

Model Curriculum for Three/Four Year Degree
Course (With Multiple Entry /Exit Option)
Based on NEP-2020



Zoology

**(SINGLE MAJOR AND TWO MINORS)
(BATCH 2024-2027)**

**SAMBALPUR UNIVERSITY
JYOTI-VIHAR, BURLA, SAMBALPUR, ODISHA-768019**

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UG PROGRAMME IN ZOOLOGY

Program Outcomes (PO):

- PO1 - Students gain knowledge and skill in the fundamentals of animal sciences, understands the complex interactions among various living organisms.
- PO2 – Analyse complex interactions among the various animals of different phyla, their distribution and their relationship with the environment.
- PO3 – Apply the knowledge of internal structure of cell, its functions in control of various metabolic functions of organisms.
- PO4 – Understands the complex evolutionary processes and behaviour of animals.
- PO5 – Correlates the physiological processes of animals and relationship of organ systems.
- PO6 – Gain knowledge of small scale industries like sericulture, fish farming, bee keeping, aquaculture, animal husbandry, poultry farm.
- PO7 – Understands about various concepts of genetics and its importance in human health.
- PO8 - Apply the knowledge and understanding of Zoology to one's own life and work.
- PO9 – Develops empathy and love towards the animals

Program Specific Outcomes (PSO):

- PSO1. Understand the nature and basic concepts of cell biology, genetics, taxonomy, physiology, biochemistry, ecology, evolutionary biology, developmental biology and applied and economic zoology.
- PSO2. Analyse the relationships among animals, plants and microbes.
- PSO3. Perform procedures as per laboratory standards in the areas of Taxonomy, Physiology, Ecology, Cell biology, Genetics, tools and techniques of Zoology, Biochemistry, molecular biology, Reproductive Biology and Animal biotechnology.
- PSO4. Understand the applications of biological sciences in Apiculture, Aquaculture, Sericulture, Animal Husbandry, Poultry Farm.
- PSO5. Gains knowledge about effective communication and skills of problem solving methods.
- PSO6. Contributes the knowledge for Nation building.

COURSE STRUCTURE

THREE-YEAR DEGREE COURSE WITH A SINGLE MAJOR AND TWO MINOR

SEMESTER	Core I	Core II	Core III	Multidisciplinary	AEC	SEC	VAC	Community Engagement and services/Field work/Internship	Total Minimum Credit
I	2x4=8	1x4=4		1x3=3	1x4=4 Odia		1x3=3 Env Studies and Disaster Management		22
II	2x4=8		1x4=4	1x3=3	1x4=4 English	1x3=3			22
*VOCATIONAL COURSE I (4 CREDIT)									44
III	3x4=12	1x4=4		1x3=3			1x3=3		22
IV	3x4=12		1x4=4					1x4=4	20
*VOCATIONAL COURSE II (4 CREDIT)									42
V	3x4=12	1x4=4				1x3=3	1x3=3		22
VI	2x4=8		1x4=4			1x3=3	1x3=3		18
									40
TOTAL	15x4=60	3x4=12	3x4=12	3x3=9	2x4=8	3x3=9	4x3=12	1x4=4	126

- ❖ In case a student opts for NCC and clears 'C' certificate, additional 16 credits shall be awarded and total credit shall be $126+16 = 142$ credit.
- ❖ One credit is equivalent to one hour of lecture or tutorials or two hours of practical work/field work per week in a semester. One Credit will be generally equivalent to 15 hours of instructions.
- ❖ Each semester shall comprise of 15 weeks of academic activities with a minimum of 90 working days.

*Vocational Course:

- ❖ Students may choose vocational courses after 2nd Semester and 4th Semester for Certificate Course or Diploma Course respectively with 4 credit each opt for exit.

EVALUATION

Distribution of Marks in Semester End and Continuous Evaluation: (Irrespective of credit in a course/Paper)

Course Type	Maximum Marks	Semester-End theory Mark	Continues Evaluation Marks /Sessional	Mid Semester theory Mark	Semester-End and Practical mark	Mid Semester Practical Mark
Without Practical	100	60	20	20	----	--
With Practical	100	50	10	10	20	10

Distribution of Sessional Marks

Course Type	Maximum Mark	Mid Semester	Attendance	Surprise Test/Quiz	Assignment/Presentation
Without Practical	40	20	Above 95%- 5 Marks	10	05
With Practical	30	(Theory 10 + Practical 10)=20	85%-94%- 4 Marks	05	Nil
			75%-84%- 3 Marks		

Examination Question Pattern of Term End Examination

The term end theory examination shall be for 100 marks of three hour's duration, the weightage shall be 50 with practical and 60 without practical.

Question Pattern	With Practical	Without Practical
Part-I –Objective	Answer in MCQ /One word /Sentence. (All are Compulsory)	1x10=10
Part-II- Very Short Type	Answer maximum 50 words (All are Compulsory)	1x10=10
Part-III- Short Type	Answer maximum 250 words Answer any 8 out of 10 questions	2x9=18
Part-IV- Long Type	Answer maximum 800 words Answer any 4 out of 5 questions	5x8=40
Total		8x4=32
Total		100
For Practical Paper	One Major Experiment-10 Record- 05 Viva voce-05	100

U G ZOOLOGY(MAJOR) UNDER NEP 2020

COURSE AT A GLANCE

Sl No	SEME STER	PAPER	COURSE TITLE	CREDIT	FULL MARK
MAJOR					
1	I	PAPER -I(Theory)	Invertebrates:protista to Echinodermata	4	100
2		PAPER -I(Practical)	Invertebrates:protista to Echinodermata		
3		PAPER -II(Theory)	Diversity of Chordates: Protochordates to Mammalia	4	100
4		PAPER -II(Practical)	Diversity of Chordates: Protochordates to Mammalia		
5	II	PAPER -III(Theory)	Microbiology	4	100
6		PAPER -III(Practical)	Microbiology		
7		PAPER -IV(Theory)	Cell Biology	4	100
8		PAPER -IV(Practical)	Cell Biology		
9	III	PAPER -V(Theory)	Principles of Ecology	4	100
10		PAPER -V(Practical)			
11		PAPER -VI(Theory)	Physiology: Controlling and Coordinating systems	4	100
12		PAPER -VI(Practical)			
13		PAPER -VII(Theory)	Fundamentals of Biochemistry	4	100
14		PAPER -VII(Practical)	Fundamentals of Biochemistry		
15	IV	PAPER -VIII(Theory)	Endocrinology & Reproductive Biology	4	100
16		PAPER -VIII(Practical)			
17		PAPER -IX(Theory)	Comparative Anatomy of Vertebrates	4	100
18		PAPER -IX(Practical)			
19		PAPER -X(Theory)	Physiology: Life Sustaining Systems	4	100
20		PAPER -X(Practical)			
21	V	PAPER -XI(Theory)	Biochemistry of Metabolic Processes Programme Outcome	4	100
22		PAPER -XI(Practical)			
23		PAPER -XII(Theory)	Principles of Genetics	4	100
24		PAPER -XII(Practical)			
25		PAPER -XIII(Theory)	Molecular Biology	4	100
26		PAPER -XIII(Practical)			

27	VI	PAPER -XIV(Theory)	Developmental Biology	4	100
28		PAPER -XIV(Practical)			
29		PAPER -XV(Theory)	Taxonomy and Evolutionary Biology	4	100
30		PAPER -XV(Practical)	Taxonomy and Evolutionary Biology		
ZOOLOGY (MINOR)					
1	I	PAPER -I(Theory)	Invertebrates:protista to Echinodermata	4	100
2		PAPER -I(Practical)			
3	II	PAPER -I(Theory)	Invertebrates:protista to Echinodermata	4	100
4		PAPER -I(Practical)			
5	III	PAPER -II(Theory)	Diversity of Chordates: Protochordates to Mammalia	4	100
6		PAPER -II(Practical)			
7	IV	PAPER -II(Theory)	Diversity of Chordates: Protochordates to Mammalia	4	100
8		PAPER -II(Practical)			
9	V	PAPER -III(Theory)	Microbiology	4	100
10		PAPER -III(Practical)			
11	VI	PAPER -III(Theory)	Microbiology	4	100
12		PAPER -III(Practical)			
MULTIDISCIPLINARY COURSES UNDER NEP-2020					
1	I	PAPER I	Vector Borne Diseases and Epidemiology	3	100
2	II	PAPER II	Apiculture	3	100
3	III	PAPER III	Environmental Impact Assessment and Environmental management plant(EIA and EMP)	3	100
SKILL ENHANCEMENT COURSES (SEC) UNDER NEP-2020					
1	II	PAPER I (Theory and Practical)	Fermentation Technology and Industrial Enzymes	3	100
2	V	PAPER II (Theory and Practical)	Molecular Diagnostics	3	100
2	VI	PAPER III (Theory and Practical)	Vermitechnology	3	100
VALUE AIDED COURSES (VAC) UNDER NEP – 2020					
1	I	PAPER I	Environmental studies and Disaster Management	3	100
2	III	PAPER II	Research Methodology	3	100
3	V	PAPER III	Biodiversity and Conservation	3	100
4	VI	PAPER IV	Food Preservation and Processing	3	100

SUMMER VOCATIONAL COURSE UNDER NEP – 2020					
1		PAPER I	Environmental Conservation	4	100
2		PAPER II	Recombinant DNA Technology	4	100
Community Engagement and Services/ Field work/ Internship					
1	IV		Community Engagement and Services/ Field work/ Internship	4	100

SEMESTER I

PAPER I

Invertebrates: Protista to Echinodermata

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the general characteristics of non-chordate groups of organisms.
- Acquire knowledge regarding classification of the taxa with examples.
- Develop an understanding of important phenomena associated with each taxon.
- Acquire skills in identifying representative species of groups studied.
- Illustrate phylogenetic distribution of lower groups of Non-chordates.
- Understand elaboration of coelomic evolution and metamerism on Coelomates with their classification up to their class and excretion system in Annelidans.
- Recognize insect vision, respiration and metamorphosis in Arthropoda with reference to Termites and in evolutionary significance of Onychophora with general characteristics.
- Obtain an over view of the general features, respiration, Gastropodan evolution, mechanism of torsion, and significance of larval life stages.
- Acquire knowledge on general characters and classification of Echinoderms and their affinities with Chordates.

Course Outcome:

- Utilize information to understand the differences of the groups studied.
- Develop skills in examining diversity of the taxa.
- Develops skills in elaborating the general features and evolutionary significance of the coelomate from Annelida to Echinoderms.
- Impactful visual understanding and enables the students to correlate the evolutionary significance of each organism on the phylogenetic tree.
- Study on various general features and characteristics of body symmetry and arrangement with various vision types, excretory systems and developmental stage give a strong fundamental understanding on the subject on Coelomates.

Learning Outcome

- Systematically understand the diverse group of organisms from Protista to Cnidaria and Ctenophora
- Systematically understand the diverse group of organisms that make up Phyla Platyhelminthes and Nematelminthes.
- Understand the diverse organisms that make up Phyla from Annelida, Arthropoda and Onychophora.
- Understand the diverse organisms that make up Phyla from Mollusca and Echinodermata and significant processes associated.

Unit 1: Protista to Cnidaria and Minor Phylum Ctenophora

General characteristics and Classification up to classes. Locomotion, Nutrition and Reproduction in Protista, Life cycle and pathogenicity of *Plasmodium vivax*, Canal system and spicules in sponges, Metagenesis in Obelia, Polymorphism in Cnidaria, Corals and coral reefs, Evolutionary significance of Ctenophora.

Unit 2: Platyhelminthes and Nemathelminthes

General characteristics and Classification up to classes. Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*, Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*. Parasitic adaptations in helminthes

Unit 3: Annelida, Arthropoda and Onychophora

General characteristics and Classification up to classes. Evolution of coelom and metamerism. Excretion in Annelida, Vision and Respiration in Arthropoda. Metamorphosis in Insects. Social life in bees and termites. Onychophora: General characteristics and Evolutionary significance.

