ketogenesis.

Practical Credit: 1

1. Preparation of standard acid and alkali and its standardization.
2. Preparation of phosphate and acetate buffers with different pH.
3. Determination of pKa for glycine and glutamic acid.
4. Estimation of protein content by Biuret method.
2. Calorimetric estimation of glucose.
3. Estimation of casein in milk.

(*Subject to UGC guidelines)

Recommended Books and References:

- Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, VEdition, 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. andWell, 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, IIEdition, BIOS Scientific Publishers Ltd., U.K

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MAJOR 11
DEVELOPMENTAL BIOLOGY

Theory Credit: 3

Unit 1: Introduction
History of Embryology: Preformation theory, Biogenetic law, Germplasm theory, Gradient theory and organizer theory of Spemann.
Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division.

Unit 2: Early and Late Embryonic Development
Gametogenesis: Spermatogenesis and Oogenesis; Types of eggs; Fertilization (External and Internal); Blocks to polyspermy; Planes and patterns of cleavage; Fate maps (including Techniques); Early development of frog and chick up to gastrulation.
Fate of Germ Layers; Extra-embryonic membranes in birds; Placenta (structure, types and functions of placenta).

Unit 3: Post Embryonic Development and Implications of Developmental Biology.
Metamorphosis: Changes, hormonal regulations in amphibians and insects.
Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each).
Teratogenesis; Teratogenic agents and their effects on embryonic development; Stem cell (Types and significance); Amniocentesis.

Practical Credit: 1

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

Recommended Books and References:

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

MAJOR 12
PRINCIPLES OF GENETICS

Theory Credit: 3

Unit 1: **Mendelian Genetics and its Extension.**
Principles of inheritance; Concept of genotype, phenotype, dominance, and recessive.
Incomplete dominance and co-dominance; Multiple alleles; Lethal alleles; Epistasis; Pleiotropy; Sex-linked; sex-influenced and sex-limited characters inheritance.

Unit 2: **Linkage, Crossing Over and Mutations.**
Linkage; Crossing over; Cytological basis of crossing over; Molecular mechanisms of crossing over including models of recombination; Recombination frequency as a measure of linkage intensity; Two factor and three factor crosses.
Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens.

Unit 3: **Sex Determination, Extra-chromosomal Inheritance, Polygenic Inheritance and Transposable Genetic Elements.**
Chromosomal mechanisms of sex determination in Drosophila and Man; Antibiotic resistance in Chlamydomonas; Mitochondrial mutations in Saccharomyces; Infective heredity in Paramecium; Maternal effects (Shell coiling in Snail).
Polygenic inheritance with suitable examples; Conjugation, Transformation and Transduction in Bacteriophage; Transposons in bacteria; Transposons in and humans.

Practical Credit: 1

1. To study the Mendelian laws and gene interactions with reference to experiments on monohybrid, dihybrid, trihybrid, test cross and back cross.
2. Chi-square analyses using seeds/beads/Drosophila.
3. Linkage maps based on data from Drosophila crosses.
4. Mounting of sex comb of *D. melanogaster*
5. Study of human karyotype (normal and abnormal).
6. Pedigree analysis of some human inherited traits.

Recommended Books and References:

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

MAJOR 13
BIOSYSTEMATICS & EVOLUTIONARY BIOLOGY

Theory Credit: 3

Unit 1: Biosystematics
Definition, Importance and Applications of Biosystematics in Biology; Principle of Binominal Nomenclature, Principle of Priority, Principle of Coordination, Principle of the First Reviser, Principle of Homonymy, Principle of Typification, Structure, Gender agreement, Commission. Molecular Taxonomy: Source of variation, satellite DNA (Mini and micro DNA), Molecular markers – RFLP, RAPD and AFLP, Ribotyping and DNA sequencing.

Unit 2: Product of evolution
Micro evolutionary changes; inter – population variations; clines; Races; Geological time scale and major events in the evolutionary time scale; Stages in Evolution of man; Concepts of neutral evolution; Convergent evolution; sexual selection; Co-evolution; Concepts and rate of change in gene frequency through natural selection; Molecular divergence;

Unit 3: Sources of variations.
Hardy- Weinberg Law, Factor influencing H-W equilibrium; Genetic load and its mechanism of working; Genetic Drift; Role of Migration and Mutation in changing allele frequencies; Species concepts; Isolating mechanisms; Modes of speciation: allopatric and sympatric; Adaptive radiation/ macro evolution.

Practical Credit: 1

1. Analysis of morphometric variations in selected natural populations.
2. Preparation of taxonomic keys for identification of the studied populations.
3. Karyotype test for species identification.
4. Identifying specimen samples of vertebrates and invertebrates by Taxonomic procedures (collection, preservation, curating).
5. Study of homologous and analogous organs in vertebrates with photos and pictures.
6. Study of fossils.
7. Study of Hardy- Weinberg equilibrium in human population by taking example of blood group system (ABO).
8. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies

Recommended Books and References:

- Douglas, J.Futuyma (1997). Evolutionary Biology. Sinauer Associates.
- Snustad. S Principles of Genetics.
- Principles of Animal Taxonomy – G.G Simpson- Oxford & IBH Publication.
- Elements of Taxonomy – E. Mayer – Tata Mcgraw Hill Co.
- Biosystematics and Taxonomy – R.C. Tripathi- University Book House.
- Biodiversity, Taxonomy and Ecology – G K Singh- Alp Books.
- Theory and Practices of Animal Taxonomy- VC Kapoor – Oxford and Ibh Co.
- Fundamentals of Biodiversity and Taxonomy (HB) – J.Juneja- Cubertech Publications.

MAJOR 14
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

Theory Credit: 3

Unit 1: Introduction to Animal Behaviour and Patterns of Behaviour
Origin and history of Ethology; Brief profiles of Karl Von Frish, Ivan Pavlov, Konrad Lorenz and Niko Tinbergen; Proximate and ultimate causes of behavior; Methods and recording of a behavior.
Stereotyped Behaviours (Orientation, Reflexes); Individual Behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning and classical and operant conditioning.

Unit 2: Social and Sexual Behaviour
Social Behaviour: Communication and the senses; Altruism; Insects' society with Honey bee as example; Foraging in honey bee and advantages of the waggle dance.
Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Sexual conflict in parental care.

Unit 3: Concept of Chronobiology; Biological Rhythm and Clocks.
Biological oscillation: Concept of average, amplitude, phase and period; Adaptive functional significance of biological clocks.
Short- and Long- term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin.
Chronopharmacology, Chronomedicine and Chronotherapy.

Practical Credit: 1

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. Study and actogram construction of locomotor activity of suitable animal models.
6. Study of circadian functions in humans (daily eating, sleep and temperature pattern.
7. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.

Recommended Books and References:

- David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.
- Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge, UniversityPress, UK.
- John Alcock, Animal Behaviour, Sinauer Associate Inc., USA.
- Paul W. Sherman and John Alcock, Exploring Animal Behaviour, Sinauer Associate Inc., Massachusetts, USA.
- Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. De Coursey (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.

MAJOR 15
ENVIRONMENT AND PUBLIC HEALTH

Theory Credits: 3

Unit 1: Introduction
Public Health and Environmental Health: Definition and concept; Approach to Public Health Environment; Sources of environmental hazards; hazard identification and accounting; fate of toxic and persistent substances in the environment; dose response evaluation; exposure assessment.

Unit 2: Waste Management Technologies
Sources of waste, types and characteristics, Sewage disposal and its management; Solid waste disposal; Biochemical waste handling and disposal; Nuclear waste handling and disposal; Waste from thermal power plants; Case histories on Bhopal gas tragedy and Chernobyl disaster.

Unit 3: Climate change and Diseases
Climate change, Greenhouse gases and Global warming; Acid Rain; Groundwater toxicity; Ozone layer destruction; Effect of climate change on public health.
Diseases: Causes, Symptoms and Control of Tuberculosis, Asthma, Cholera, Minamata and Typhoid.

Practical Credits: 1

1. To determine pH, Cl, SO_4, NO_3 in soil samples from different locations.
2. To determine pH, Cl, SO_4, NO_3 in water samples from different locations.
3. Determine the hardness of water in the given sample.
4. Determine the organic carbon in soil.

Recommended Books and References:

- 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.

MAJOR 16 (A)
FISH BIOLOGY-I

Theory Credit: 3

UNIT 1: Classification & Fishery resources
General description of fish; systematic classification of fishes (upto classes); Modern trends in fish taxonomy; fish barcoding; Cold water fish and fisheries of India; Floodplain (wetland) fisheries; status and distribution of freshwater fish diversity of northeast India; Migration; Application of remote sensing and GIS in fisheries; Fishing crafts and Gears.

