

Jananayak Chandrashekhar Vishwavidyalaya, Ballia

M. Sc. Zoology Syllabus

(w.e.f. 2022-23)

Programme Name: M.Sc. (Zoology) Programme Code: PG Zool 100

INTRODUCTION:

The term Zoology is derived from ancient Greek *zōion*, meaning animal, and *logos*, meaning knowledge or study. It is the branch of biology that studies the animal kingdom, including the structure, embryology, evolution, classification, habits, and distribution of animals. The formal study of Zoology can be said to have originated with Aristotle who studied the structure and development of animals. However, modern Zoology has its origin with the studies of Carl Linnaeus, Antonie van Leeuwenhoek, Robert Hooke, Charles Darwin, Gregor Mendel and many others. However, with the march of science, the study of animals has largely moved on to deal with adaptations, relationships between groups, behavior and ecology, physiology and biochemistry, cytology, genetics and molecular biology, etc.

PROGRAM OUTCOMES:

After studying M.Sc. in Zoology Program, the students will acquire a deeper understanding of:

- Animal biodiversity and the basic features of their distribution through different taxonomic categories.
- The architecture and structure of living beings at morphological, anatomical, histological and cellular levels.
- The mechanism of the functioning of life at physiological, biochemical, genetic and molecular levels.
- The mechanism and patterns of embryonic development of animals.
- The applied aspects of the subject, like Fisheries, Entomology or cytological techniques.

Programme Structure: The programme structure of post-graduation in Zoology is as follows:

- The post-graduation programme in Zoology of this University will comprise of four semesters.
- Every semester will have 5 (4 theory and 1 practical) papers of 4 credits each.
- In 1st or 2nd semester, the student will have to opt for a **minor elective paper** of 4/5 credits from a faculty other than his main faculty.
- In every semester, the student has to do a **research project** of 4 credits (thus, a total of 16 credits in 4 semesters) under the supervision of a supervisor as nominated by the head of the department.
- There may be a co-supervisor also from any industry, company, technical or research institute.
- These projects may be inter-disciplinary or multi-disciplinary and may be in the form of research project/industrial training/internship/survey work etc.
- The reports of the projects carried out in 1st and 2nd semesters will be compiled together and submitted in the form of one PROJECT REPORT/DISSERTATION at the end of first year. It will be evaluated out of 100 marks (8 credits) at the end of the first year jointly by the supervisor and the external examiner appointed by the University.
- Similarly, the reports of the projects carried out in 3rd and 4th semesters will also be compiled together and submitted in the form of another PROJECT REPORT/DISSERTATION at the end

of the second year. It will also be evaluated out of 100 marks (8 credits) at the end of the second year jointly by the supervisor and the external examiner appointed by the University.

- If a student publishes a research paper out of his research project in a UGC-CARE listed journal, he may be given up to 25 additional marks, provided the maximum marks of the project will remain 100. The marks of the research projects will be converted into grades that will be incorporated in the final calculation of CGPA too. The final result of M.Sc. (Zoology) programme will be declared on the basis of CGPA.
- The courses to be taught in these semesters are given below:

M. Sc. Previous I- Semester

SN	Paper	Name of Paper	Course code	Teaching Hours	Credit	Marks
1	I Paper	Comparative study of Lower non-chordates	(PG Zool 101)	60	4	100
2	II Paper	Biostatistics, Biosystematics and Bioinstrumentation	(PG Zool 102)	60	4	100
3	III Paper	Environmental Biology and Bioinformatics	(PG Zool 103)	60	4	100
4	IV Paper	Biochemistry	(PG Zool 104)	60	4	100
5	V Paper	Lab work	(PG Zool-P 105)	120	4	100
6	Project 1			120	4	(To be evaluated at the end of 2 nd Sem.)
			TOTAL	480	24	500

II- Semester

SN	Paper	Name of Paper	Course code	Teaching Hours	Credit	Marks
1	I Paper	Comparative study of Higher non- chordates	(PG Zool 201)	60	4	100
2	II Paper	Animal Physiology	(PG Zool 202)	60	4	100
3	III Paper	Cytology and Genetics	(PG Zool 203)	60	4	100
4	IV Paper	Molecular Biology	(PG Zool 204)	60	4	100
5	V Paper	Lab work	(PG Zool-P 205)	120	4	100
6	Project 2			120	4	(Project1+ Project2 in the form of Dissertation) 100
			TOTAL	480	24	600

7	One Minor Elective subject from other faculty In 1st or 2nd Semester			60	4/5	100
			Sub Grand Total of M.Sc. Previous	1020	52/53	1200

M. Sc. FINAL

III- Semester

NOTE: Papers I, II, and III are compulsory. The student has to opt for one paper only from IVA, IVB, and IVC. In the V paper (Lab Work), part A is compulsory for all, but in the part B, the student will opt only for A, B or C according to the optional paper in paper IV.