Unit 4: Mollusca and Echinodermata

General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Evolutionary significance of trochophore larva. Water-vascular system in Echinoderms, Larval forms in Echinodermata

TEXT BOOKS

- ✓ *Kotpal RL; Modern Textbook of Zoology – Invertebrates; Rastogi Publications - Meerut; 2016 edition.*
- ✓ *Richard Brusca, W. Moore, Stephen M. Shuster. Invertebrates; OUP USA; 3 edition (19 January 2016).*

SUGGESTED READINGS

- ✓ *Richard Fox, Robert D. Barnes, Edward E. Ruppert, Invertebrate Zoology: A Functional Evolutionary Approach, Brooks/Cole; 7th edition edition 2003*
- ✓ *Barrington, E.J.W. Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.*
- ✓ *Hyman, L.H. Invertebrate Series (Recent edition).*
- ✓ *Parker JJ and WA Haswel Textbook of Zoology. Vol I and II.*
- ✓ *Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.*
- ✓ *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.*

Invertebrates: Protista to Echinodermata

Practical

1. Study of whole mount of Euglena, Amoeba and Paramecium, Binary fission and Conjugation in Paramecium.
2. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Euplectella*, *Spongilla*, Spicules and Spongin fibers.
3. Study of Cnidarians *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora.*, *Ctenophore*.
4. Study of Life cycle stages of *Fasciola hepatica*, *Taenia solium* and *Ascaris lumbricoides* (Slides/micro-photographs).
5. Study of Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinaria*.
6. Study of Arthropods – Crab, *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx mori*, *Periplaneta americana*, termites, honey bees and *Peripatus*
7. Study of Molluscs and Echinodermata- *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*.
Echinodermata - *Pentaceros/Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*
8. Study of digestive system, nephridia of earthworm (Virtual), T.S. through pharynx, gizzard, and typhlosolar region of earthworm, Mounting of mouth parts and dissection of digestive system and nervous system (Virtual) of *Periplaneta americana*.
9. To submit a Project Report on any related topic.

Suggested Reading

- ✓ *Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. S Chand Publication.*
- ✓ *S.S Lal. (2019) Practical Zoology (Invertebrate) Rastogi Publications.*

PAPER II

Diversity of Chordates: Protochordates to Mammalia

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The students learn about the salient features, diversity and distribution of all Chordates.
- To know the evolution of aquatic, amphibious and terrestrial vertebrates.
- To understand the importance of distribution of vertebrates in different realms.

Course Outcome:

- Understanding the origin, larval forms, distribution and adaptation of different vertebrates.
- Accumulating the knowledge and understanding on the classification, affinities and comparative anatomy of different vertebrates and their evolutionary significance.
- Learning the mechanism of flight and aquatic adaptations in birds and mammals.
- Obtaining knowledge pertaining to the distribution of animals particularly vertebrate in different realms.

Learning Outcome:

- Gain understanding of Protochordates and origin of Chordates.
- Knowledge regarding characteristics and classification of Agnatha, Pisces, Amphibia, and evolution of tetrapoda.
- Understanding characteristics and classification of Reptiles and Aves and their connecting links.
- Comprehend characteristics and organization of mammals, in addition to their distribution in zoogeographical realms.

Unit 1: Protochordates and Origin of Chordates

General characteristics and outline classification Chordata (Protochordata: Hemichordata, Urochordata and Cephalochordata). Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordat; Dipleurula concept and the Echinoderm theory of origin of chordates.

Unit 2: Agnatha, Pisces & Amphibia

General characteristics and classification up to order. Migration, Parental care in fishes, Accessory respiratory organs in Pisces, Evolutionary significance of Dipnoi. Amphibia: Origin of Tetrapoda (Evolution of terrestrial ectotherms); Parental care.

Unit 3: Reptilia & Aves

General characteristics and classification up to order. Affinities of Sphenodon; Poison apparatus and Biting mechanism in snakes. Archaeopteryx- a connecting link; Flight adaptations and Migration in birds.

Unit 4: Mammals & Zoogeography

General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages. Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.

PRACTICAL

1. Protochordata: *Balanoglossus*, *Herdmania*, *Branchiostoma*, Urochordata, Sections of *Balanoglossus* through proboscis and branchio-genital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slides of *Herdmania* spicules, *Doliolum*, *Salpa*
2. Agnatha: *Petromyzon* and *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*, Salamander.
5. Reptilia: *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Chamaeleon*, *Ophiosaurus*, *Draco*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*, *Zamenis*, *Crocodylus*. Key for Identification of poisonous and non-poisonous snakes
6. Aves: Study of six common birds from different orders. Types of beaks and claws. Study of feathers.
7. Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes*, *Erinaceous*.
8. Power point presentation on study of any two examples representing two different classes.. Submission of report on local species.

Text Books:

- ✓ *Kotpal RL; Modern Textbook of Zoology –Vertebrates; Rastogi Publications - Meerut; 2016 edition*
- ✓ *Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.*
- ✓ *Tiwari SK (2006) Fundamentals of World Zoogeography, Sarup & Sons.*

Suggested Readings:

- ✓ *Pough H. Vertebrate life, VIII Edition, 2007 Pearson International.*
- ✓ *Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jonesand Bartlett Publishers Inc.*
- ✓ *Hickman CP, Roberts LS, Keen S, Larson A, I'AnsonH, Isenhour DJ Integrated Principle of Zoology, 14th edition, 2008, McGrawHill publication.*

SEMESTER II

PAPER III

Microbiology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Knowledge of microbial diversity and classification.
- To understand microbial culture, growth and reproduction.
- To understand the importance of viral pathogenicity, nature of viral transmission.
- To comprehend the importance of Anti-viral drugs and vaccines.

Course Outcome:

- Obtaining knowledge pertaining to future scopes and modern trends of microbiology.
- Understanding the experimental approaches to explore the origin of microbes.
- Understanding the morphology, classification and significance of host-vector relationship.
- Learning the mechanism of action of microbial toxins and pathogenicity.
- Obtaining knowledge on pathogenic manifestation of Oncoviruses & HIV.

Learning Outcome:

- Finding the historical background and modern experimental approaches to understand the origin and development of microbiology.
- Analysing the general features, classification and pathogenicity of Archea and Eubacteria.
- Deducing knowledge on role of microbes in agriculture and healthcare sector.
- Interpreting the mechanism of antibacterial and anti-viral their mode of action, and importance of vaccines.

Unit-1

History and development of microbiology: Biogenesis and abiogenesis, Contribution of Francesco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Robert Koch (germ theory), Edward Jenner and Alexander Fleming's experiments on discovery of Penicillin, Modern trends and future scope of Microbiology.

Unit-2

Microbial systems of classification: General features of Bergey's manual for classification of microbes, Whittaker's five kingdom concept, Carl Woese's 3 domain classification, Lynn Margulis theory of endosymbiotic theory. General features of Archaea: Structure, Nutrition and Reproduction.

General features, pathogenicity of Mycoplasma, Rickettsia and Spirochaetes.

Unit-3

Isolation, culture and maintenance of microorganisms: Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and healthcare industry. Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction).

Unit-4

Virion and viroids: General characteristics and classification of viruses, morphology, nature of viral transmission. Bacteriophage replication, Oncoviruses & HIV: structure, transmission, pathogenicity and replication. Microbial toxins: types, mode of actions and pathogenicity (Exo and Endo-toxin). Antibiotics and their mode of action, Anti-virals and vaccine.

PRACTICAL

1. Study on aseptic techniques in microbiology: various methods of sterilization process.
2. Preparation and formulation of microbial media and methods of inoculation.
3. Methods of isolation of bacteria: spread plate, streak plate, pour plate, serial dilution.
4. Sampling and quantification of microorganisms in air, water and soil.
5. Morphological identification of microorganisms from various habitats through simple staining, differential staining, acid fast staining, spore staining.
6. Methods of microscopic measurements, micrometer (ocular and stage), haemocytometer.
7. Preparation of bacterial growth curve.

PAPER -IV

Cell Biology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Introducing prokaryotic and eukaryotic cells and their features, ultrastructure of plasma membrane and mechanism of transport of molecules across plasma membrane.
- To know the structure, function and properties of endomembrane & cytoskeletal network system and cell organelles.
- To understand the importance of mitochondria in aerobes, the role of mitochondrial electron transport chain, oxidative phosphorylation & mechanism of ATP synthesis.
- To study the structure and packaging of chromosome in nucleus, behaviour of chromosome during cell division, cell cycle and its regulation.

Course Outcome:

- Understanding the difference between prokaryotic and eukaryotic cells and the mechanism of transportation across their membrane system.
- Understanding the role of cytoskeleton in maintaining structural frame work, cell motility and cell organelles.
- Deciphering the role of mitochondria in cellular respiration and energy production.
- Obtaining knowledge on structure and function of nucleus, cell division and regulation of cell cycle.

Learning Outcome

Understanding Cell junctions and mechanism of transportation across membrane.

- Obtaining knowledge on structural and functional aspect of cytoskeleton and endomembrane system.
- Obtaining knowledge on nucleus, nucleosome and cell division and cell cycle regulation.
- Knowledge about mitochondrial respiratory chain, chemi-osmotic hypothesis and functions of peroxisome.

Unit 1: Overview of cells and plasma membrane

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure. Transport across membranes: Active and Passive transport,

Facilitated transport. Cell junctions: Tight junctions, Desmosomes, Gap junctions.

Unit 2: Cytoskeleton & Endomembrane System

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments;

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

Unit 3: Mitochondria and Peroxisomes

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis;

Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis. Peroxisomes.

Unit 4: Nucleus, Cell Division and Cell signalling

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus; Chromatin:

Euchromatin and Heterochromatin and packaging (nucleosome); Mitosis, Meiosis, Cell cycle and its regulation; GPCR and Role of second messenger (cAMP).

Text Books:

- ✓ *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.*

Suggested Readings:

- ✓ *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.*
- ✓ *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.*
- ✓ *Suvarna S, Lyton C, Bancroft JD (2013) Theory and practice of histological techniques, Churchill Livingstone, Elsevier, UK*
- ✓ *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.*

PRACTICAL

1. Understanding of simple and compound microscopes.
2. To study different cell types such as buccal epithelial cells, striated muscle cells using Methylene blue/any suitable stain (virtual/ slide/slaughtered tissue).
3. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.

4. Study of various stages of meiosis in grasshopper testis
5. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
6. 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 Mercuric bromophenol blue/Fast Green
7. Demonstration of osmosis (RBC/ Egg etc.).

Suggested Reading:

1. Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. S Chand Publication.
2. S.S Lal. (2019) Practical Zoology (Invertebrate) Rastogi Publications.

SEMESTER-III PAPER V

Principles of Ecology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the concept of an ecosystem, its attributes, factors and functioning.
- Learn about population attributes, growth patterns, strategies; regulation and interactions.
- To appraise learners regarding various community characteristics.
- Comprehend biological data, learn graphical representation of data, sampling techniques, grasp basic statistics.
- Acquire skills on plotting survivorship curves, quadrat method of determining population density, diversity indices, techniques of preservation and mounting of plankton, determination of ecological parameters.

Course Outcome:

- Utilize information to understand interrelations and working of an ecosystem.
- Demonstrate the ability to comprehend data, plot graphs, present data and apply basic statistics.

Learning Outcome:

- Understand food chain dynamics and energy flow patterns.
- Gain knowledge about population dynamics.
- Understand community stratification and succession.
- Gain knowledge about representation of data, data processing and analysis.

Unit 1: Ecosystem and Applied Ecology

Ecology: Autecology and synecology, Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Laws of limiting factors, Study of physical factors- (Light, temperature).