UNIT 2: Anatomy & Physiology
Digestive system; anatomical differentiation and modification; Types of fins and their modifications; Locomotion in fishes; Respiratory system in fishes; gill structure; mechanism of respiration; exchange of gases; accessory respiratory organs. Forms and function of swim bladder; Electric organs; Excretory system in fish; Types of excretion and regulation; Salt and water balance in freshwater, marine and brackish water fishes; acid-base balance.

UNIT 3: Aquaculture
Different farming systems; Types of ponds; Extensive, semi-intensive, intensive, composite/poly culture, Hatcheries; Heliculture; prawn culture; Preservation and processing of harvested fish, Fishery by-products; Principle of preservation, handling and packaging of fish for marketing.

Practical Credit: 1

1. Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera*, *Exocoetus*, *Hippocampus*, *Gambusia*, *Labeo*, *Heteropneustes*, *Anabas*.
2. Morphometric and meristic characters of fishes.
3. Identification of important freshwater fish species.
4. Analysis of morphometric variations in teleosts.
5. Analysis of meristic variations in teleosts.
6. Estimation of pH, conductivity, Alkalinity, Dissolved oxygen, free carbon dioxide and Water temperature.
8. Determination of primary productivity by LB – DB method.
9. Study of different types of scales (through permanent slides/ photographs).

Recommended Books and References:

- Q. Bone and R Moore, Biology of Fishes, Taylor 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.

MAJOR 16 (B)
ENTOMOLOGY-I

Theory Credit: 3

Unit 1: Insect origin and Morphology
Origin and evolution of insects; Classification of insects (up to orders with characters and examples); Mouthparts: structure and variations; Antennae: structure and variations; Wings: structural variations and venation; Leg: structure and variations; Genitalia: structure and variations.

Unit 2: Digestive, Respiration, Excretion and endocrine system in Insects
Insect alimentary tracts; Process of digestion and absorption; water and electrolyte absorption.
Tracheal system: Structure, ventilation and diffusion of gases; mechanism of respiration in terrestrial and aquatic insects.
Malpighian tubules: Structure and function; Structure of insect eye; mechanism of vision; Basic components of nervous system;
Endocrine centres; Neurosecretory cells; corpora cardiac; corpora allata; prothoracic glands. Juvenile hormones: Major types: biosynthesis and degradation: mode of action.

Unit 3: Insect Integument and Immune System
Structure of insect integument; chemistry and functions of various components of cuticle; Sclerotization in cuticle; Flight mechanism.
Innate immunity in insects; Types functions and role of hemocytes; chemistry and function of hemoloymph; Antimicrobial peptides in insects; Glycerol-3-phosphate shuttle in flight muscles; proline metabolism; trehalose metabolism.

Practical Credit: 1

1. Techniques of insect collection, data recording; preservation and display of insects.
2. Study of museum specimens representing major insect's orders.
3. Study of morphology of grasshopper to show various organs.
4. Study of different mouth parts, legs, antennae and wings
5. Preparation of external genitalia of grasshopper, cockroach and housefly.
6. Dissection of alimental canal of cockroach/grasshopper/honeybee.
7. Study of male and female reproductive systems in cockroach.
8. Dissection of nervous system of adult grasshopper/cockroach.
9. Assay of amylase from salivary gland of cockroach.
10. Estimation of total proteins in hemolymph.

Recommended Books and References:

- Klowden M.J (2013) Physiological systems in insects, 3rdEdn., Academic Press.
- Gilbert L.I (2011) Insect Endocrinology, 1stEdn. Academic Press.
- Chapman R.F. (2000) The Insects: Structure and Function, 4thEdn. Cambridge univ. Press.
- Gullan P.J and Cranston P.S (1994) The insects, an outline of Entomology, Chapman & Hall.
- Kerkut G.A and Gilbert L.I (1985) Comprehensive insect Physiology, Biochemistry and Pharmacology, Vols. 1-12 Ed. Pergamon Press, oxford.
- Blum M.S (1985) Fundamentals of insects Physiology, Biochemistry and Pharmacology, (1970) The Physiology of insect Physiology. John Willey Sons, New York, Chicester, Brisbane, Toronto and Singapore.
- Imms. A.D. (1964) The Text book of Entomology. Methuen Co., London.
- Wiggleswoth, V.B. (1984) The Principles of Insect Physiology, 8thEdn. Chapman and Hall.

MAJOR 17
BIOTECHNIQUES AND BIOSTATISTICS

Theory Credit: 3

Unit 1: Biotechniques-I
Microscopy: Light, phase-contrast, fluorescent and electron microscopy; Methods in Cell Biology: Cell and tissue culture; Principle and application of tracer techniques: Autoradiography, radioimmunoassay; Immunological techniques: Immuno-diffusion, immuno-electrophoresis, Enzyme linked Immunosorbant assay (ELISA); Spectrophotometry and Spectroflourometry; Tissue processing and separation of various sub-cellular organelles by centrifugation.

Unit 2: Biotechniques-II
Chromatography: Adsorption, ion-exchange, gel filtration, affinity and high performance liquid chromatography (HPLC); Electrophoresis: Iso-electrophoresis and pulse field electrophoresis.
Blotting Technique: Southern, Northern and Western blotting.
Sequencing of nucleic acids; Polymerase Chain Reaction (PCR).

Unit 3: Biostatistics
Sampling and Variables; Frequency distribution; Measure of central tendency: Mean median and mode.
Measure of variation: mean deviation, Standard deviation and Coefficient of variation.
Distribution: Normal, Binomial and Poisson distribution.
Tests of significance: t-test, Chi-square test, ANOVA; Correlation and Regression.

Practical Credit: 1

1. Use of different types of microscope: phase contrast, fluorescent and electron microscope.
2. Demonstration of ELISA/radioimmunoassay techniques.
3. Estimation of certain biomolecules using spectrophotometry
4. Amplification of a target gene by PCR
5. Determination of molecular size by agarose gel electrophoresis.
6. Computation of average, variances, standard deviation.
7. Regression analysis and fitting straight line for a bivariate data.
8. Students‘t’ test, chi-square test and computation of ANOVA for one-way.

Recommended Books and References:

- Norman G. R and Striner D.L (2014) Biostatistics: The bare essentials, 4th Edn., PMPH-USA Limited.
- Wilson K. and Walker J. (2010) Principles and Techniques of Practical Biochemistry, Cambridge University Press.
- Nelson and Cox (2013) Lehninger Principles of Biochemistry, 6th Edn.
- Marc M. Triola M.D and Tiola (2009) Biostatistics for the biological and health sciences: Books a La Carte Edn. Prentice Hall College Div.
- Plummer D.T. (2008) Introduction to Practical Biochemistry, 3rd Edn., Tata McGraw Hill.
- Hayat M.A (2000) Principal and Techniques of Electron Microscopy: Biological Application, 4thEdn.
- Rodney F. Boyer (2000) Modern Experimental Biochemistry 3rd Edn., Prentice Hall.
- Elston R.C. and Johnson W.D. (1994) Essential Biostatistics 3rd Edn., Prentice Hall.
- Switzer R.L. and Garrity L.F (1999) Experimental Biochemistry. 3rd Edn.
- Murad H. and Antique M.V.A. (1991). Biological Techniques in electron Microscopy, CBS publication.

MAJOR 18
RESEARCH METHODOLOGY

Theory Credit: 3

Unit 1: Basic concepts of research
Meaning, Objectives, Approaches and Types of research; Research Process: Scientific method in research (eight steps); Importance of literature reviewing in defining a problem, identifying gap areas from literature review; Research Communication and scientific documentation: Project proposal writing, Research report writing, (Structure of a scientific paper), Thesis, dissertation, research article. Presentation techniques: Oral presentation, Assignment, Seminar, Debate, Workshop, Colloquium, Conference. Sources of Information: Primary and secondary sources. Library- Books, Journals, Periodicals, Reviews, Internet. Search engines, online libraries, e-Books, e-Encyclopedia, Institutional Websites. Plagiarism.

Unit II: Animal Collection
Tools & techniques; Sampling techniques; Quadrate Line transect.
Collection methods, techniques and equipment's-Plankton, Insects, Fish, Bird Preservation Techniques – Taxidermy rearing techniques.
Collection of primary data: Observation method and Interview method; Collection of data through questionnaires; Collection of secondary data; Difference between survey and experiment; Falsification and fabrication of data.

Unit III: Bioethics and Biostatistics
Introduction, Animal rights and animal laws in India, Prevention of cruelty to animals Act 1960, Biodiversity Act 2003.
Concept of 3 R – conservation (Refined- to minimize suffering, Reduced – to minimize animals, Replaced – modern tools and alternate means). Laboratory animal use, care and welfare, Animal protection initiatives- Animal Welfare Board of India, CPCSEA, ethical commitment.
Concept of standard error; Definition and characteristics of hypothesis; Basic concepts concerning testing of hypothesis – null hypothesis and alternative hypothesis, the level of significance, two-tailed and one-tailed tests; Procedure for hypothesis testing.