SN	Paper	Name of Paper	Course code	Teaching Hours	Credit	Marks
1	I Paper	Comparative study Proto-chordates and Lower-vertebrates	(PG Zool 301)	60	4	100
2	II Paper	Development Biology	(PG Zool 302)	60	4	100
3	III Paper	Endocrinology	(PG Zool 303)	60	4	100
STREAM A: FISH						
4	IV A Paper	FISH: Taxonomy and Morphology	(PG Zool 304A)	60	4	100
OR STREAM B: ENTOMOLOGY						
4	IV B Paper	ENTOMOLOGY: Morphology, Physiology, Development and Ecology	(PG Zool 304B)	60	4	100
OR STREAM C: CELL BIOLOGY						
4	IV C Paper	CELL BIOLOGY – Cytological Techniques	(PG Zool 304C)	60	4	100
5	V Paper	Lab work Part- A. (General) Part- B. (Optional)	(PG Zool-P 305) (PG Zool-P 305 A/B/C)	60 60	4	100
6	Project 3			120	4	(To be evaluated at the end of 4th Sem.)
			TOTAL	480	24	500

IV- Semester

NOTE: Papers I and II are compulsory. The student has to opt for only one stream from stream A, Stream B and Stream C for their third and fourth papers. In the V paper (Lab Work), part A is compulsory for all, but in the part B, the student will opt only for A, B or C according to their optional stream for papers III and IV.

SN	Paper	Name of Paper	Course code	Teaching Hours	Credits	Marks
1	I Paper	Comparative study of Higher- Vertebrates	(PG Zool 401)	60	4	100
2	II Paper	Animal Behavior	(PG Zool 402)	60	4	100
STREAM A: FISH						
3	III A Paper	FISH: Applied Ichthyology and Development	(PG Zool 403A)	60	4	100
4	IV A Paper	FISH: Physiology and Ecology	(PG Zool 404A)	60	4	100
OR STREAM B: ENTOMOLOGY						
3	III B Paper	ENTOMOLOGY- Evolution and Taxonomy	(PG Zool 403B)	60	4	100
4	IV B Paper	ENTOMOLOGY- Economic Entomology	(PG Zool 404B)	60	4	100
OR STREAM C: CELL BIOLOGY						
3	III C Paper	CELL BIOLOGY - Ultrastructure and Morphodynamics of cell	(PG Zool 403C)	60	4	100
4	IV C Paper	CELL BIOLOGY- Cell Regulation and Principles of Biotechnology	(PG Zool 404C)	60	4	100
5	V Paper	Lab work Part- A. (General)	(PG Zool-P 405)	60	2	50
		Part- B. (Optional)	(PG Zool-P 405 A/B/C)	60	2	50
6	Project 4			120	4	(Project3 + Project 4 in the form of Dissertation) 100
			TOTAL	480	24	600
			Sub Grand Total of M.Sc. Final	960	48/49	1100
			GRAND TOTAL	1980	100/101	2300

M. Sc. (Zoology)**I- Semester****Course Name: (Paper I) – Comparative study of Lower non-chordates (Credits 4)**

Course Outcomes: After studying this course, the students will be able to-

1. Learn an idea about certain specific features of different animals of lower non-chordate phyla: Protozoa - Aschelminthes
2. Understand the evolutionary aspects of animals through the growing hierarchy of phyla.
3. Appreciate the significance of lower non-chordates in the economy and health issues of people.