Unit 2: Population

Attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion Exponential and logistic

growth, equation and patterns, r and K strategies. Population regulation - density- dependent and independent factors, Population interactions, Gause's Principle with laboratory and field examples.

Unit 3: Community

Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Ecotone and edge effect; Ecological succession with one example. Theories pertaining to climax community.

Unit – 4: Biometry

Biological data, graphical representation of data (frequency polygon and histogram), sampling techniques, measures of central tendency (Mean, median and mode), Measures of dispersion (range, quartile deviation, mean deviation and standard deviation), Hypothesis and hypothesis testing (Chi-square test, t- test).

Text Book:

- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition*
- ✓ *Smith and Smith, Elements of Ecology, Global Edition; Pearson Education India; ninth edition (14 May 2015).*
- ✓ *Myra Samuels, J. Witmer, A. Schaffner, Statistics for the life sciences, Prentice Halls, Boston, 4th edition, 2012.*

Suggested Readings:

- ✓ *Kormondy, (2017). Concepts of Ecology, Updated 4/e, Pearson.*
- ✓ *Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.*
- ✓ *Ricklefs, R.E., (2000). Ecology. 5th Edition. Chiron Press.*
- ✓ *Dash M.C., Fundamentals of Ecology. Mc GrawHill*
- ✓ *Smith TM and Smith RL, Elements of Ecology, 8th Edition, Pearson education INC, USA*
- ✓ *Miller, G.T. and Spoolman, S.E. (2017) Environmental Science, 14th Edition. Cengage Publication, New Delhi.*

- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition.*
- ✓ *Cengage Publication, New Delhi*
- ✓ *Web site: <https://www.cbd.int/>*
- ✓ *Baneerjee Pranab Kumar, Introduction to biostatistics, S Chand & Company; 3rd Rev. Edn. 2006 edition*
- ✓ *Chainy GBN, Mishra G, MohantyPK, 2004, Basic Biostatistics, Kalyani Publisher.*

PRACTICAL

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton collection, preservation and mounting, Measurement of temperature, turbidity/penetration of light, determination of pH, Dissolved Oxygen content (Winkler's method), BOD, COD, Free CO₂, Hardness, TDS.
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.
5. Chi-square analysis using seeds/beads/Drosophila.
6. Problems on standard deviation.
7. Graphical representation of data (Frequency polygon and Histogram).

Suggested Reading:

- ✓ *Practical Ecology by David Slingsby, Ceridwen Cook, Red Globe Press London.*
- ✓ *Practical Methods in Ecology by Henderson Peter A. John Wiley and Sons Ltd.*
- ✓ *Practical Ecology by Rao K S, K.S. Rao. Anmol Publications.*

PAPER-VI

Physiology: Controlling and Coordinating systems

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Develop an understanding of tissues and tissue systems with clarity on types and functions of each.
- Acquire knowledge on the muscle and nervous system.
- Obtain information about various receptors, their functioning and understand the mechanism of action.

Course Outcome:

- Acquire skills in differentiating tissues based on their structure and functions.
- Gain insights on the controlling and coordinating systems of the body.

Learning Outcome:

- Gain knowledge about tissue composition and function.
- Understand muscle types and mechanism of action.
- Understand functioning of different type of receptors.
- Acquire knowledge on osmoregulation and thermoregulation.

Unit 1: Tissues & Tissue system

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue. Structure and types of bones and cartilages, Ossification, bone growth and resorption.

Unit 2: Muscle & Nervous System

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction. Introduction to CNS, PNS and ANS. Structure of neuron, Types of neurons, Action potential and its propagation, Synapse and synaptic transmission, Neuromuscular junction; Reflex action.

Unit 3: Physiology of Special senses

Sensory Neurons-types; Physiology and pathway- hearing and balance, Olfaction, Gustation and Vision. Interoception – Nociceptors, Baroreceptors, Chemoreceptors, Thermoreceptors, Osmoreceptors, Cutaneous Receptors.

Unit 4: Homeostasis

Homeostasis and body fluids, Sources of body water and loss, Control of homeostasis, Homeostatic imbalances. Osmoregulation in fish, thermoregulation in Poikilotherms, homeotherms and heterotherms.

Text Books:

- ✓ *Marieb EN and Hoehn K, Human Physiology, (2013), 9th edition, Pearson Education, USA.*
- ✓ *Endocrinology, Hadley ME and Levine JE (2009), Pearson Education India; 6 edition.*
- ✓ *Textbook of Medical Physiology, Guyton & Hall, Elsevier, 12th edition, 2016.*

Suggested Books:

- ✓ *Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition., Lippincott W. & Wilkins*
- ✓ *Martini F H, Nath J L and Bartholomew E F (2015) Fundamentals of Anatomy and Physiology. Pearson Education Publication,*
- ✓ *Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hecourt Asia PTE Ltd. /W.B.Saunders Company.*
- ✓ *Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.*

Practical**Physiology: Controlling and Coordinating systems**

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex).
2. Study of permanent slides- Squamous epithelium, Striated muscle fibres, nerve cells and others relevant to the theory.
3. Microtomy: Preparation of permanent slides.
4. Models of mammalian tissues (Any five) /photographs.
5. Effect of salt concentration on cells.

PAPER VII
Fundamentals of Biochemistry
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- To gain understanding of fundamentals of biochemistry and biological macromolecules.
- To understand structure, classification, properties and significance of biomolecules.
- Acquire knowledge on nomenclature, classification and mechanism of enzyme action, regulation and its kinetics.

Course Outcome:

- To understand the structure and biological importance of protein, carbohydrates, lipids, nucleic acids and enzymes.
- Providing knowledge on types of amino acids and its polymeric form.
- Learning the structure and pairing of nucleotides, denaturation and denaturation kinetics of DNA.
- Obtaining knowledge on enzymes and isoenzymes, specificity, inhibition, derivation of Michaelis-Menten equation.

Learning Outcome:

- Gaining knowledge on different classes of biological macromolecules such as carbohydrates, lipids and nucleic acids.
- Understanding the structure of proteins and its monomers.
- Learning the structure of nucleic acids, denaturation and renaturation kinetics of DNA.
- Interpret the activities of enzymes and isoenzymes.

Unit 1: Carbohydrates & Lipids

Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates; Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

Unit 2: Proteins

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

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

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

Unit 3: Nucleic Acids

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

Unit 4: Enzymes

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

Text Books:

- ✓ *Satyanarayan and Chakrapani, (2017) Biochemistry, Elsevier; Fifth edition*
- ✓ *Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.*
- ✓ *Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto, Biochemistry, 8th edition, 2015.*
- ✓ *Victor W., Rodwell, David A., Bender, Kathleen M., Botham, Peter J., Kennelly, P. Anthony, Harper's Illustrated Biochemistry, 31st edition.*

Suggested Readings:

- ✓ *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.*
- ✓ *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 Publication.*
- ✓ *Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.*
- ✓ *Devasena T. (2010). Enzymology Oxford University Press; 1 edition*
- ✓ *Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.*

Fundamentals of Biochemistry

Practical:

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH, temperature and inhibitors on the action of salivary amylase/Urease/acid or alkaline phosphatase
5. Demonstration of proteins separation by SDS-PAGE.

SEMESTER-IV

PAPER VIII

Endocrinology & Reproductive Biology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Insights on the history of endocrinology, study endocrine glands, hormones, control and regulation
- Acquire knowledge on the various facets of the reproductive system and their endocrine aspects.

Course Outcome:

- Essential clarity on endocrine gland structures, hormones, functions and their regulation.
- Scientific knowledge base on reproductive health and endocrine control.

Learning Outcome:

- Acquire information on the history of endocrinology, endocrine glands, and hormones.
- Gain an understanding of the Hypothalamo-hypophysial axis and regulation of hormone action.
- Understand the endocrine aspects of reproductive system.
- Recognize different aspects of reproductive health and Assisted Reproductive Technology.

Unit 1: Introduction to Endocrinology

A brief history of endocrinology, Types of endocrine glands (Pituitary, Pineal, Thyroid, Parathyroid, Adrenal, Pancreas), their histology, hormones, functions and disorders; General characteristics of Hormones, Classification, Hormone receptors, Mechanism of hormone action (steroidal and non-steroidal hormones) and transduction .

Unit 2: Hypothalamo-hypophysial Axis and Regulation of Hormone Action

Structure of hypothalamus, Hypothalamic nuclei, Neurosecretions, Neurohormones and their functions, Hypothalamo-hypophysial portal system, Hypothalamic-pituitary-gonadal axis,

Hormone action at cellular and molecular level, Genetic control of hormone action. Regulation-Feedback mechanisms.

Unit 3: Reproductive System-endocrine aspects

Testis: Histology; Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Sperm transportation in male tract; Ovary: Histology, folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles and their regulation, Ovum transport in the fallopian tubes; Sperm transport in the female tract, fertilization, prevention of polyspermy; Hormonal control-implantation and gestation, foeto-maternal

relationship; Parturition and Lactation.

Unit 4: Reproductive Health

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: sex selection, sperm banks, frozen embryos, in vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST; Modern contraceptive technologies; Demographic terminology used in family planning.

Text Books:

- ✓ *C. Donnell Turner (2012) General Endocrinology Pub- Affiliated East-West press Pvt. Ltd.-New Delhi; 6th Edition*
- ✓ *Hadley, M.E. and Levine J.E. (2007). Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey*
- ✓ *Austin, C.R. and Short, R.V. (1982) Reproduction in Mammals. Cambridge University Press.*
- ✓ *C. Donnell Turner (2012) General Endocrinology Pub- Affiliated East-West press Pvt. Ltd.-New Delhi; 6th Edition*
- ✓ *Tandulwadkar Sunita R (2015) The Art & Science Of Assisted Reproductive Technology, Jaypee Brothers Medical Publishers*

Suggested Readings:

- ✓ *Stephen Nussey and Saffron Whitehead (2001). Endocrinology: An Integrated Approach; Oxford: BIOS Scientific Publishers*
- ✓ *Tony M. Plant and Anthony J. Zeleznik (2015) Knobil and Neill's Physiology of Reproduction, Academic Press*

Endocrinology & Reproductive Biology

Practical:

1. Dissect and display of Endocrine glands in laboratory bred rat*.
2. Study of the permanent slides of all the endocrine glands.
3. Study and identification of endocrine disorders through images.
4. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat*.
5. Demonstration of Castration/ ovariectomy in laboratory bred rat*.
6. Estimation of plasma level of any hormone using ELISA.
7. Designing of primers of any hormone.
8. Examination of vaginal smear from live animals and examination of Human vaginal exfoliate cytology.
9. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectomy, castration and vasectomy in rats. (*Subject to UGC guidelines)

10. Sperm count and sperm motility in rat.
11. Study of modern contraceptive devices.
12. Report on endocrine disorders in human.
13. Paper chromatographic separation of hormones.
14. Hypophysectomy in fish (Tilapia/catfish/ locally available fish)

PAPER IX
Comparative Anatomy of Vertebrates
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand anatomical significance of organ system in vertebrates.
- Comprehend structure, function and various derivatives of Integumentary, Skeletal, digestive, respiratory, circulatory, urinogenital and nervous system.

Course Outcome:

- Learner gains detailed overview of the anatomical resemblance amongst vertebrates hierarchies.
- Acquires knowledge on cellular development of organ systems in the vertebrates and linear progression of cellular derivatives during organogenesis.
- Understand the process of linear and vertical cellular evolutionary processes.

Learning Outcome:

- Acquire knowledge of the integument, and skeleton systems.
- Gain knowledge on the Gastro intestinal canal, associated glands, and respiration system.
- Obtain knowledge of the Circulatory and Urinogenital systems and their evolution.
- Comparative study of mammalian nervous system & sense organs.