Practical Credit: 1
1. Computation of standard error through statistical software.
2. Writing of literature review.
3. Similarity check through plagiarism software.
4. Writing of project proposal.
5. Preparation of primary and secondary data.
6. Data analysis through SPSS.
8. Visit to research centre and report writing.

Recommended Books and References:

- Anthony, M, Graziano, A.M. and Raulin, M.L. 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
- Walliman, N. 2011.Research Methods- The Basics. Taylor and Francis, London, New York.
- Wadhera, B.L.: Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, 2002, Universal Law publishing.
- C.R.Kothari: Research Methodology, New Age International, 2009.
- Coley, S.M. and Scheinberg, C.A. 1990, "Proposal writing". Stage Publications.

MAJOR 19
ENDOCRINOLOGY

Theory Credit: 3

Unit 1: Introduction to Endocrinology
Concept of hormones as chemical messengers: endocrine, paracrine and autocrine hormones; Classification, general characteristic and transport of hormones; Hormone action at cellular level; Hormone receptors, transduction and regulation; Hormone action at molecular level; Molecular mediators; Genetic control of hormone action.

Unit 2: Central Endocrine Glands
Structure of hypothalamus; Hypothalamic nuclei and their functions; Neurosecretions and Neurohormone; Regulation of neuroendocrine glands; Feedback mechanisms.
Pituitary: Structure, hormones and their functions; Hypothalamo-hypophysial portal system; Disorders of pituitary gland.
Pineal gland: Structure, hormone secretions and their functions in biological rhythms and reproduction.

Unit 3: Peripheral Endocrine Glands
Structure, hormones secretion, functions and regulation of thyroid gland, parathyroid gland, adrenal gland, pancreas, ovary and testis; Hormonal regulation of estrous and menstrual cycle; Disorders of endocrine glands.

Practical Credit: 1

1. Dissect and display of Endocrine glands in laboratory bred rat.*
2. Study of the permanent slides of all the endocrine glands.
3. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat.*
4. Demonstration of Castration/ ovariectomy in laboratory bred rat.*
5. Study of estrous cycle in albino rat/mouse.
6. Estimation of plasma level of any hormone using ELISA.
7. Designing of primers of any hormone.

(*Subjected to UGC guidelines)

Recommended Books and References:

- General Endocrinology C. Donnell Turner Pub- Saunders Toppan.
- Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead. Oxford: BIOS Scientific Publishers; 2001.
- Hadley, M.E. and Levine J.E. 2007. Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
- Vertebrate Endocrinology by David O. Norris.

MAJOR 20
IMMUNOLOGY

Theory Credit: 3

Unit 1: Overview of Immune System
Cell and molecules involved in innate immunity; Organs of the Immune system; Adjuvants, haptens and B and T-cell epitopes; Anatomical barriers & Inflammation; Adaptive immunity (Cell mediated and humoral); Passive: Artificial and natural Immunity; Active: Artificial and natural Immunity; Factors influencing immunogenicity.

Unit 2: Immunoglobulins
Antibodies (Immoglobulins): definition, general structure of Ig; Structure and functions of different classes of immunoglobulins; Antigen-antibody interactions; Immunoassays (Principles of ELISA and RIA), Monoclonal antibodies in therapeutics and diagnosis.

Unit 3: MHC, Complement System and Hypersensitivity
Structure and functions of MHC class 1 and class II; Endogenous and exogenous pathways of antigen processing and presentation; Properties and functions of cytokines.
Components and pathways of complement activation (alternate and classical).
Gell and Coombs' classification of hypersensitivity and brief description of various types of Hypersensitivities.

Practical Credit: 1

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. Enumeration of total count of WBC.
5. Demonstration of:
   a. ELISA.
   b. Immunoelectrophoresis.

(* Subject to UGC guidelines)

Recommended Books and References:

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

MAJOR 21 (A)
FISH BIOLOGY - II

Theory Credit: 3

Unit 1: Physiology
Endocrine system in fish: hypothalamo-hypophysial system, neurosecretory system and neuro-hypophysial hormones; Functional morphology of Pituitary gland. Types of excretion and regulation; Osmotic regulation; Bioluminescence; Mechanoreceptors; Types of Scales; Use of scales in determination of age of fish.

Unit 2: Reproduction & genetics
Reproductive system in Fish; Spermatogenesis, Oogenesis and Vitellogenesis; Genetic structure of random mating populations; Scope, application, role of genetics in fish selection and breeding; Sex reversal, hybridization, gynogenesis, polyploidy, hybrid vigour; Sexual maturation and Breeding cycle. Transgenic fish: Development and application; Zebrafish as a model organism in research.

Unit 3: Fish Diseases & Bionomics
Types of fish diseases, symptoms and prophylaxis; Diseases diagnostic tools; Technique for isolation and identification of fungi; Biological indicators and indices of water quality; Absolute and relative growth; length – weight relationship; condition factor; relative condition factor. Hepatosomatic index; gonadosomatic index; index of fitness; ponderal index.
Different types of nutrient requirements; feed formulation (General principles, different steps of feed formulation).

Practical Credit: 1

1. Length-weight relationship and K-factor.
2. Gonadosomatic index, absolute and relative fecundity.
3. Gut content analysis of locally available fish species.
4. Estimation of protein in fish tissues.
5. Estimation of phospholipid in fish tissues.
6. Study of fish diseases from chart and micrograph
7. Rearing of live fish food.
8. Histology of gut, liver and kidney.
9. Induced breeding of IMC.

Recommended Books and References:

- Kumar S. and Tembhire M. (2011) fish and Fisheries, New Central book Agency (P) Ltd. (NCBA).
- Jhingran V.G (2007) Fish and fisheries of India, 3rdedn. Hindustan Publishing Corporation, India.
- Evan D. H. (2006) The Physiology of Fishes, CRC Press, Boca Raton, U.S.A.
- Arratia G., Kapoor B.G., Chardon M. And Diago R. (2003) Catfishes (Vol.1 & II), Science Pub. Inc., USA. 7. Hart P. and Reynold J.D. (2002) Handbook of Fish Biology and Fisheries (Volumn I & II) Blackwell Publishing. USA.
- Wright P. and Anderson P. (200) NitogenExcretin (In Fish Physiology, Vol. 21) Academic Press, USA.
- Wootton R.J. (1994) Ecology of Teleost Fishes, Chaman and Hall. London.
- Moyle P. B. And Cech J.J. Jr. (1988) Fishes: An Introduction of Icthyology, Prentice Hall, New Jersey, USA.
- Matty A.J. (1995) Fish Endocrinology, Croom Helm Ltd. Australia.
- Lagler K.F., Bardach J.E., Miller R.R and passion D.M (1977) Icthyology, John Wiley and Sons

MAJOR 21 (B)
ENTOMOLOGY-II

Theory Credit: 3

Unit 1: **Beneficial Insects**
Insect life history patterns; voltinism; polymorphism and polyphenism.
Eusocial insects from Hymenoptera and Isoptera: Life cycle and Development.
Introduction of Lac culture: Life cycle of the lac insects; Lac cultivation, Composition & uses of Lac.
Introduction to Sericulture: Life cycle of the silk moth, cultivation, composition and uses of silk.
Introduction to Apiculture: Types of honey bees, Bee keeping and economic importance of honey bee.

Unit 2: **Insects and plants**
Plant feeding insects; plant host range, types of insect injury to plants, relationship of pest injury and quality of produce; Life cycle, Damage, and control of pest: *Eariasvitella, Sesamiainferens, leptocorisa acuta, Pyrilla perpusilla, Sitophilus oryzae.*

Unit 3: Insect Pest management
Concepts of Insect pest; Insects as plant pests.
Principles and methods of cultural, biological and chemical control; Uses of sex attractants, Pheromones and hormones in insect control; Concept of IPM; Information required in dealing with a pest problem.

Practical Credit: 1

1. Study household and stored grain pests.
2. Study if insect pest of agricultural crops.
3. Study of insect medical and veterinary importance.
4. Study of any three beneficial insects and their products.
5. Study of appliances used in chemical control.
6. Determination LC50 value of some chemicals.