Unit 1: Integumentary & Skeletal System

Structure, functions and derivatives of integument (Scale, claw, nail, hair, feather and dentition). Axial and appendicular skeleton, Jaw suspensorium, Visceral arches.

Unit 2: Digestive & Respiratory System

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

Unit 3: Circulatory and Urinogenital system

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

Unit 4: Nervous System & Sense Organs

Comparative account of brain; Nervous system, Spinal cord, Cranial nerves in mammals. Classification of receptors: Brief account of visual and auditory receptors in man. Chemo and mechano-receptors

Practical

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, Varanus, Fowl, Rabbit.
3. Carapace and plastron of turtle /tortoise (Photographs, charts etc).
4. Mammalian skulls: One herbivorous and one carnivorous animal.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) through ICT tools.
6. Project report submission on Integumentary derivatives.

Text Books:

- ✓ Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education
- ✓ Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies
- ✓ R. K. Saxena and Sumitra Saxena (2016). Comparative Anatomy of Vertebrates 2nd edition.

Suggested Readings:

- ✓ *Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate tructure, JohnWiley and Sons*
- ✓ *Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House*

PAPER X
Physiology: Life Sustaining Systems
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Knowledge of critical physiological processes.
- Understand anatomical attributes of Digestive, Respiratory, Renal and Cardiovascular system.
- Learn and develop an understanding of vital life-sustaining physiological processes.

Course Outcome:

- Appraise the significance of anatomical structures and physiological events.
- Apply information to understand the functioning of organisms.
- Demonstrate the ability to appreciate the occurrence of physiological actions.
- Understand interrelationships of life processes.
- Acquire practical skills in identifying different organs, and perform laboratory work based on theoretical applications

Learning Outcome:

- Acquire knowledge on digestion, respiration, renal and heart physiology.
- Understand the composition of blood grouping, functions and Blood clotting.

Unit 1: Physiology of Digestion

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

Unit 2: Physiology of Respiration

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

Unit 3: Renal Physiology

Structure of kidney and its functional unit, Mechanism of urine formation, Regulation of water balance, Regulation of acid-base balance, Homeostatic regulation of tubular reabsorption and secretion.

Unit 4: Blood and Physiology of Heart

Haemopoiesis, Components of blood and their functions; Structure and functions of haemoglobin, Blood clotting system, Blood groups: Rh factor, ABO and MN.

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

Practical:

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Preparation of blood smear for differential count.
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 slides: oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.

Text Books:

- ✓ Marieb E.N. and Hoehn K.N. (2009) Human Physiology. Pearson Education Publication, 9th edition
- ✓ Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.
- ✓ Guyton & Hall, (2016) Textbook of Medical Physiology. Elsevier, 12th edition.

Suggested Readings:

- ✓ 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.
- ✓ Moyes C.D., Schulte PM (2016), Principles of physiology, 2nd edition, Pearson education, 3rd.
- ✓ Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Herculat Asia PTE Ltd. W.B. Saunders Company.

SEMESTER -V

PAPER XI

Biochemistry of Metabolic Processes (4Credit, Theory-45h and Practical – 30h)

Programme Outcome

- Understanding of catabolism, anabolism and regulatory mechanism of intermediary metabolism.
- To learn the processes of carbohydrate, lipid and protein metabolism.
- To obtain knowledge on redox regulation and electron transport system.

Course Outcome:

- Gain overall knowledge and understanding on metabolic pathways and shuttle systems.
- Gain knowledge on carbohydrate metabolism related processes.
- Understanding of β -oxidation and catabolism of amino acids.
- Understanding on mitochondrial respiratory chain and oxidative phosphorylation.

Learning Outcome:

- Gain knowledge on the compartmentalization of metabolic pathways.
- Understand role of intermediate and carbohydrate regulatory metabolism.
- Gain knowledge on β and omega oxidation of saturated fatty acids.
- Understand the role of mitochondria in energy production during electron transport.

Unit 1: Overview of Metabolism

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

Unit 2: Carbohydrate Metabolism

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

Unit 3: Lipid and protein Metabolism

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

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

Unit 4: Oxidative Phosphorylation

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

Practical

1. Estimation of total protein in given solutions
2. Measurement of SGOT and SGPT activity.
3. Determination of GSH level in serum/tissue.
4. Measurement of GST activity.
5. To study the enzymatic activity of Trypsin/ Lipase.
6. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
7. Dry Lab (Virtual): To trace the labelled C atoms of Acetyl-CoA till they evolve as CO₂ in the TCA cycle.

Text Books:

- ✓ *Satyanarayan and Chakrapani, (2017) Biochemistry, Elsevier; Fifth edition.*
- ✓ *Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.*

Suggested Readings:

- ✓ 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.
- ✓ Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- ✓ Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.

PAPER XII

Principles of Genetics

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Obtain knowledge on the basic principles of genetics.
- To provide knowledge on the mechanism of sex determination and extra-chromosomal inheritance.
- To learn the process of DNA recombination, transposons and transposable elements.

Course Outcome:

- Acquire knowledge on the fundamentals of Mendelian and non-Mendelian genetics, chromosomal mapping and interaction of genes.
- Providing the knowledge and understanding on linkage, crossing over, sex determination and role of extra-chromosomal inheritance.
- Obtaining knowledge on chromosomal aberration, cause and consequences of mutations.

Learning Outcome:

- Understand principles of Mendelian genetics.
- Discern types of gene mutations and chromosomal aberrations with detection methods..
- Gain an understanding of mechanisms of sex determination and extra chromosomal inheritance.
- Understand the process of recombination and transposable genetic elements.

Unit 1: Mendelian Genetics, Linkage, Crossing Over and Chromosomal Mapping

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance. Polygenic inheritance with suitable examples; simple numerical based on it.

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

Unit 2: Mutations

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

Unit 3: Sex Determination & Extra-chromosomal Inheritance

Chromosomal mechanisms of sex determination in *Drosophila* and Man; Criteria for extra-chromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces*, Cytoplasmic inheritance in *Paramecium*.

Unit 4: Recombination in Bacteria and Viruses & Transposable Genetic Elements

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in human.

Practical

1. Study of Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from *Drosophila* crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Experiments on epistatic interactions including test cross and back cross.
7. Experiments on probability and Chi-square test.
8. Study on sex linked inheritance in *Drosophila*.

Text Books:

- ✓ *Benjamin Pierce, (2015) Genetics- A Conceptual Approach, 5th edition, WH Freemanpublication*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition.*

Suggested Readings:

- ✓ *Benjamin Cummings. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition.*
- ✓ *Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wileyand Sons Inc.*
- ✓ *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.*

PAPER- XIII

Molecular Biology

Programme Outcome:

- Detailed information on DNA structure, different forms, their properties and types of RNA.
- Understanding mechanism of DNA replication and repair in prokaryotes and eukaryotes.
- Gain knowledge on mechanism of transcription and translation in prokaryotic and eukaryotic cells.
- Acquire knowledge on post transcriptional modifications of RNA.

Course Outcome:

- Gain knowledge on details of Watson-Crick Model of DNA, RNA types .
- Understand the process of DNA replication, transcription, translation and their regulatory mechanisms.
- Gain knowledge on genetic code & regulatory machinery.
- Understand gene expression and role of RNA interference elements.

Learning Outcome:

- Gain knowledge on the fundamentals of double helical structure of DNA, denaturation and renaturation kinetics DNA, mechanism of replication and repair of DNA.
- Acquire knowledge on process of transcription, translation and post-processing regulatory mechanisms.
- Obtain knowledge on splicing mechanism, RNA editing, Processing of rRNA and tRNA.
- Understand operon concept and regulation.

Unit 1: Nucleic Acids, DNA Replication & Repair

Salient features of DNA: Watson and Crick model of DNA, DNA denaturation and renaturation kinetics, Cot curves, C-value paradox, Salient features of RNA

DNA Replication in prokaryotes and eukaryotes: Semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear ds-DNA and RNA priming, replication of telomeres.

DNA repair mechanism: Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair.

Unit 2: Transcription & Translation

Transcription: RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors and regulation

of transcription.

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

Unit 3: Post Transcriptional Modifications and Processing of Eukaryotic RNA

Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of rRNA and tRNA.

Unit 4: Gene Regulation &Regulatory RNAs

Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from Lac-operon and Trp-operon; Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing, RNA interference, miRNA, si-RNA.

Text books:

- ✓ Karp G, Iwasa J, Marshall W. Karp's Cell and Molecular Biology, 9th Edition. John Wiley and Sons. Inc. ISBN: 978-1-119-59816-9
- ✓ Krebs JE, Goldstein ES, Kilpatrick ST. (2018) Lewin's Gene XII, Jones and Bartlett Publishers, Inc. ISBN: 9781284104493.
- ✓ DeRobertis E. D. P. (2017) Cell and Molecular Biology 8th Edition. ISBN: 10-8184734506, 13-978-8184734508
- ✓ Lodish H, Berk A, Kaiser CA, Kreiger M, Bretscher A, Ploegh H, Amon A, Martin KC. (2016) Molecular Cell Biology.8th Edition. WH Freeman. ISBN: 10-1464183392, 13-978-1464183393

Suggested Readings:

- ✓ *Becker W. M., Kleinsmith L.J., Hardin J, Bertoni G.P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.*
- ✓ *Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P (2002) Molecular Biology of the Cell, 4th Edition. ISBN: 10-0815332181, 13-978-0815332183*
- ✓ *Cooper G.M. and Robert E. Hausman R.E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.*
- ✓ *McLennan A., Bates A., Turner, P. and White M. (2015). Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.*
- ✓ *Lewin's Genes XII- by Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick*

PRACTICAL
Molecular Biology

1. Study of Polytene chromosomes from Chironomus / Drosophila larvae.
2. Preparation of liquid culture medium (LB) and raise culture of E.coli..
3. Estimation of the growth kinetics of *E. coli* by turbidity method.
4. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
5. Quantitative estimation of calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A 260 nm measurement).
6. Quantitative estimation of RNA using Orcinol reaction.
7. Study and interpretation of electron micrographs/photograph showing (a) DNA replication, (b) Transcription and (c) Split genes.

SEMESTER-VI

PAPER XIV

Developmental Biology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the phases of development, changes, regulation and the concepts of ageing and teratogenesis.
- Gain knowledge on In- Vitro fertilization and amniocentesis.

Course Outcome:

- Understand the basic concepts of gametogenesis, fertilization and embryogenesis.
- Gain knowledge on interferences in developmental biology.

Learning Outcome:

- Apprise the historical perspectives of Developmental Biology with the basic concepts.
- Understanding of the phases and changes associated with early, late and post-embryonic development

Unit 1: Introduction to Developmental Biology, Gametogenesis & Fertilization

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division. Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy.

Unit 2: Early Embryonic Development

Cleavage: Planes and patterns of cleavage, Types of Blastula, Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers.

Unit 3: Late Embryonic Development

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

Unit 4: Post Embryonic Development & Interferences in Developmental Biology

Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with

one example each); Ageing: Concepts and Theories. Teratogenesis: Teratogenic agents and their effects on embryonic development; In vitro fertilization, Stem cell (ESC), Amniocentesis.

Text Books:

- ✓ *Lewis Wolpert (2010). Principles of Development. II Edition, Oxford University Press.*
- ✓ *Gilbert, S. F. (2017). Developmental Biology, XI Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.*

Suggested Readings:

- ✓ *Carlson, R. F. Patten's Foundations of Embryology.*
- ✓ *Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.*
- ✓ *Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).*

Developmental Biology

Practical:

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 *Drosophila* culture/chick embryo development.
6. Study of developmental stages by raising chick embryo in the laboratory.
7. Estimation of calcium in egg shell.
8. Estimation of carbohydrates and proteins in egg.