Recommended Books and References:

- Blum M.S (1985) Fundamental of Insect Physiology, John Wiley and Sons.
- Imms A.D. (1977). A General textbook of entomology, 10thEdn. Methuen & Co. London.
- Gullan P.J and Cranston P.S (2010) The Insects: An Outline of Entomology. Wiley-Blackwell.
- Hermes, W.B. (1995) Medical and Veterinary Entomology. CAB International U.K.
- Hermes, W.B. (1950) Medical Entomology, Macmillan and Co. NY. 6. Hill D.S (1994) Agricultural Entomology, Oregon Timber Press.
- Ramakrisnan, T.V. (1984). Handbook of Economic Entomology of South India, International Books and Periodicals Service India.
- Lamb. K.P (1974). Economic entomology in the tropics, London, Academic Press.
- Abhrol D.P (2009) Bees and Bee Keepings in India, Kalyani Publishers, New Delhi.
- Fenemore P.G and Prakash Alka (1995). Applied Entomology, Wiley Eastern limited New Age International.

MAJOR 22
REPRODUCTIVE BIOLOGY

Theory Credit: 3

Unit 1: Reproductive Endocrinology
Gonadal hormones and mechanism of hormone action, steroids, glycoprotein hormones, and prostaglandins, hypothalamo – hypophyseal – gonadal axis, regulation of gonadotrophin secretion in male and female; mechanism of sex differentiation.

Unit 2: Functional anatomy of Human reproduction
Testis: Histology, cellular functions, germ cell system renewal; Androgen synthesis and metabolism; sperm maturation; Accessory glands functions.
Ovary: Histology, folliculogenesis, ovulation, corpus luteum formation and regression; Reproductive cycles (human) and their regulation.

Unit 3: Fertilization
Fertilization in human; Hormonal control of implantation; Hormonal regulation of gestation, parturition and Lactation; foeto-maternal relationship.
Reproductive Health: Infertility in male and female (causes, diagnosis and management); Assisted Reproductive Technology: Sex selection, Sperm banks, Frozen embryos, in-vitro fertilization, ET, IUT, ZIFT, GIFT, ICSI.

Practical Credit: 1

1. Study of animal house: set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Examination of vaginal smear rats from live animals.
3. Surgical techniques: principles of surgery in endocrinology, Ovarectomy, hysterectorny, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
5. Human vaginal exfoliates cytology through microphotograph/demonstration*
6. Sperm count and sperm motility in rat (with the aid of models, videos, chart etc or demonstration*)
7. Study of modern contraceptive devices.

(* Subject to UGC guidelines)

Recommended Books and References:

- Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
- Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
- Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
- Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population information Programme.
- Singh, Shio Kumar. Mammalian Endocrinology and Male Reproductive Biology.
- Whittle, A.C. Vertebrate Reproduction: A Textbook of vertebrate reproduction.

MAJOR 23
PARASITOLOGY

Theory Credit: 3

Unit 1: Introduction to Parasitology
Parasite, Parasitoid and Vectors (mechanical and biological vector); Parasitic adaptations: morphological, anatomical, physiological, biochemical; Host specificity: concept and definition, kinds of specificity, determining factors; Zoonotic parasitic diseases and their control.
Microbial product: Industrial, agricultural and food microbiology.

Unit 2: Life cycles of Parasites
Morphology, life cycle, mode of infection, Pathogenicity of: Protozoan parasite *Plasmodium* and Leishmania, Intestinal flagellate *Giardia*, Trematodes *Schistosoma haematobium* and *Hymenolepis nana*, Nematode *Wuchereria bancrofti*; Vaccine strategies of nematodes; Plant & Soil nematodes (cysts and citrus nematodes).

Unit 3: Molecular approach to parasites
Molecular biology of plasmodium: drug targets, mechanism of drug resistance and vaccine strategies; Trypanosoma: Diploid & Sexual stage, Molecular characteristics of surface coat and Variable surface glycoprotein (VSG); Platyhelminthes: Inseminative behaviour and parthenogenesis.
Chromosome germ line limited DNA & chromatin diminution in Ascaris.

Practical Credit: 1

1. Study of permanent slides or micro photographs or museum specimens of selected parasites of representatives groups of protozoans, parasites, helminthes and arthropods.
2. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry]
3. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a by-product]
4. Studying the infection of tomato plant by root knot nematode.
5. Study of life cycle, role as vector & control measures of: a) Ticks (Argas, Boophilus) b) Mosquito - anyone from- Anopheles/ Aedes/ Culex c) Any two flies: Tabanus/ Phlebotomus/ Sarcophaga. Cyclops
6. Ectoparasites & Endoparasites of wild rat, cattle, dog, chick & human including stages in excreta.

Recommended Books and References:

- Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
- Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwll. U.K.
- Introduction to Environmental Engineering & Science Gilbert M. Masters. Parasitoses and Zoonoses, Bose,M., New central book agency (P) Ltd.
- Parasitology (Protozoology and Helminthology) in relation to clinical medicine. Chatterjee, K. (2009). 13th Edn. CRC publisher New Delhi.
- Genome sequence of the human malaria parasite Plasmodium falciparum nature 419:498- 511. Gardner M.J. et al (2002) Practical exercises in Parasitology: Edited by D. W. Halton, Queen's University Belfast, J. M. Behnke, University of Nottingham I. Marshall, Liverpool School of Tropical Medicine.
- Helminthes, Arthropods and Protozoa of domesticated animals. Soulsby, E.J.L. (1983). 7th Edn, Lea & Febiger, Philadelphia.
- Parasitology by Chandler and Chands 10. Parasitology, medical Publisher Calcutta, 1987, K.D. Chaterjee. 11. Parasitology – by Ramnik Sood, C.B.S., Publisher, New Delhi – 1993.

MINOR COURSES

MINOR 1
NON-CHORDATES I: PROTOZOANS TO PSEUDOCOELOMATES

Theory Credits: 3

Unit 1: Protozoa

General characteristics and classification up to classes.
Morphological study of *Amoeba*, *Euglena* and *Paramaecium*.
Mode of locomotion and nutrition in *Amoeba* and *Paramecium*.
Mode of reproduction in *Amoeba* and *Euglena*.
Conjugation and Endomixis in P*aramaecium*.

Unit 2: Porifera and Cnidaria

Porifera: General characteristics and classification up to classes; *Sycon* with special reference to structure, reproduction and development; Spicules in sponges; Canal system.
Cnidaria: General characteristics and classification up to classes; Metagenesis in *Obelia*; Polymorphism in Cnidaria; Brief account of corals and coral reefs and their importance.

Unit 3: Ctenophora, Platyhelminthes and Nemathelminthes

General characteristics of Ctenophora.
General characteristics and classification up to classes of Platyhelminthes; Study of *Fasciola hepatica* with reference to structure, reproduction, life cycle and pathogenicity.
General characteristics and classification up to classes of Nemathelminthes; Study of *Ancylostoma duodenali* with special reference to structure, reproduction, life cycle and pathogenicity; Parasitic adaptations in helminthes.

Practical Credits: 1

1. Study of whole mount of *Amoeba*, *Monocystis* and *Trypanosoma*.
2. Binary fission and conjugation in *Paramecium*.
3. Culture of *Paramecium* or *Euglena*.
4. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Spongilla*, *Obelia*, *Physalia*, *Gorgonia*.
5. One specimen/slide of any Ctenophore .
6. Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/microphotographs) .
7. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs).
8. Temporary mounting of Spicules and Gemmules.

Recommended Books and References:

- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science.
- Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.
- Kotpal, R. L. (2005): Modern text book of Zoology Invertebrates (Animal Diversity-I). Rastogi Publications pp 795-831. Rastogi V. B. (2015): Invertebrate Zoology. Publisher- Kedar Nath Ram Nath.
- Verma, P. S. (2015): A Manual of Practical Zoology Invertebrates. S. Chand & Company Pvt. Ltd. Ram Nagar, New Delhi-110055.
- Yadav, V., Yadav, P. Varshney, V. K., Varshney, V. C. (2015): Text Book of Practical Zoology-I. Publisher- Kedar Nath Ram Nath Merrut.

MINOR 2
NON-CHORDATES II: COELOMATES

Theory Credits: 3

Unit 1: Coelomates and Annelida
Evolution and types of coelom and metamerism; Significance of coelom and metamerism. General characteristics and classification of Annelida up to classes; Locomotion and Reproduction in Annelida.

Unit 2: Onychophora and Arthropoda
General characteristics and Evolutionary significance of Onychophora.
Arthropoda: General characteristics and classification up to classes; Vision and respiration in Arthropoda; Larval forms of crustacean; Metamorphosis in Insects.
Social life in bees and termites.

Unit 3: Mollusca and Echinodermata
Mollusca: General characteristics and classification up to classes; Respiration in Mollusca; Torsion and detorsion in Gastropoda; Pearl formation in bivalves; Evolutionary significance of Trochophore larva.
Echinodermata: General characteristics and classification up to classes; Water-vascular system in Asteroidea; Larval forms in Echinodermata; Affinities with Chordates.