PAPER -XV

Taxonomy and Evolutionary Biology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Familiarize learners with concepts of Taxonomy.
- Gain overview of the beginning of life and evolutionary theories.
- Understand various physical forces or stress pressures during evolution.
- Gain knowledge on correlates of epigenetic changes in the cellular footprints of animals and genetic lineages exerted through various physical forces.
- Comprehend the origin of evolution in Hominides with reference to Primates, validate evidence of human origin by molecular and phylogenetic sequence analysis.

Course Outcome:

- Understand concepts of taxonomy. Obtain knowledge of life initiation and its evolution through the chronological landscape.
- Know the evolutionary relationship of organisms with response to various physical forces leading to adaptive evolution.
- Strengthen student's analytical approach to evolutionary relationships.

Learning Outcome:

- Acquisition of knowledge on concepts of taxonomy and species.
- Acquaint learners with theories of evolution, evidences, and the process of changes over time.
- Gain knowledge on construction and interpretation of phylogenetic tree in relation to evolution.

Unit 1: Concepts of Taxonomy

Importance & Applications of biosystematics; taxonomic characters, Hierarchy categories; biological classification; Taxonomic procedures: collections, preservation, curation, identification, Keys; International Code of Zoological Nomenclature (ICZN): operative principles, important rules; Zoological nomenclature; Chemo and sero taxonomy, Cytotaxonomy, Numerical taxonomy, and DNA barcoding. Taxonomic publications: Kinds, Major features of manuscript for publication.

Unit 2: Theories, Evidences of Evolution and Extinction

Life's Beginnings: Chemogeny, RNA world, Biogeny, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse), Sources of variations: Heritable variations and their role in evolution. Extinctions, Background and mass extinctions (causes and effects), detailed example of K-T extinction.

Unit 3: Process of Evolutionary changes

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one

unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection). Genetic Drift (mechanism, founder's effect, bottleneck phenomenon); Role of Migration and Mutation in changing allele frequencies.

Unit 4: Products of evolution, Species concept, Origin and Evolution of man

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation-allopatric, sympatric, Parapatric. Adaptive radiation/ macroevolution (exemplified by Galapagos finches). Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin. Phylogenetic trees, multiple sequence alignment, construction and interpretation of phylogenetic trees.

Text Books:

- ✓ *Principle of Animal Taxonomy; G.G. Simpson. Oxford IBH Publishing Company.*
- ✓ *Elements of Taxonomy. E. Mayer.*
- ✓ *The diversity of life (The College Edition), E.O.Wilson. W.W. Northern & co.*
- ✓ *Theory and Practice of Animal Taxonomy. V.C. Kapoor. Oxford & IBH Publishing Co. Pvt. LTD.*
- ✓ *Advancement in Invertebrate Taxonomy and Biodiversity. Rajeev Gupta. Agrobios International. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.*
- ✓ *Rastogi B.B., (2018). Organic Evolution, MedTech; 3rd edition*

Suggested Readings:

- ✓ *B.K. and Hallgrimson, B. (2008). Evolution IV Edition. Jones and Barlett Publishers.*
- ✓ *Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.*
- ✓ *Ridley, M (2004) Evolution III Edition Blackwell publishing Hall.*

Taxonomy and Evolutionary Biology

Text Books

- ✓ *Principles of Taxonomy by Ashok Verma.*
- ✓ *Evolutionary Biology with Practical by Tripurari Mishra.*

ZOOLOGY -MINOR

Minor (Paper- I)

Semester-I / II

Invertebrates: Protista to Echinodermata

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the general characteristics of non-chordate groups of organisms.
- Acquire knowledge regarding classification of the taxa with examples.
- Develop an understanding of important phenomena associated with each taxon.
- Acquire skills in identifying representative species of groups studied.
- Illustrate phylogenetic distribution of lower groups of Non-chordates.
- Understand elaboration of coelomic evolution and metamerism on Coelomates with their classification up to their class and excretion system in Annelidans.
- Recognize insect vision, respiration and metamorphosis in Arthropoda with reference to Termites and in evolutionary significance of Onychophora with general characteristics.
- Obtain an over view of the general features, respiration, Gastropodan evolution, mechanism of torsion, and significance of larval life stages.
- Acquire knowledge on general characters and classification of Echinoderms and their affinities with Chordates.

Course Outcome:

- Utilize information to understand the differences of the groups studied.
- Develop skills in examining diversity of the taxa.
- Develops skills in elaborating the general features and evolutionary significance of the coelomate from Annelida to Echinoderms.
- Impactful visual understanding and enables the students to correlate the evolutionary significance of each organism on the phylogenetic tree.
- Study on various general features and characteristics of body symmetry and arrangement with various vision types, excretory systems and developmental stage give a strong fundamental understanding on the subject on Coelomates.

Learning Outcome

- Systematically understand the diverse group of organisms from Protista to Cnidaria and Ctenophora
- Systematically understand the diverse group of organisms that make up Phyla Platyhelminthes and Nematelminthes.
- Understand the diverse organisms that make up Phyla from Annelida, Arthropoda and Onychophora.
- Understand the diverse organisms that make up Phyla from Mollusca and Echinodermata and significant processes associated.

Unit 1: Protista to Cnidaria and Minor Phylum Ctenophora

General characteristics and Classification up to classes. Locomotion, Nutrition and Reproduction in Protista, Life cycle and pathogenicity of *Plasmodium vivax*, Canal system and spicules in sponges, Metagenesis in Obelia, Polymorphism in Cnidaria, Corals and coral reefs, Evolutionary significance of Ctenophora.

Unit 2: Platyhelminthes and Nematelminthes

General characteristics and Classification up to classes. Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*, Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*. Parasitic adaptations in helminthes

Unit 3: Annelida, Arthropoda and Onychophora

General characteristics and Classification up to classes. Evolution of coelom and metamerism. Excretion in Annelida, Vision and Respiration in Arthropoda. Metamorphosis in Insects. Social life in bees and termites. Onychophora: General characteristics and Evolutionary significance.

Unit 4: Mollusca and Echinodermata

General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Evolutionary significance of trochophore larva. Water-vascular system in Echinoderms, Larval forms in Echinodermata

TEXT BOOKS

- ✓ *Kotpal RL; Modern Textbook of Zoology – Invertebrates; Rastogi Publications - Meerut; 2016 edition.*
- ✓ *Richard Brusca, W. Moore, Stephen M. Shuster. Invertebrates; OUP USA; 3 edition (19 January 2016).*

SUGGESTED READINGS

- ✓ *Richard Fox, Robert D. Barnes, Edward E. Ruppert, Invertebrate Zoology: A Functional Evolutionary Approach, Brooks/Cole; 7th edition edition 2003*
- ✓ *Barrington, E.J.W. Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.*
- ✓ *Hyman, L.H. Invertebrate Series (Recent edition).*
- ✓ *Parker JJ and WA Haswel Textbook of Zoology. Vol I and II.*
- ✓ *Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.*
- ✓ *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.*

Invertebrates: Protista to Echinodermata

Practical

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*, Binary fission and Conjugation in *Paramecium*.
2. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Euplectella*, *Spongilla*, Spicules and Spongin fibers.
3. Study of Cnidarians *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora.*, *Ctenophore*.
4. Study of Life cycle stages of *Fasciola hepatica*, *Taenia solium* and *Ascaris lumbricoides*
 - i. (Slides/micro-photographs).
5. Study of Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinaria*.
6. Study of Arthropods – Crab, *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx mori*, *Periplaneta americana*, termites, honey bees and *Peripatus*
7. Study of Molluscs and Echinodermata- *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*.
 - i. Echinodermata - *Pentaceros/Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*
8. Study of digestive system, nephridia of earthworm (Virtual), T.S. through pharynx, gizzard, and typhlosolar region of earthworm, Mounting of mouth parts and dissection of digestive system and nervous system (Virtual) of *Periplaneta americana*.
9. To submit a Project Report on any related topic.

Suggested Reading

- ✓ *Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. S Chand Publication.*
- ✓ *S.S Lal. (2019) Practical Zoology (Invertebrate) Rastogi Publications.*

MINOR PAPER II

(SEMESTER III/IV)

Diversity of Chordates: Protochordates to Mammalia

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The students learn about the salient features, diversity and distribution of all Chordates.
- To know the evolution of aquatic, amphibious and terrestrial vertebrates.
- To understand the importance of distribution of vertebrates in different realms.

Course Outcome:

- Understanding the origin, larval forms, distribution and adaptation of different vertebrates.
- Accumulating the knowledge and understanding on the classification, affinities and comparative anatomy of different vertebrates and their evolutionary significance.
- Learning the mechanism of flight and aquatic adaptations in birds and mammals.
- Obtaining knowledge pertaining to the distribution of animals particularly vertebrate in different realms.

Learning Outcome:

- Gain understanding of Protochordates and origin of Chordates.
- Knowledge regarding characteristics and classification of Agnatha, Pisces, Amphibia, and evolution of tetrapoda.
- Understanding characteristics and classification of Reptiles and Aves and their connecting links.
- Comprehend characteristics and organization of mammals, in addition to their distribution in zoogeographical realms.

Unit 1: Protochordates and Origin of Chordates

General characteristics and outline classification Chordata (Protochordata: Hemichordata, Urochordata and Cephalochordata). Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordat; Dipleurula concept and the Echinoderm theory of origin of chordates.

Unit 2: Agnatha, Pisces & Amphibia

General characteristics and classification up to order. Migration, Parental care in fishes, Accessory respiratory organs in Pisces, Evolutionary significance of Dipnoi.

Amphibia: Origin of Tetrapoda (Evolution of terrestrial ectotherms); Parental care.

Unit 3: Reptilia & Aves

General characteristics and classification up to order. Affinities of Sphenodon; Poison apparatus and Biting mechanism in snakes. Archaeopteryx- a connecting link; Flight adaptations and Migration in birds.

Unit 4: Mammals & Zoogeography

General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages. Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.

PRACTICAL

1. Protochordata: *Balanoglossus*, *Herdmania*, *Branchiostoma*, Urochordata, Sections of *Balanoglossus* through proboscis and branchio-genital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slides of *Herdmania* spicules, *Doliolum*, *Salpa*
2. Agnatha: *Petromyzon* and *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*, Salamander.
5. Reptilia: *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Chamaeleon*, *Ophiosaurus*, *Draco*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*, *Zamenis*, *Crocodylus*. Key for Identification of poisonous and non-poisonous snakes
6. Aves: Study of six common birds from different orders. Types of beaks and claws. Study of feathers.
7. Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes*, *Erinaceous*.
8. Power point presentation on study of any two examples representing two different classes.. Submission of report on local species.

Text Books:

- ✓ *Kotpal RL; Modern Textbook of Zoology –Vertebrates; Rastogi Publications - Meerut; 2016 edition*
- ✓ *Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.*
- ✓ *Tiwari SK (2006) Fundamentals of World Zoogeography, Sarup & Sons.*

Suggested Readings:

- ✓ *Pough H. Vertebrate life, VIII Edition, 2007 Pearson International.*
- ✓ *Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jonesand Bartlett Publishers Inc.*
- ✓ *Hickman CP, Roberts LS, Keen S, Larson A, I'AnsonH, Isenhour DJ Integrated Principle of Zoology, 14th edition, 2008, McGrawHill publication.*

MINOR PAPER III
(SEMESTER V/VI)
Microbiology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Knowledge of microbial diversity and classification.
- To understand microbial culture, growth and reproduction.
- To understand the importance of viral pathogenicity, nature of viral transmission.
- To comprehend the importance of Anti-viral drugs and vaccines.

Course Outcome:

- Obtaining knowledge pertaining to future scopes and modern trends of microbiology.
- Understanding the experimental approaches to explore the origin of microbes.
- Understanding the morphology, classification and significance of host-vector relationship.
- Learning the mechanism of action of microbial toxins and pathogenicity.
- Obtaining knowledge on pathogenic manifestation of Oncoviruses & HIV.