Practical Credits: 1

1. Study of following specimens: Annelids - Aphrodite, *Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria*.
   Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta*, termites and honeybees
   Onychophora - *Peripatus*
   Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus*.
   Echinodermates - *Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria and Antedon*
2. Dissection/model/video of digestive system, reproductive system, nervous system 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. Temporary mount of Setae of earthworm, Radula of *Pila*.*

(*Subjected to UGC guidelines)

Recommended Books and References:

- Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science.
- Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.

MINOR 3
CELL BIOLOGY

Theory Credit: 3

Unit 1: Overview of cell, Plasma membrane and Endomembrane System
Prokaryotic and Eukaryotic cells; Virus, Viroids, Mycoplasma and Prions.
Plasma Membrane: Various models of plasma membrane structure; Transport across membranes: Active and Passive transport; Cell Junctions: Tight junctions, Desmosomes and Gap junction.
Structure and functions of Endoplasmic Reticulum, Golgi apparatus and Lysosomes; Protein sorting and Transport-system (ER, Golgi apparatus, Lysosome).

Unit 2: Mitochondria, Peroxisomes & Cytoskeleton
Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis, Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis; Peroxisomes; Cytoskeleton: Structure and Functions of Microtubules, Microfilaments and Intermediate filaments.

Unit 3: Nucleus, Cell Division and Cell Signalling
Nucleus: Nuclear envelope, Nuclear pore complex and Nucleolus. Chromatin: Euchromatin and Hetrochromatin and packaging (nucleosome); Lampbrush, polytene and Supernumerary chromosomes; Mitosis, Meiosis, Cell cycle and its regulation; GPCR and Role of second messenger (cAMP).

Practical Credit: 1

1. Preparation of permanent slide to demonstrate:
   i. DNA by Feulgen reaction.
   ii. DNA and RNA by MGP.
   iii. Mucopolysaccharides by PAS reaction.
   iv. Proteins by Mercurobromophenol blue/Fast Green.
2. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
3. Preparation of temporary stained squash on onion root tip to study various stages of mitosis.
4. Study of various stages of meiosis.
5. Preparation of Polythene Chromosome from *Chironomous* Larva.
6. Study of Cell Organelles (slides/ micrograph).

Recommended Books and References:

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

MINOR 4
ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEMS

Theory Credit: 3

Unit 1: Tissues, Bone and Cartilage
Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue.
Structure and types of bones and cartilages, Ossification, bone growth and reabsorption.

Unit 2: Nervous System and Muscle
Types of neurons: Myelinated and non-myelinated neurons; Origin of action potential and its propagation across the myelinated and non-myelinated nerve fibers.
Types of synapses; Synaptic transmission and Neuromuscular junction; Reflex action and its types.
Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus.

Unit 3: Endocrine System
Hypothalamus (neuroendocrine gland); neuroendocrine control of anterior pituitary.
Hormones secretion and their mechanism of action: pineal, pituitary, thyroid, parathyroid, pancreas, adrenal, ovary and testis.

Practical Credits 1

1. *Recording of simple muscle twitch with electrical stimulation (or Virtual)
2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
3. Preparation of temporary mounts: Squamous epithelium and Striated muscle fibres
4. Study of permanent slides of Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
5. *Microtomy: Preparation of permanent slide of any five mammalian (Goat/white rat) tissues
6. *Dissection of Endocrine Glands in albino mice.
7. *Dissection of reproduction system in albino mice.

(*Subject to UGC guidelines)

Recommended Books and References:

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

MINOR 5
DEVELOPMENTAL BIOLOGY

Theory Credit: 3

Unit 1: Introduction
History of Embryology: Preformation theory, Biogenetic law, Germplasm theory, Gradient theory and organizer theory of Spemann.
Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division.

Unit 2: Early and Late Embryonic Development
Gametogenesis: Spermatogenesis and Oogenesis; Types of eggs; Fertilization (External and Internal); Blocks to polyspermy; Planes and patterns of cleavage; Fate maps (including Techniques); Early development of frog and chick up to gastrulation.
Fate of Germ Layers; Extra-embryonic membranes in birds; Placenta (structure, types and functions of placenta).

Unit 3: Post Embryonic Development and Implications of Developmental Biology.
Metamorphosis: Changes, hormonal regulations in amphibians and insects.
Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each).
Teratogenesis; Teratogenic agents and their effects on embryonic development; Stem cell (Types and significance); Amniocentesis.

Practical Credit: 1

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

Recommended Books and References:

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

MINOR 6
ENVIRONMENT AND PUBLIC HEALTH

Theory Credits: 3

Unit 1: Introduction
Public Health and Environmental Health: Definition and concept; Approach to Public Health Environment; Sources of environmental hazards; hazard identification and accounting; fate of toxic and persistent substances in the environment; dose response evaluation; exposure assessment.

Unit 2: Waste Management Technologies
Sources of waste, types and characteristics, Sewage disposal and its management; Solid waste disposal; Biochemical waste handling and disposal; Nuclear waste handling and disposal; Waste from thermal power plants; Case histories on Bhopal gas tragedy and Chernobyl disaster.

Unit 3: Climate change and Diseases
Climate change, Greenhouse gases and Global warming; Acid Rain; Groundwater toxicity; Ozone layer destruction; Effect of climate change on public health.
Diseases: Causes, Symptoms and Control of Tuberculosis, Asthma, Cholera, Minamata and Typhoid.

Practical Credits: 1

1. To determine pH, Cl, SO_4, NO_3 in soil samples from different locations.
2. To determine pH, Cl, SO_4, NO_3 in water samples from different locations.
3. Determine the hardness of water in the given sample.
4. Determine the organic carbon in soil.

Recommended Books and References:

- 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.

MINOR 7
ENDOCRINOLOGY

Theory Credit: 3

Unit 1: Introduction to Endocrinology
Concept of hormones as chemical messengers: endocrine, paracrine and autocrine hormones; Classification, general characteristic and transport of hormones; Hormone action at cellular level; Hormone receptors, transduction and regulation; Hormone action at molecular level; Molecular mediators; Genetic control of hormone action.

Unit 2: Central Endocrine Glands
Structure of hypothalamus; Hypothalamic nuclei and their functions; Neurosecretions and Neurohormone; Regulation of neuroendocrine glands; Feedback mechanisms.
Pituitary: Structure, hormones and their functions; Hypothalamo-hypophysial portal system; Disorders of pituitary gland.
Pineal gland: Structure, hormone secretions and their functions in biological rhythms and reproduction.

Unit 3: Peripheral Endocrine Glands
Structure, hormones secretion, functions and regulation of thyroid gland, parathyroid gland, adrenal gland, pancreas, ovary and testis; Hormonal regulation of estrous and menstrual cycle; Disorders of endocrine glands.

Practical Credit: 1

8. Dissect and display of Endocrine glands in laboratory bred rat.*
9. Study of the permanent slides of all the endocrine glands.
10. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat.*
11. Demonstration of Castration/ ovariectomy in laboratory bred rat.*
12. Study of estrous cycle in albino rat/mouse.
13. Estimation of plasma level of any hormone using ELISA.
14. Designing of primers of any hormone.

(*Subjected to UGC guidelines)

Recommended Books and References:

- General Endocrinology C. Donnell Turner Pub- Saunders Toppan.
- Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead. Oxford: BIOS Scientific Publishers; 2001.
- Hadley, M.E. and Levine J.E. 2007. Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
- Vertebrate Endocrinology by David O. Norris.

MINOR 8
PARASITOLOGY

Theory Credit: 3

Unit 1: Introduction to Parasitology
Parasite, Parasitoid and Vectors (mechanical and biological vector); Parasitic adaptations: morphological, anatomical, physiological, biochemical; Host specificity: concept and definition, kinds of specificity, determining factors; Zoonotic parasitic diseases and their control.
Microbial product: Industrial, agricultural and food microbiology.

Unit 2: Life cycles of Parasites
Morphology, life cycle, mode of infection, Pathogenicity of: Protozoan parasite *Plasmodium* and Leishmania, Intestinal flagellate *Giardia*, Trematodes *Schistosoma haematobium* and *Hymenolepis nana*, Nematode *Wuchereria bancrofti*; Vaccine strategies of nematodes; Plant & Soil nematodes (cysts and citrus nematodes).

Unit 3: Molecular approach to parasites
Molecular biology of plasmodium: drug targets, mechanism of drug resistance and vaccine strategies; Trypanosoma: Diploid & Sexual stage, Molecular characteristics of surface coat and Variable surface glycoprotein (VSG); Platyhelminthes: Inseminative behaviour and parthenogenesis.
Chromosome germ line limited DNA & chromatin diminution in Ascaris.

Practical Credit: 1

1. Study of permanent slides or micro photographs or museum specimens of selected parasites of representatives groups of protozoans, parasites, helminthes and arthropods.
2. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by product of the industry]
3. Study of nematode/cestode parasites from the intestines of Poultry bird [Intestine can be procured from poultry/market as a by-product]
4. Studying the infection of tomato plant by root knot nematode.
5. Study of life cycle, role as vector & control measures of: a) Ticks (Argas, Boophilus) b) Mosquito - anyone from- Anopheles/ Aedes/ Culex c) Any two flies: Tabanus/ Phlebotomus/ Sarcophaga. Cyclops
6. Ectoparasites & Endoparasites of wild rat, cattle, dog, chick & human including stages in excreta.

Recommended Books and References:

- Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
- Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwll. U.K.
- Introduction to Environmental Engineering & Science Gilbert M. Masters. Parasitoses and Zoonoses, Bose,M., New central book agency (P) Ltd.
- Parasitology (Protozoology and Helminthology) in relation to clinical medicine. Chatterjee, K. (2009). 13th Edn. CRC publisher New Delhi.
- Genome sequence of the human malaria parasite Plasmodium falciparum nature 419:498- 511. Gardner M.J. et al (2002) Practical exercises in Parasitology: Edited by D. W. Halton, Queen's University Belfast, J. M. Behnke, University of Nottingham I. Marshall, Liverpool School of Tropical Medicine.
- Helminthes, Arthropods and Protozoa of domesticated animals. Soulsby, E.J.L. (1983). 7th Edn, Lea & Febiger, Philadelphia.
- Parasitology by Chandler and Chands 10. Parasitology, medical Publisher Calcutta, 1987, K.D. Chaterjee. 11. Parasitology – by Ramnik Sood, C.B.S., Publisher, New Delhi – 1993.

MULTIDISCIPLINARY COURSES (MDC)

MDC 1 (A)
TRADITIONAL KNOWLEDGE-I

Theory credit: 2

Unit 1: Knowledge Systems
Traditional knowledge and Indigenous Knowledge systems; Traditional knowledge vs. Science. Definition of Culture and its characteristics, Enculturation, Acculturation, Cultural relativism, nature-culture dichotomy, problems of indigenous Knowledge loss, Gender differences in Naga society on indigenous knowledge. Cultural significance of names, history of places of settlements, Classification of landscape (cultivation, sacred places).

Unit 2: Methodological approach to the study of Traditional Knowledge
Ethics; Fieldwork methods: Interview (Formal and Informal), Participant Observation, Questionnaire, Visual Anthropological techniques (films, photography, audiography); Mapping resources in time and space; Collection, identification and classification of plants, animal and cultural artefacts and vouchers.

Practical credit: 1

1. Interviewing an elder.
2. Freelisting and pilesort exercises.
3. Collecting specimens.
4. Specimen Identification Task.
5. Ratings, rankings and paired comparisons.
6. Resource community mapping.

Recommended books & references:

- Agrawal. 1995. Dismantling the divide between indigenous and scientific knowledge. In Development and Change Vol. 26 (1995), 413439. Institute of Social Studies 1995. Blackwell Publishers, Oxford, UK.
- Anderson, E.N., D. Pearsall, E. Hunn and N. Turner. 2011. *Ethnobiology*. John Wiley & Sons.
- Berlin, B. 1992. Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies. Princeton University Press.
- Caillon, S., Cullman, G., Verschuuren, B. and Sterling, E. J. 2017. Moving beyond the human–nature dichotomy through biocultural approaches: including ecological well-being in resilience indicators. Ecology and Society 22(4):27. https://doi.org/10.5751/
- Ellen, R. 2020. The Nuaulu World of Plants. London: RAI/SK Publishing.
- Gadgil, M., Berkes, F. and Folke, C. 1993. Indigenous knowledge for biodiversity conservation. *Ambio*, pp.151-156.
- ISE Code of Ethics: https://www.ethnobiology.net/what-we-do/core-programs/ise-ethics-program/code-of-ethics/
- Kimmerer, R. 2013. *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Milkweed editions.
- Martin, G. 1995. Ethnobotany: A Methods Manual. Chapman and Hall.
- Meilleur, B. 2019. Hawaiian Seascapes and Landscapes. *Journal of the Polynesian Society* 128 (3): 305–336. DOI: dx.doi.org/10.15286/jps.128.3.305-336
- Nakashima, D. and Roue, M. 2002. Indigenous knowledge, people, sustainable practice. In Encyclopedia of Global Environmental Change (Ed-in-Chief Ted Munn). John Wiley & Sons, Ltd, Chichester, 2002

- Newing, H. (ed.). 2011. *Conducting Research in Conservation: A Social Science Perspective*. London: Routledge.
- Palmer, C.T. and Wadley, R.L. 2007. Local Environmental Knowledge, Talk, and Skepticism: Using 'LES' to Distinguish 'LEK' from 'LET' in Newfoundland. Hum. Ecol. (2007) 35:749–760.
- Pfeiffer, J. M., and Butz, R. J. 2005. Assessing cultural and ecological variation in ethnobiological research: the importance of gender. *Journal of Ethnobiology*, 25(2): 240-279.
- Pierotti, R. 2020. Learning about Extraordinary Beings. *Ethnobiology Letters* Vol. 11, No. 2, pp. 44-51
- Puri, R. 2023. Methods manual. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.
- Sheil, D., Puri, R.K., and others. 2003. Exploring biological diversity, environment and local people's perspectives in forest landscapes: Methods for a multidisciplinary landscape assessment. Jakarta: Center for International Forestry Research (CIFOR).
- Thornton, T. and Bhagwat, S. (eds). 2019. Handbook of Indigenous Environmental Knowledge: Global Themes and Practice. Routledge.
- Zarger, R.K. 2011. Learning Ethnobiology: Creating Knowledge and Skills about the Living World. Chapter 22 (pp. 371-388) in *Ethnobiology*, edited by E.N. Anderson, D. Pearsall, E. Hunn and N. Turner. John Wiley & Sons.
- Zent, S. and Maffi, L. 2008. 'Final Report on Indicator No. 2: Methodology for Developing a Vitality Index of Traditional Environmental Knowledge (VITEK) for the Project "Global Indicators of the Status and Trends of Linguistic Diversity and Traditional Knowledge"'. Terralingua. Online at http://ebookbrowse.com/vitek-report-pdf-d339995263 Sections 5.4-6.2 (pp. 33-47).

MDC 1 (B)
WILD LIFE CONSERVATION AND MANAGEMENT-I

Theory credit: 3

Unit 1: Introduction to Wildlife management

Understanding wildlife management; Values of wild life - positive and negative (Brief comparison); Conservation and policies regarding protected areas in 21st century; Importance of conservation; Conservation ethics; Conservation Vs protection; Important International conventions &treaties on nature & conservation India's role & contribution (including VISION 2040).

Unit 2: Evaluation and management of wildlife

Evaluation and management of wild life Habitat analysis; Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, and cover estimation; Standard evaluation procedures: remote sensing and GIS; Studying & analyzing Animal Tracks & signs.

Unit 3: Protected areas

Protected areas Institutions and their role in conservation; Zoological survey of India, Botanical survey of India, Forest research Institute, Eco tourism / wild life tourism; National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India; Concept of Buffer zones, Wildlife corridors Strategies to reduce human-wildlife interactions.

Recommended books & references:

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

MDC 2
TRADITIONAL KNOWLEDGE-II

Theory: 2 credits

Unit 1: Land and Livelihoods
Anthropocene, Ethnomedicine, Wild Plant Foods and Medicine, Jhum and Terrace Cultivation; Use of Animal in cultural practices; Food culture: edible and inedible animals (taboos and prohibitions), methods of preparing and preserving food in different tribal cultures; Material culture for house construction, musical instruments, basketry, fibres and dyes for clothing; Community hunting and fishing, Domesticated animals, Insect production.

Unit 2: Sustainability, Resilience and Conservation (SRC)
Ecological Edens and green primitivism, Traditional Knowledge of Soils, Seed saving, Famine Foods, Community Conserved Areas, weather forecasting, Responses to drought and flood and other disasters, Adaptation to Climate and Biodiversity Change, The SDGs, Documenting TK for resilience.

Practical: 1 Credit

1. Timelines, Seasonal Calendars and Trends.
2. Market Survey.
3. Ethno-ecological surveys of gardens, forest or rivers.
4. Seed collection and storage.
5. Communicating research to the public.