Learning Outcome:

- Finding the historical background and modern experimental approaches to understand the origin and development of microbiology.
- Analysing the general features, classification and pathogenicity of Archea and Eubacteria.
- Deducing knowledge on role of microbes in agriculture and healthcare sector.
- Interpreting the mechanism of antibacterial and anti-viral their mode of action, and importance of vaccines.

Unit-1

History and development of microbiology: Biogenesis and abiogenesis, Contribution of Francesco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Robert Koch (germ theory), Edward Jenner and Alexander Fleming's experiments on discovery of Penicillin, Modern trends and future scope of Microbiology.

Unit-2

Microbial systems of classification: General features of Bergey's manual for classification of microbes, Whittaker's five kingdom concept, Carl Woese's 3 domain classification, Lynn Margulis theory of endosymbiotic theory. General features of Archaea: Structure, Nutrition and Reproduction.

General features, pathogenicity of Mycoplasma, Rickettsia and Spirochaetes.

Unit-3

Isolation, culture and maintenance of microorganisms: Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and healthcare industry. Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction).

Unit-4

Virion and viroids: General characteristics and classification of viruses, morphology, nature of viral transmission. Bacteriophage replication, Oncoviruses & HIV: structure, transmission, pathogenicity and replication. Microbial toxins: types, mode of actions and pathogenicity (Exo and Endo-toxin). Antibiotics and their mode of action, Anti-virals and vaccine.

PRACTICAL

1. Study on aseptic techniques in microbiology: various methods of sterilization process.
2. Preparation and formulation of microbial media and methods of inoculation.
3. Methods of isolation of bacteria: spread plate, streak plate, pour plate, serial dilution.
4. Sampling and quantification of microorganisms in air, water and soil.
5. Morphological identification of microorganisms from various habitats through simple staining, differential staining, acid fast staining, spore staining.
6. Methods of microscopic measurements, micrometer (ocular and stage), haemocytometer.
7. Preparation of bacterial growth curve.

MULTIDISCIPLINARY COURSES

(FOR STUDENTS OF OTHER DISCIPLINE/SUBJECTS)

SEMESTER I

VECTOR BORNE DISEASES AND EPIDEMIOLOGY

(3 Credit, Theory- 30h and Practical -30h)

Program Outcomes

- The multidisciplinary programme is incorporated for the students to acquire the knowledge on various vector borne disease and their outbreak.
- The students will learn about role of various insects in causal behaviour towards disease manifestation.
- The target learners will be able to understand the concept of disease outbreak, spread and epidemiology.

Course Outcomes:

- Student will be able to understand the concepts of vector borne disease, vectors and host-vector relationship with specificity and their various modes of transmission.
- Target population will learn the types of insect vectors and disease caused by them.
- Students will be able to gain the knowledge on objectives and core functions of epidemiology.
- Students will gain the in-depth knowledge on epidemiological parameters like communicable and non-communicable disease and about their control measures.

Learning Outcomes:

- Knowledge gain on principles and concepts of vector borne disease.
- Student will be well acquainted with the various types of vectors for causal and spread of disease.
- Learners will be able to disseminate the gained knowledge on epidemiological functions and significant role in public health management system.
- Students will be able to distinguish and initiate control measures towards various types of communicable and non-communicable diseases.

Unit 1: Insects, Concept of Vectors, Insects as Vectors

General Features of Insects, Morphological features, Head – Eyes, Types of antennae, Mouth parts with reference to feeding habits, Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity, Classification of insects up to orders, detailed features of orders with insects as vectors – Diptera, Siphonaptera, Siphunculata, Hemiptera.

Unit 2: Vectors and diseases

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

Unit 3: Epidemiology-an introduction

Definition, Objective and uses and core functions of epidemiology, Epidemiologic approach, Historical evolution of epidemiology, Concept of health and disease, Determinants of health and diseases, Difference between epidemiology and clinical/preventive medicine, Epidemiology as the cornerstone of public

health/health - for example: contribution of Nurses' Health study, British Doctors' study and Framingham Heart Study to public health etc.

Unit 4: Disease types, mode of transmission and management

Difference between infectious and communicable diseases vs. non communicable diseases, Natural history of disease, Chain of infection, Mode and route of transmission of diseases, Meaning of outbreak or epidemic, endemic and pandemic, incubation period, latency period, clinical case, subclinical case, carrier, infectivity, pathogenicity and virulence, theories and principles of causation-epidemiological triad, web of causation, Bradford Hill criteria and Rothman's Causal pies, levels of prevention and modes of intervention.

Text Books

✓ Mathews, G. (2011). *Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases*. Wiley-Blackwell

✓ Chapman, R.F. (1998). *The Insects: Structure and Function*. IV Edition, Cambridge University Press, UK.

Suggested Readings

✓ Mike Service (2012) *Medical Entomology for Students* Cambridge University Press; 5th edition.

✓ Pedigo L.P. (2002). *Entomology and Pest Management*. Prentice Hall Publication

✓ *Understanding the fundamentals of Epidemiology- An evolving text*. Victor Schoenback and Wayne B.Rosamond (2000).

✓ *Modern Epidemiology-* Kenneth Rothman, Sebastien Haneuse , Timothy L. Lash , Tyler J. VanderWeele (2021).

MULTIDISCIPLINARY COURSES

(FOR STUDENTS OF OTHER DISCIPLINE/SUBJECTS)

SEMESTER II

Apiculture

(3 Credit, Theory- 30h and Practical -30h)

Program Outcomes

- Provide knowledge on economic aspects of livestock management.
- Make available information on lucrative facets of animal rearing and goods obtained.
- To familiarize with apiculture features

Course Outcomes

- Foundation through skilled learning for entrepreneurship.
- Acquire skills in developing economically viable ventures using bees.
- To know the basic concepts of beekeeping.
- Discern bee species, understand culture techniques, honey harvesting, and the identification and management of diseases and pests.
- Students will be equipped with practical knowledge that can be immediately applied in the field or even used to start their own beekeeping enterprise

Learning Outcomes

- Gain knowledge of the Biology of Bees, their identification, and social structure.
- Acquire skills in rearing bees and honey extraction.
- Identify pests of bees and their control and eradication.
- Skilled learning for entrepreneurship.

Unit 1:

Biology of Bees: Apis and Non-Apis Bee species and their identification. General Morphology of Apis Honey Bees. Social Organization of Bee Colony.

Unit 2:

Rearing of Bees: Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth box, Bee Pasturage, Selection of Bee Species for Apiculture, Modern Bee Keeping Equipment, Methods of Extraction of Honey (Indigenous and Modern).

Unit 3:

Diseases and Enemies: Bee Diseases and Enemies, Control and Preventive measures

Unit 4:

Bee Economy and Entrepreneurship: Products of Apiculture Industry and their uses- Honey, Bees Wax, Propolis, Pollen. Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens.

MULTIDISCIPLINARY COURSES

(FOR STUDENTS OF OTHER DISCIPLINE/SUBJECTS)

SEMESTER III

Environmental Impact Assessment and Environmental Management Plan (EIA AND EMP) (3 Credit, Theory- 30h and Practical -30h)

Program Outcomes

Program Outcomes

- Understand the basic concept of environmental impact assessment.
- Predict assessment impacts on water, air, soil, and biological components of our environment.
- Design and develop environmental management plan using local examples as case studies.
- Gain knowledge about various pollution act and understand the process of environmental clearance procedure in India.

Course Outcomes

- Identify and accept the need for a sustainable environment.
- Gain comprehensive understanding of mitigation measures.
- The course equips students with the skills to join as EIA trainee.
- Understand Environmental management system and its implementation procedure.

Learning Outcomes

- Gain knowledge about the importance of environmental audit.
- Understand the possible effects on various components of ecosystem.
- Learn the mechanism of approval of projects and core committee constitution.
- Understand the requirement and importance of Environment mitigation plan.

Unit 1

EIA: Objectives, Concept and Scope of EIA , Structure of EIA: Environmental Assessment Process , Environmental attributes-Criteria for the selection of EIA methodology, impact identification, impact measurement, impact interpretation & Evaluation, impact communication, Methods-Adhoc methods, Checklists

methods, Matrices methods, Networks methods, Overlays methods. EIA review- Baseline Conditions -

Construction Stage Impacts, post project impacts.

Unit 2

EIA Analysis: Adhoc method, Overlays, Check list, Matrices, models, comparative studies, Prediction and

Methods of Assessment of Impacts on Various Aspects of Environment; Application of various models for

the Prediction of impact on Air Environment, Water Environment, Noise Environment and Land.

Unit 3

Environmental clearance procedure for industrial and other developmental projects, Environmental

Impact

Statement (EIS), EIA of Air and Water Environment, Case Studies, List of projects requiring Environmental

clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International

agreements.

Unit 4

EMP preparation, Monitoring Environmental Management Plan, Identification of Significant or Unacceptable

Impacts Requiring Mitigation, Mitigation Plans and Relief & Rehabilitation, Stipulating the Conditions,

Monitoring Methods, Pre- Appraisal and Appraisal.

Text Books

✓ *Anjaneyulu. Y and Manickam. V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007*

✓ *Barthwal, R. R., Environmental Impact Assessment, New Age International Publishers, 2002.*

Reference Books

✓ *Jain, R.K., Urban, L.V., Stracy, G.S., Environmental Impact Analysis, Van Nostrand Reinhold Co., New York, 1991.*

✓ *Rau, J.G. and Wooten, D.C., Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1996.*

✓ *Reference Books: 1. Environmental Impact Analysis Handbook – by Rau Whooten; McGraw Hill publications*

✓ *Environmental Impact Assessment – by Larry Canter; McGraw Hill publications*

✓ *Environmental Impact Analysis – A Decision-Making Tool by R K Jain 4. Handbook of Environment Impact Assessment by Judith Petts; McGraw Hill publications*

SKILL ENHANCEMENT COURSES (SEC) UNDER NEP-2020

SEM-II

FERMENTATION TECHNOLOGY AND INDUSTRIAL ENZYMES

(3 Credit, Theory- 30h and Practical -30h)

Unit I

Introduction to fermentation: History and development of fermentation technology, basic requirements of fermentation, Types of fermentations: Aerobic and Anaerobic fermentation, Solid state and Submerged fermentation (Batch, Fed-Batch and continuous system), Upstream and Downstream processing.

Unit II

Isolation and preservation of industrial microorganisms, Controlling mechanism and regulation of catabolic and anabolic processes/pathways in microbial induction, carbon catabolite repression, feedback inhibition. Types of culture medium; Selective media, differential media, industrial media, carbon and nitrogen sources, use of anti-foaming agents.

Unit III

Basic function of fermenter for microbial and animal cell culture, fermenter design (Stirred tank, bubble columns, airlift) and body construction, various parts of fermenter. Biochemical process variables and their measurements; Measurement and control of pH, temperature, dissolved oxygen, aeration and agitation. Online analysis and control of process parameters and biosensors.

Unit IV

Enzymes of industrial applications, enzyme classification and nomenclature, quantification of enzyme activity and specific activity. Kinetics of enzyme catalyzed reaction (steady state kinetics). Industrial production of enzymes; Amylase and Cellulase. Industrial application of Enzyme immobilization (Calcium alginate beads, polyacrylamide beads).

Practical

1. Screening and Identification of industrially important microorganisms from natural habitats through microbial methods i.e. spread plate, streak plate, serial dilution, simple staining, differential staining, acid fast staining and spore staining.
2. Enumeration of starch hydrolyzing and cellulose decomposing bacteria through plate count methods.
3. Production of amylase and cellulase from steady state batch culture fermentation in Erlenmeyer flask.
4. Study on extraction and purification of enzymes (crude enzyme, partially purified enzyme) through ammonium sulphate precipitation, gel/size –exclusion chromatography (demonstration of procedures through pictomicrographs/ slides/presentations).

SKILL ENHANCEMENT COURSES (SEC) UNDER NEP-2020

SEM-V

MOLECULAR DIAGNOSTICS

(3 Credit, Theory- 30h and Practical -30h)

Programme Outcome

- Understanding of disease diagnosis and types of infectious disease.
- To diagnose diseases.
- Knowledge of advanced technology for interpretation of genetic diseases .
- Knowledge of various immunoassays and Immunohistochemistry techniques.

Course Outcome

- Acquisition of skills in disease diagnosis.
- Understanding PCR based molecular diagnosis of bacterial, viral and fungal pathogens.
- Knowledge on application of DNA sequencing and DNA finger printing.

Learning Outcome

- Learner gains knowledge on collection methods and storage of clinical samples for disease diagnosis.
- Acquire skills for detection and quantification of biological parameters for disease identification and diagnosis.
- Molecular diagnosis of pathogens through DNA sequencing, PCR and restriction enzyme based technique.
- Understanding the role of immunohistochemistry in disease diagnosis.

Unit I

Introduction and history of disease diagnosis, mode and type of infectious disease, philosophy and ethics for clinical samples. Various methods of collection, storage and transport/shipping procedures for clinical samples. Diagnosis of infectious disease caused by bacteria, fungi, viruses, protozoa and Helminthes.

Unit II

Biochemical parameters for detection and quantification of clinical samples (i.e. urine, blood, fecal matters, tissue biopsy) for bacterial disease. Detection and quantification of sugars, albumin, urea, protein, globulin and vitamins. Disease identification, genetic test for disorders, population screening for genetic disorder. Treatment and management in genetic diseases.

Unit III

Culture independent analysis of bacteria, PCR based microbial typing, Molecular diagnosis of fungal pathogens. DNA finger printing, Southern blotting and electrophoresis analysis, RAPD and RFLP techniques, DNA sequencing (Sanger). Multiplex-PCR analysis.

Unit IV

Principle and diagnosis techniques of immunoassays: Radio immunoassay (RIA), Enzyme linked immunosorbent assay (ELISA), chemiluminescent immunoassay (CIA), fluorescent antibody test/ immunoassay (FIA). Principle and techniques of Immunohistochemistry. Application of Biosafety cabinets and containment for clinical specimens. Good laboratory practices in handing clinical samples.

Practical

1. Introduction to Biosafety Laboratory (BSL-1 to 4) level for bacteria/ cell culture.
2. Culture and analysis of pathogenic microbes from clinical samples (Refer: BSL-1/2).
3. Preparation of buffer solutions, reagents and culture media.
4. Isolation of chromosomal and plasmid DNA from bacteria.
5. Isolation of genomic DNA from tissue.
6. Spectrophotometric Quantitation of genomic DNA.
7. Gel electrophoresis of DNA and PCR amplification (procedure demonstration through Pict micrograph/ slides/ video lectures)

SKILL ENHANCEMENT COURSES (SEC) UNDER NEP-2020

SEM-VI

VERMITECHNOLOGY

(3 Credit, Theory- 30h and Practical -30h)

Objectives:

1. To introduce the students with the scope and importance of vermitechnology.
2. To introduce the students with different methods of vermicomposting.
3. To introduce the students with the role of vermicomposting.

Outcomes:

1. Students would understand the scope and importance of vermitechnology.
2. Students would get the skill to produce vermicompost.
3. Students would understand the use of vermicomposting and its potential & constant in India

Learning Outcome:

1. Students will learn about the scope and importance of vermitechnology.
2. Students will be able to know different methods of vermicomposting
3. Students will be able to comprehend the role of vermicomposting and its potential

Unit I:

Vermiculture: Definition, scope and importance; Common earthworm species for vermiculture; Environmental parameters; Culture methods-warmery-breeding techniques; monoculture & polyculture

Unit II:

Vermicomposting of wastes in field its, ground heaps, tank method, roof shed method, harvesting the compost, storage, vermiwash-preparation & application

Unit III:

Use of vermicomposting in organic farming; management of solid wastes using vermitechnology; predator/pathogen control in wormeries; potential and constraints for vermiculture in India.

PRACTICALS

1. Isolation of common earthworms species
2. Preparation of culture bed using cow dungs and plant wastes.
3. Culture of vermiworms.
4. Determination of moisture content of vermicompost.
5. Determination of water holding capacity of vermicompost.

Text Books:

✓ Sreenivasan, E. (2014). *Handbook of Vermicomposting Technology. The Western India Plywoods Ltd, Kerala, India.*

Reference book:

✓ Anand, K., & Sinha, P. B. (2020). *Vermitechnology: a solution for agricultural waste. In Innovative Waste Management Technologies for Sustainable Development (pp. 273- 290). IGI Global.*

✓ Walia, S. S., & Kaur, T. (2024). *Vermitechnology: History and Its Applications. In Earthworms and Vermicomposting: Species, Procedures and Crop Application (pp. 37-53). Singapore: Springer Nature Singapore.*

VALUE AIDED COURSES (VAC) UNDER NEP-2020

ENVIRONMENTAL STUDIES AND DISASTER MANAGEMENT

SEMESTER-I

For Under Graduate Compulsory Courses for Arts, Science and Commerce

FULL MARK-100 (Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

- a) Air pollution
- b) Water pollution
- c) Soil pollution
- d) Marine pollution
- e) Noise pollution
- f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

- a) Forest resources: Use and over-exploitation, deforestation, case studies.
Timber extraction, mining, dams and their effects on forest and tribal people.
- b) Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
- c) Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
- d) Food resources : World food problems, changes caused by agriculture and Overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.
- e) Energy resources : Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:-

Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. **Disaster Management:** Types of disasters (natural and Man-made) and their causes and effect)
2. **Vulnerability Assessment and Risk analysis:** Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lightning)
3. **Institutional Framework:** Institutional arrangements for disaster management (National Disaster

Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)

4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre-Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stakeholders participation, Corporate Social Responsibility (CSR)

5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment

(6 Period)

A.

- a) Environmental Ethics: Issues and possible solutions.
- b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
- c) Environment Protection Act
- d) Air(Preservation Control of Pollution) Act
- e) Water(Preservation Control of Pollution) Act
- f) Wildlife Protection Act
- g) Forest Conservation Act
- h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)

B. Human Population and the Environment

Population Ecology: Individuals, species, population, community. Human population growth, population control method Urbanisation and its effect on society

Unit 5: Field work

(15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge ,etc.

VALUE AIDED COURSES (VAC) UNDER NEP-2020

SEMESTER -III

RESEARCH METHODOLOGY

(Credit point: 3 Full mark 100 Total Hours: 45)

COURSE OUTCOME

After completion of this course, students will be able to

- Understand the need and importance of research
- Develop skills to identify samples for various types of research
- Differentiate between different types of research
- Explore relevant literature review using primary and secondary sources
- Acquire proficiency to develop research proposal

COURSE CONTENTS

UNIT-I Introduction To Research Methodology

[12 Hours]

Learning Outcome-

- □ *The students will be able to gain insight about the meaning, purpose and types of research*
- Meaning, Significance, Objectives of research, Research methods v/s research methodology, Ethics for research

Types of research -Pure and applied research, Qualitative and Quantitative research Exploratory, Descriptive, Experimental, Analytical, Action research. Case Study, Field Studies, Surveys. Criteria of good research, Planning of research – Selection of a problem for research, Formulation of selected problem, Hypothesis, Research design.

Unit II Research Methods

[11 Hours]

Learning Outcome-

- *The students will understand various methods of research and their applicability*

Review of Literature – Need for reviewing literature, what to review and for what purpose, Literature search procedure, Sources of literature, Note taking, Identification of Research Gap.

Data Collection Method- Choice of methods for data collection, Observation-Types of observation. Experimentation- Planning and conducting experiment, Types of experiment- Laboratory and field, Interview – Definition, Characteristics and Types of Interviews-Structured, Unstructured, Focused, Clinical, Depth, Interviewing Process-Preparation, Introduction, Developing rapport, Carrying the interview forward, Recording interview and Closing interview. Content Analysis-Meaning, Procedure, Recording units and applications.

Tools for Data Collection- Tools-Observation Schedule, Interview guide, Interview schedule, Questionnaire, Rating Scale, Check List, Opinionnaire, Data Sheet, Schedule for institutions, Inventories.

UNIT-III Sampling Techniques, Field Work and Report Writing

[11 Hours]

Learning Outcome-

- *The students will be able to understand various sampling techniques in research*
- *The students will develop skills of preparing research proposal and writing research report scientifically.*

Sampling- Concept of population and sample, Characteristics of a good sample design. Basis of

sampling, Sampling Techniques and Methods- Probability sampling -Simple Random sampling, Stratified sampling ,Systematic random sampling, Cluster, Area sampling ,Multi-stage sampling. Non-Probability Sampling–Convenience sampling, Purposive sampling, Quota sampling and Snow-ball sampling.

Field Work- Nature of field work, Selection and training of investigators, Sampling frame, Field operations and Field administration.

Report Writing – Research report format- Report outline, Prefatory items. Body of the report- Introduction Design of the study, Result ,Findings and Discussion, Summary, Conclusions and Recommendations, Terminal items- Bibliography ,Appendix , Style sheet- APA .

UNIT-IV Activities to Be Conducted

[11 Hours]

Learning Outcome-

- *Students will gain hands-on experience on application of research methodology*
- ✓ Identify the research gap through the review of literature.
- ✓ Collect data on a researchable topic through schedule questionnaire.
- ✓ Prepare a project report within one thousand words.
- ✓ Visit any organization and prepare a report by using case study method.
- ✓ Prepare a list of references on a topic by following APA style sheet.

Text books

1. C. R Kothari and Garg G, Research Methodology: Methods and Techniques , New Age International Publishers, Pvt ltd , New Delhi.
2. C. R Kothari and Garg G ,Research Methodology: Methods and Techniques , New Age International Publishers .,Pvt ltd , New Delhi
3. O. R Krishnaswami and M .Ranganatham, Methodology of research in Social Sciences. Himalaya Publishing House.

Reference Books:

1. Kumar R , Research Methodology,
2. Education and Communication for Development , O.P Dahama, O.P . Bhatnager.

E-resources:

1. <https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf>
2. <https://ebooks.inflibnet.ac.in/antp13/chapter/research-process-and-design/>

Subject Teacher- Any Teacher with Ph.D.

Sample Question

1. What do you mean by research? [1 mark]
2. Differentiate between fundamental and applied research? [2 mark] [Within 50 words]
3. Explain various steps of research proposal. [5 mark] [within 300 word]
4. Discuss the characteristics of good sampling and briefly explain about various types of probability sampling. [8 mark] [within 500 to 800 words]

VALUE AIDED COURSES (VAC) UNDER NEP-2020

SEMESTER -V

BIODIVERSITY AND CONSERVATION

(Credit point: 3 Full mark 100 Total Hours: 45)

VALUE AIDED COURSES (VAC) UNDER NEP-2020

SEMESTER -VI

FOOD PRESERVATION AND PROCESSING

(Credit point: 3 Full mark - 100 Total Hours: 45)

Food Preservation and Processing

Course Outcome:

- To learn about methods and principles of food preservation.

Learning Outcome:

- Students will gain expertise to establish start up unit on Food preservation and processing. LO2: Students will get knowledge on schemes providing Micro Credit Linkage.
- Students will be acquainting with knowledge of quality Certification of food products.

Unit-I-Methods of Food preservation and Processing:

Concept, Scope and importance of Food Preservation, Classification of food preservatives and additives

Different Methods of Food processing. Packaging, Labelling of processed food products.

Unit –II: Setting up a new start up unit:

Quality certification and branding, Machineries and equipment's required to set up the unit.