Recommended books & references:

- Li, X., Junqueira, A.B. and Reyes-García, V. 2021. At the Crossroad of Emergency: Ethnobiology, Climate Change, and Indigenous Peoples and Local Communities. *Journal of Ethnobiology*, *41*(3), pp.307-312.
- Maffi, L. and Woodley, E. 2010. *Biocultural Diversity Conservation: A Global Sourcebook.* Routledge.
- Benyei, P., Arreola, G., Reyes-Garcıa, V. 2020. Storing and sharing: A review of indigenous and local knowledge conservation initiatives. *Ambio* 2020, 49:218–230 https://doi.org/10.1007/s13280-019-01153-6
- Singh, R.K., Pretty, J. and Pilgrim, S. 2010. Traditional knowledge and biocultural diversity: learning from tribal communities for sustainable development in northeast India. Journal of Environmental Planning and Management Vol. 53 (4): 511–533
- Salick, J., Konchar, K. and Nesbitt, M., 2017. *Curating biocultural collections: a handbook*. Kew Publishing, Royal Botanic Gardens; in association with Missouri Botanical Garden; University of Chicago Press.
- Thorn, J.P., Thornton, T.F., Helfgott, A. and Willis, K.J., 2020. Indigenous uses of wild and tended plant biodiversity maintain ecosystem services in agricultural landscapes of the Terai Plains of Nepal. *Journal of ethnobiology and ethnomedicine*, *16*(1), pp.1-25.
- Vaughan, M. 2018. *Kaiaulu: Gathering Tides*. Chapter 3 Care and Cultivation. Oregon U. Press.

MDC 2 (B)
WILD LIFE CONSERVATION AND MANAGEMENT-II

Theory credit: 3

Unit 1: Brief history of human and wildlife

Journey of mankind from predator to conservator; Prehistoric association between wildlife and humans: conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; Bishnoi community; Positive values provided by wildlife conservation (monetary, recreational, scientific and ecological benefits).

Unit 2: Wildlife protection regulations

IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range; Brief introduction to Wildlife Protection Act of 1972, Forest act 1927, Environmental Protection Act 1986, and Forest conservation Act 1920; introduction of Tiger task force, Status of current protected areas in India.

Unit 3: Human and wildlife

Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation; Luxury hotels within protected areas vs. displacement of native tribes; Introduction to tribal rights in India, demographic profile of tribes in India, importance of forest produces to tribal populations; Scheduled tribes and other traditional Forest dwellers (Recognition of forest right) Act, 2006.

Recommended books & references:

- Conover, M. 2001. Resolving Human Wildlife Conflicts, CRC Press.
- Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation 13: 458-466.
- Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. International Biodeterioration & Biodegradation 45: 97-102.
- Paty, C. 2007. Forest Government and Tribe. Concept Publishing Company.
- Treves, A. & Karanth, K. U. 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17: 1491-1499.
- Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. People and Wildlife, Conflict or Coexistence? (No. 9). Cambridge University Press.

MDC 3
FUNDAMENTALS OF LIFE SCIENCES

Theory Credits-3

Unit 1: Classification of organism
Characteristics of living organisms; Hierarchical classification system of living organisms; General features of life form and their classification* (up to kingdom); Binomial system of naming species.

Unit 2: Introduction to cell, biomolecules and genetics
Structure and function of prokaryotic and eukaryotic cells. Introduction to biomolecules (nucleic acids, proteins, carbohydrates and lipids). Inheritance: Definition and meaning, mode of inheritance, sex determination, genotype and phenotype, Mendelian inheritance.

Unit 3: Introduction to bio-resources, evolution and ecology
Bio-resources and their economic importance (microbes, plants, and animals). Biological evolution: meaning, types and processes; Introduction to ecology, biodiversity, and wildlife management.

** Five kingdom classification to be followed.*

Recommended Books and References:

- Bruce, A., Dennis, B., Karen, H., Alexander, J., Julian, L., Martin, R., Keith, R. and Peter W. (2009). Essential Cell Biology. (3rd ed.). Garland Publishing. London.
- De Robertis, E. D. P. and De Robertis, L. M. F. (1987). Cell and Molecular Biology, (8^{th} ed.). Lea and Febiger.
- Gardener, E. J., Simmons, M. J., and Snustad, D. P. (2005). Principles of Genetics. (8th ed.). John Wiley and Sons.
- Hall, B.K. and Hallgrimsson, B. (2008), Strickberger's Evolution, (4th ed.). Jones and Bartlett Publishers.
- Krishnamurthy, K.V. (2003). Textbook of Biodiversity. (1st ed.). Science Publisher, Chennai.
- Mader, S.S. (2008). Concepts of Biology. (Indian ed.).CBS Publishers. New Delhi.
- Sharma B.D. (1999). Indian Wildlife Resources, Ecology and Development. (1st ed.).Daya Publishing House, Delhi.
- Sharma, P. D. (1990). Ecology and Environment, 7th Edition. Rastogi Publications. Meerut.
- Singh S.K. (2005). Textbook of Wildlife Management (2nd ed.). International Book Distributing Company, Lucknow.

SKILL ENHANCEMENT COURSES (SEC)

SEC 1 (A)
APICULTURE

Theory Credit: 1

Unit 1: Introduction to Apiculture
Bee Biology; Caste of Bees; Stages of development in honey bees; Benefits of bee keeping; Bee food plants; Locating an apiary; Establishment of a beehive; Management of colonies; Seasonal Management; Pests and diseases in beehive; Safety measures;

Practical Credit: 2

1. Identification of honey bee species.
2. Assembling a beehive.
3. Bee keeping equipment's.
4. Study of bee products (honey, pollen, beewax, royal jelly, propolis, bee venom).
5. Lighting a smoker (Demonstration).
6. Bee colony inspection (Demonstration).
7. Installing/fixing and storage of comb foundation sheets (Demonstration).
8. Harvest of honeycomb.
9. Extraction of honey from honeycomb.
10. Processing of extracted honey.
11. Quality testing of honey (Purity and adulteration).
12. Maintenance of beekeeping record.
13. Field visit to bee farm and report writing.

Recommended Books and References:

- 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, New Delhi.
- National Institute of Open Schooling, Beekeeping (650), www.nios.ac.in.

SEC 1 (B)
AQUARIUM FISH KEEPING

Theory Credit: 1

Unit 1: Introduction to Aquarium Fish Keeping
Potential scope of Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fishes.
Biology of Aquarium Fishes: Common characters and sexual dimorphism of Fresh water and Marine.
Live Fish Transportation: transportation of seeds & breeders; Fish handling, packing and forwarding techniques.
Maintenance of Aquarium: General Aquarium maintenance; budget for setting up an Aquarium Fish Farm as a Cottage Industry.

Practical Credit: 2

1. Study of aquarium fishes such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish, *Channa bleheri, Channa barca*
2. Study of types of fish feeds: Prepare ornamental fish feed
3. Introduction to Aquarium accessories and equipments.
4. Making of aquarium: Prepare and manage aquariums (Project)
5. Preparation of formulated fish feed
6. Identification of aquarium plants. (Photos, Media, Specimens)
7. Principle of fish feed formulation; Preparation and composition of formulated fish feeds.
8. Collection/Study and Identification of ornamental fish diseases and prophylactic measures.

Recommended Books and References:

- G. Helfman, Bruce B. Collette, D.E. Facey, B. W. Bowen: The Diversity of Fishes: Biology, Evolution, and Ecology, John Wiley & Sons.
- R. J. Wootton: Fish Ecology, Springer
- W. Vishwanath, W.S. Lakra and U.K. Sarkar: Fishes of North East India, NBFGR Publication, Lucknow
- Handbook of Fisheries and Aquaculture – ICAR
- A. D. Dholakia: Ornamental Fish culture and Aquarium Maintenance, Daya pub. House, New Delhi
- A. Saxena: Aquarium Management. Daya pub. House, New Delhi
- C.B.L. Srivastava: Aquarium fish keeping. Kitab Mahal, Allahabad
- K. Rataj, and R. Zukal: Aquarium Fishes and Plants. Spring Books, London.
- K.L.Tekrival and A.A. Rao: Ornamental aquarium fishes of India. TFH United Kingdom

SEC 2 (A)
MEDICAL DIAGNOSTICS

Theory Credit: 1

Unit 1 Diagnostics Methods

Introduction to Medical Diagnostics and its Importance; Blood composition; Differential Leucocyte Count (D.L.C) using Leishman's stain; Platelet count using haemocytometer; Erythrocyte Sedimentary Rate (E.S.R); Packed Cell Volume (P.C.V).
Tumours: Types (Benign/Malignant), Detection and metastasis.