Government schemes and micro credit linkage (MKUY and MSME)

Unit-III: Practical:

Preparation and packaging of processed food product- Jam, Jelly, Sauce, Squash, RTS drink, Murraba, Candy, Pickle, Chips, Ragi papad. Field visit to a food processing unit. Report writing and presentation.

Reference Books:

- *Food Processing and Preservation, G. Subhalaxmi, Sobha A UDIP, Padmini S Ghugra, New Age International Publishing.*

SUMMER VOCATIONAL COURSE UNDER NEP – 2020

(Students may choose vocational courses after 2nd Semester and 4th Semester for Certificate Course or Diploma Course respectively with 4 credits each opt for exit)

VOCATIONAL COURSE I (AT END OF ONE ACADEMIC YEAR)

ENVIRONMENTAL CONSERVATION

(4 CREDIT)

SUMMER VOCATIONAL COURSE UNDER NEP – 2020

(Students may choose vocational courses after 2nd Semester and 4th Semester
for Certificate Course or Diploma Course respectively with 4 credits each opt for exit)

VOCATIONAL COURSE II (AT END OF TWO ACADEMIC YEAR)

RECOMBINANT DNA TECHNOLOGY

(4CH)

Community Engagement & Services / Field Work/ Internship

Semester – IV (4 Credits, Contact Hours: 60hrs)

Students have to engage in a **field- based learning/Internship** under the guidance of an external entity in **Semester IV**. The curricular component of ‘community engagement and service’ will involve activities that would expose students to the socio-economic issues in society so that the theoretical learning’s can be supplemented by actual life experiences to generate solutions to real-life problems.

APPENDIX-2

SAMPLE QUESTION SET

UG (NEP) C-I ZOOL -1.1.1 (Non-Chordates I: Protista to Pseudocoelomates) END SEMESTER EXAMINATION (2024 BATCH ONWARDS)

MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I **Marks**

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

- Q 1. a) Muscular swellings or lappets are typical of the larva stage... of *Fasciola hepatica*.

PART-II

(At least two questions from any of the units) [2]

- Q 2. a) Write the unique features of Class Phytomastogophorea?

PART-III

(At least two questions from any of the units) [5]

- Q 3. a) What is the evolutionary significance of Ctenophora?

PART-IV

(At least two questions from any of the units) [8]

- Q 4. a) How are helminths adapted to a parasitic mode of life?

OR

- b) What are the typical features of Nematelminthes?

UG (NEP) C-I ZOOLOGY -2.3.3 (Principles of Ecology)
END SEMESTER EXAMINATION (2024 BATCH
ONWARDS) MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

- Q 1. a) The process by which a plant or animal becomes established in a new habitat is known as__.

PART-II

(At least two questions from any of the units) [2]

- Q 2. a) What are the difference between R and K strategies?

PART-III

(At least two questions from any of the units) [5]

3. a) What do you understand by mode of a data series? State how is it calculated for ungrouped and grouped data? Give a practical situation where you will recommend the use of mode.

PART-IV

(At least two questions from any of the units) [8]

- Q 4. a) Why ecotone is known as the zone of stress? Explain with examples that why the productivity is higher in transitional zones of ecosystem

OR

- b) Define survivorship curve. Describe the three general types of survivorship curves with examples. How is the survivorship curve used?

**UG (NEP) C-I ZOOL -2.4.1 (Physiology I)
END SEMESTER EXAMINATION (2024 BATCH
ONWARDS) MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

1. a) G proteins are made up of----- subunits.

PART-II

(At least two questions from any of the units) [2]

- Q 2. a) Differentiate between G-actin and F- actin.

PART-III

(At least two questions from any of the units) [5]

- Q 3. a) Why are skeletal muscle fibers fast contracting?

PART-IV

(At least two questions from any of the units) [8]

- Q 4. a) Explain the four steps of cross-bridge cycle and add a note on ATP generation pathway in a skeletal muscle.

OR

- b) How does the stimulus pass through synaptic cleft? List the main events.

UG (NEP) C-I ZOOL -2.3.2 (Cell Biology)
END SEMESTER EXAMINATION (2024 BATCH
ONWARDS) MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) Microtubules are made up of long hollow cylinder of protein components known as _____.

PART-II

(At least two questions from any of the units) **[2]**

- Q 2. a) What do you mean by semi-autonomous nature of mitochondria?

PART-III

(At least two questions from any of the units) **[5]**

- Q 3. a) Describe how GTP hydrolysis destabilizes microtubule polymerization.

PART-IV

(At least two questions from any of the units) **[8]**

- Q 4. a) Describe the structure of nuclear envelope proteins and its function in cell division.

OR

- b) Describe the various models of plasma membrane structure in brief.

UG (NEP) C-I ZOOL -1.2.1 (Chordates)
END SEMESTER EXAMINATION (2024 BATCH
ONWARDS) MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

- Q 1. a) There are two main groups of fish, namely _____ and _____ based on the composition of the endoskeleton.

PART-II

(At least two questions from any of the units) [2]

- Q 2. a) Specify the environmental factors might have led to the evolution of the tetrapod limb?

PART-III

(At least two questions from any of the units) [5]

- Q 3. a) What is the difference between the continental drift hypothesis and the plate tectonics theory?

PART-IV

(At least two questions from any of the units) [8]

- Q 4. a) Write in brief the significance of larval forms of protochordates in phylogenetic studies of Chordates ?

OR

What is retrogressive metamorphosis? Describe in detail retrogressive metamorphosis in Herdmania.

**UG (NEP) C-I ZOOLOGY -2.5.1 (Comparative anatomy of
Vertebrates) END SEMESTER EXAMINATION (2024
BATCH ONWARDS)
MODEL QUESTION PATTERN**

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) Surface of palm, soles, fingers and toes present with series of grooves and ridges for exhibiting friction, grips and traction are known as ____.

PART-II

(At least two questions from any of the units) **[2]**

- Q 2. a) How many air sacs are present in avian respiratory system?

PART-III

(At least two questions from any of the units) **[5]**

- Q 3. a) Compare pronephrous and mesonephrous kidney system in vertebrates.

PART-IV

(At least two questions from any of the units) **[8]**

- Q 4. a) Give an elaborative description of epidermal derivatives of skin in vertebrates.

OR

What Give a comparative account of general plan of brain development in vertebrates.

UG (NEP) C-I ZOOL -2.5.2 (Physiology-II)
END SEMESTER EXAMINATION (2024 BATCH ONWARDS)
MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

(One mark each in the form of fill in the blanks/one word answer covering all units) [1]

- Q 1. a) The fraction of blood composed of packed red blood cells achieved using centrifugation is known as _____.

PART-II

(At least two questions from any of the units) [2]

- Q 2. a) Name the ions responsible for inhibition of trypsin secretion in pancreas.

PART-III

(At least two questions from any of the units) [5]

- Q 3. a) What is van't Hoff's law? Explain the osmolarity and osmotic pressure of a solution.

PART-IV

(At least two questions from any of the units) [8]

- Q 4. a) Explain in brief, the transport of oxygen and exchange of carbon dioxide in blood.

OR

What State Frank-Starling law of heart and blood flow.

UG (NEP) C-I ZOOL -2.3.1 (Microbiology)
END SEMESTER EXAMINATION (2024 BATCH ONWARDS)
MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units)

[1]

- Q 1. a) Entry of enveloped viruses into host cells is mediated by membrane fusion and

PART-II

(At least two questions from any of the units)

[2]

- Q 2. a) What are the major differences between transformation and transduction?

PART-III

(At least two questions from any of the units)

[5]

- Q 3. a) Explain the role of microbes in health care and agriculture with suitable examples.

PART-IV

(At least two questions from any of the units)

[8]

- Q 4. a) Explain the different types of microbial toxins and their mode of action.

OR

- a) Explain the significant features of Bergey's manual for the classification of microbes.

UG (NEP) C-I ZOOL -2.6.1 (Molecular Biology)

END SEMESTER EXAMINATION (2024 BATCH ONWARDS) MODEL QUESTION PATTERN

The figures in the right-hand margin indicate Marks.

FULL MARKS: 50

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units)

[1]

Q 1. a) What is the main enzyme that plays a major role in formation of thymine dimer?

PART-II

(At least two questions from any of the units)

[2]

Q 2. a) Differentiate between B DNA and Z DNA?

PART-III

[5]

Q 3. a)

termination in prokaryotes.

PART-IV

(At least two questions from any of the units)

[8]

Q 4. a) Discuss the mechanism of gene regulation in Tryptophan Operon.

OR

a) Explain the sequence of events during DNA replication in eukaryotes and explain the role of various enzymes.

ULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units)

[1]

Q 1. a) Grave's disease is associated with

PART-II

(At least two questions from any of the units)

[2]

Q 2. a) How is polyspermy prevented?

PART-III

(At least two questions from any of the units)

[5]

Q 3. a) Discuss the techniques for assisted reproduction.

PART-IV

(At least two questions from any of the units)

[8]

- Q 4. a) Explain the Hypothalamo-hypophysial Axis with reference to feedback regulation of hormones.

OR

- a) Explain the molecular mechanism of hormone action with reference to non-steroidal hormones.

UG (NEP) C-I ZOOL -2.5.3 (Fundamentals of Biochemistry)

END SEMESTER EXAMINATION (2024 BATCH ONWARDS)

MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units)

[1]

- Q 1. a) What is the total number of ATP molecules produced from ADP by glycolysis of one glucose molecule?

PART-II

(At least two questions from any of the units)

[2]

- Q 2. a) Differentiate between Glycogenolysis and Glycogenesis?

PART-III

(At least two questions from any of the units)

[5]

- Q 3. a) Explain the Inhibitors and un-couplers of the Electron Transport System.

PART-IV

(At least two questions from any of the units)

[8]

- Q 4. a) Give an account of β – the oxidation of saturated, even carbon fatty acid, along with its energetics and regulation.

OR

- a) Explain the process and purpose of ketogenesis.

UG (NEP) C-I ZOOL -2.4.2 (Fundamentals of Biochemistry)
END SEMESTER EXAMINATION (2024 BATCH ONWARDS)

MODEL QUESTION PATTERN

FULL MARKS: 50

The figures in the right-hand margin indicate Marks.

- | | PART-I | Marks |
|------|---|--------------|
| | (One mark each in the form of fill in the blanks/one word answer covering all units) | [1] |
| Q 1. | a) Individual monosaccharides are linked byto form polysaccharides | |
| | PART-II | |
| | (At least two questions from any of the units) | [2] |
| Q 2. | a) What are nucleosides and nucleotides? | |
| | PART-III | |
| | (At least two questions from any of the units) | [5] |
| Q 3. | a) Explain the mechanism of enzyme action. | |
| | PART-IV | |
| | (At least two questions from any of the units) | [8] |
| Q 4. | a) Explain the basic structure of Immunoglobulins. Discuss their classes and functions. | |

OR

- a) Explain the structure and types of DNA.

UG (NEP) C-I ZOOL -2.5.4 (Principles of Genetics)

END SEMESTER EXAMINATION (2024 BATCH ONWARDS) MODEL QUESTION

PATTERN

The figures in the right-hand margin indicate Marks. FULL MARKS: 50

PART-I

Marks

(One mark each in the form of fill in the blanks/one word answer covering all units) **[1]**

- Q 1. a) In case of two gene interaction, the gene which is masking the expression of another is called _____ and the gene whose expression is masked is called _____

PART-II

(At least two questions from any of the units) **[2]**

- Q 2. a) Differentiate between back cross and test cross?

PART-III

(At least two questions from any of the units) **[5]**

- Q 3. a) Explain the types of chromosomal aberrations.

PART-IV

(At least two questions from any of the units) **[8]**

- Q4. A. Give an account of chromosomal mechanisms of sex determination in *Drosophila*.

OR

- a. Explain the process of Linkage and crossing over.