Practical Credit: 2

1. Preparation of stained blood film to study various types of blood cells.
2. Diagnostic Methods of Urine Analysis for glucose.
3. Diagnostic Methods of Urine Analysis Protein.
4. Testing of blood glucose using Glucometer/Kit.
5. Testing of Hypertension by Sphygmomanometer,
6. Types of tumour: slides/specimens /microphotograph.
7. Medical imaging: X-Ray of Bone fracture, PET, MRI and CT scan (using photographs).
8. Non-infectious Diseases: Causes, types, symptoms, diagnosis and prevention of Diabetes (Type I and Type II).
9. Infectious Diseases: Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis.
10. Diagnostic Methods Used for Urine Analysis: Physical characteristics and abnormal constituents.

Recommended Books and References:

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

SEC 2 (B)

SERICULTURE

Theory Credit: 1

Unit 1: Introduction to Sericulture

Sericulture Industry; Status of Sericulture Industry in India.
Classification and Life cycle of *Bombyx mori*.
Rearing of Silkworm (Grainage Technology); Supply of seed to rearers and commercial rearing;
Spinning of cocoons and Post-cocoon processing.
Diseases of Silkworm: Maggot disease, Pebrine, Polyhedrosis, Flacherie, Green muscardine.

Practical Credit: 2

1. Identification and characteristics of Mulberry, Tasar, Eri and Muga: egg, larva, pupa, cocoon and moth and yarns.
2. Dissection of silk gland.
3. Methods of applications of silkworm bed disinfectants for management of silkworm diseases.
4. Rearing Techniques: Harvesting and preservation technique; leaf selecting for different instants; mulberry leaf estimation.
5. Identification of moulting larva, care during moulting and mounting density.
6. Harvesting of cocoons and assessment of cocoons.
7. Rearing appliances used in rearing and seed preparation of non-mulberry silkworms (Drawings/sketches).
8. Rearing of silkworms and record maintenance book.
9. Local silkworm rearing field visit.

Recommended Books and References:

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

SEC 3 (A)
VERMICOMPOSTING TECHNIQUES

Theory credit: 1

Unit 1: Introduction to Vermicomposting and management
Basic body structure of earthworm.
Epigeic, Endogeic and Anecic earthworm.
Reproductive life cycle of useful species of earthworms.
Vermicomposting: Introduction, history and scope.
Different methods of vermicomposting: Small- and large-scale Bed method, Pit method.
Role of vermicompost in organic farming.
Pests and pathogens of earthworm and its prevention and precaution.

Practical Credit: 2

1. Scientific classification of Earthworm.
2. Key to identify different types of earthworms.
3. Study of digestive system of earthworm.
4. Study of reproductive system of earthworm.
5. Study of life stages & development of *Eisenia fetida*.
6. Study of life stages & development of *Eudrilus eugeniae*.
7. Study of Vermiculture, Vermiwash & Vermicompost equipments, devices.
8. Establishment of vermicomposting unit: Pit method, Bed method and vermiwash unit.
9. Vermicompost production, harvesting and packaging.
10. Study of cocoon and vermicast.
11. Study the effects of vermicompost and vermiwash on any two short duration crop plants.
12. Analysis of available N, Organic carbon.
13. Analysis of available P and available K.
14. Field trip to important biodiversity sites- collection of native earthworms & their identification.
15. Project report and presentation.

Recommended Books and References:

- Clive .A. Edwards and Lofty (1977), Biology of Earthworms: Chapman and Hall Ltd.,London.
- Chauhan, A 2012, Vermitechnology, Vermiculture, Vermicompost and Earthworms: Vermiculture, Vermicomposting, Vermitechnology and Mirobes: Lambert Academic Publishing, Germany.
- Kumar (2005), Verms and Vermitechnology: APH Publishing.
- Lekshmy and Santhi (2012), Vermitechnology: Sara Publications, New Delhi, India.
- The Complete Technology Book on Vermiculture and Vermicompost: National Institute of Industrial Research (2010): Published by National Institute of Industrial Research, Delhi-7, India.
- Sinha, R. K. et.al (2010), Vermitechnology-The Emerging 21st Century Bioengineering technology for sustainable development and protection of human health and environment-Review : Dynamic Soil and Dynamic Plant, Global Science Books.
- Sharma S. et .al, (2009), Earthworm and Vemitechnology –Review, Dynamic Soil and Dynamic Plant: Global Science Books.

SEC 3 (B)
POULRY FARMING

Theory credit: 1

Unit 1: Introduction to Poultry Farming
Poultry production and marketing system (with reference to Nagaland).
Organised sector, Semi organised sector and Backyard sector in the villages.
Role of poultry in livelihood.
Basic tenets of poultry housing; Preparation of shed before brooding.
Feeding of poultry: Nutrition & feeding and Ration requirements.
Poultry diseases – symptoms, control and management; Vaccination programme.

Practical Credit 2

1. Identification of external body parts of a bird.
2. Identification of chicken breeds.
3. Handling of birds.
4. Brooding of chicks.
5. Rearing, feeding and watering of chicks, growers and layers.
6. Debeaking, delicing, deworming and spraying.
7. Candling and grading of eggs.
8. Judging and culling of layers.
9. Calculation of production cost of an egg and one kilogram live broiler.
10. Poultry farm daily routine check list.
11. Preparation of project report for banking and insurance.
12. Visit to a poultry farm.

Recommended Books and References:

- Das D, Das B C, nayak N (2021). TextBook on Poultry Management. Narendra Publishing House.
- Eiri (2008). Handbook of poultry farming and feed formulations (Pb). Engineers India Research Institute.
- Virender Singh (2021). The Complete Guide of Poultry Farming: Eggs Production, Raising Chickens
- Amazon Digital Services LLC – Kdp.
- Society for Climate Resilient Agriculture in Nagaland (SoCRAN), FOCUS-IFAD, Training manual on animal husbandry in Nagaland focusing on piggery and poultry.
- Sreenivasaiah., P. V., 2015. Textbook of Poultry Science. 1st Edition. Write & Print Publications, New Delhi
- Jull A. Morley, 2007. Successful Poultry Management. 2nd Edition. Biotech Books, New Delhi"
- Hurd M. Louis, 2003. Modern Poultry Farming. 1st Edition. International Book Distributing Company, Lucknow."
- http://www.asci-india.com/BooksPDF/Small%20Poultry%20Farmer.pdf
- https://nsdcindia.org/sites/default/files/MC_AGR-Q4306_Small-poultry-farmer-.pdf .
- http://ecoursesonline.iasri.res.in/course/view.php?id=335 .
- https://swayam.gov.in/nd2_nou19_ag09/preview.

VAC 2
FOOD, NUTRITION AND HEALTH

Theory Credit: 3

Unit 1: Basic concept of food and Nutritional Biochemistry
Food Components and food-nutrients; Concept of a balanced diet, nutritional requirements and dietary pattern for children and adults.
Macronutrients: Definition and Introduction of Carbohydrates, Lipids and Proteins; their dietary sources and roles.
Micronutrients: Vitamins- types and their dietary sources and importance.
Minerals- Iron, calcium, sodium and iodine: their biological functions.

Unit 2: Health-I
Definition and concept of health.
Major nutritional Deficiency diseases: Protein malnutrition (kwashiorkor and marasmus);
Deficiency disorders of Vitamin A, Iron and Iodine.
Social health problems: alcoholism & drug abuse.
Acquired Immuno Deficiency Syndrome (AIDS): causes, treatment and prevention.

Unit 3: Health-II
Bacterial infection (cholera, typhoid fever, dysentery): causes, transmission, symptoms and prevention.
Protozoan infection (amoebiasis, giardiasis): causes, transmission, symptoms and prevention.
Parasitic infection (taeniasis and ascariasis): causes, transmission, symptoms and prevention.
Viral infection (hepatitis, poliomyelitis: causes, transmission, symptoms and prevention.

Recommended Books and References:

- Mudambi, SR and Rajagopal, MV. Fundamentals of Foods, Nutrition and Diet Therapy; Fifth Ed; 2007; New Age International Publishers.
- Srilakshmi B. Nutrition Science; 2002; New Age International (P) Ltd.
- Srilakshmi B. Food Science; Fourth Ed; 2007; New Age International (P) Ltd.
- Swaminathan M. Handbook of Foods and Nutrition; Fifth Ed; 1986; BAPPCO.
- Bamji MS, Rao NP, and Reddy V. Text Book of Human Nutrition; 2009; Oxford & IBH Publishing Co. Pvt Ltd.
- Wardlaw GM, Hampl JS. Perspectives in Nutrition; Seventh Ed; 2007; McGraw Hill.
- Lakra P, Singh MD. Textbook of Nutrition and Health; First Ed; 2008; Academic Excellence.
- Manay MS, Shadaksharaswamy. Food-Facts and Principles; 1998; New Age International (P) Ltd.
- Gibney et al. Public Health Nutrition; 2004; Blackwell.