Unit 1: Protozoa**1 credit**

- i. General characters and Classification
- ii. Osmoregulation- Contractile vacuoles and mechanism of osmoregulation,
- iii. Locomotion- Locomotor organelles and methods of locomotion
- iv. Nutrition- Holozoic, Holophytic, Saprozoic and Myxotrophic nutrition
- v. Reproduction- Asexual and sexual
- vi. Protozoa and Diseases

Unit 2: Porifera**1 Credit**

- i. General characters and Classification
- ii. Phylogenetic origin and evolution of Metazoa.
- iii. Cellular Organization- Pinacoderm, Choanoderm, Mesenchyme
- iv. Skeleton- Spicules and spongin
- v. Reproduction- Asexual and Sexual
- vi. Canal System- Types and functions of canal system

Unit 3: Coelenterata and Ctenophora**1 Credit**

- i. General characters and Classification
- ii. Polymorphism- Basic forms and patterns. Importance of polymorphism
- iii. Reproduction in Coelenterates: Colony formation and Metagenesis
- iv. Coral Reefs
- v. General Organization and affinities of Ctenophora

Unit 4: Platyhelminthes and Aschelminthes**1 Credit**

- i. General characters and Classification
- ii. Parasitism in Platyhelminthes and Aschelminthes,
- iii. Parasitic adaptations in Trematodes and Cestodes- Morphological and physiological adaptations
- iv. Larval stages of Trematodes and Cestodes
- v. General organization and affinities of Rotifers

Assignments:

1. Reproductive strategies in Protozoans

2. Significance of canal system in Porifera.
3. Importance of coral and effect of pollution on corals
4. Helminths: diseases and their treatment.

Suggested Readings:

1. Brusca, R.C. and Brusca, G. J. (2003). Invertebrates. Sinauer Associates, Sunderland, Massachusetts
2. Jenet Moore., (2006). An Introduction to the invertebrates. (2nd Ed.). Cambridge University Press.
3. Jordan, E. L. and Verma, P. S. (2009). Invertebrate Zoology. S Chand Publications
4. Kotpal, R. L. Modern Textbook of Zoology- Invertebrates. (12th Ed.), Rastogi Publication.
5. Richard Fox, Robert D. Barnes, Edward E. Ruppert (2006). Invertebrate Zoology: A Functional Evolutionary Approach. 7th Ed. Brooks/Cole
6. T Jeffery Parker, William A Haswell (2011). A Text-Book of Zoology. Nabu Press

Course name: (Paper II) - Biostatistics, Biosystematics and Bioinstrumentation (Credits 4)

Course Outcomes: After studying this course, the students will be able to-

1. Learn the basics of biostatistics and biosystematics.
2. Understand certain biological techniques and microscopy.
3. Learn the applications of tools and techniques in biological studies.

Unit 1: Biostatistics

1 Credit

- (i) Levels of Measurement (nominal data, ordinal data, interval data, and ratio data)
- (ii) Measures of central tendencies (Mean, Median, Mode),
- (iii) Measures of Variability (Standard deviation, Variance and Standard error)
- (iv) Analysis of Variance: one way and two way ANOVA, Multivariate ANOVA

Unit 2: Biosystematics

1 Credit

- (i) Speciation- Types and mechanism of speciation
- (ii) Species Concept- Species category and different species concept,
- (iii) Theories of Biological Classification.

Unit 3: Biological Techniques

1 Credit

- (i) Principles of Colorimetry and Spectrophotometry- Lambert Beer Law,
- (ii) Centrifugation- Principles and technique,
- (iii) Chromatography- Principles, types and applications

(iv) Electrophoresis- Principles, agarose and polyacrylamide gel electrophoresis, 2D electrophoresis and their applications, Western and Southern Blotting.

Unit 4: Microscopy

1 Credit

- (i) Basic principles of microscopy and their applications
- (ii) Types of objectives lenses, numerical aperture, limit of resolution, resolving powers of different microscopes
- (iv) Phase contrast microscope, Fluorescence Microscope
- (v) Electron microscope: SEM & TEM
- (vi) Confocal microscope

Assignments:

1. Describe different patterns of classification
2. Describe the principles of centrifugation and chromatography.
3. Explain the principle and construction of phase contrast microscopy.
4. Give an account of principles and construction of electron microscope
5. What do mean by electrophoresis? Explain its different types.

Suggested Readings

1. Boyer, Rodney F. (2012). Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition. Pearson.
2. Gupta S.P, (2005), Statistical Methods, Sultan Chand & Sons, New Delhi.
3. Kapoor, V.C. (2019). Theory and Practice of Animal Taxonomy and Biodiversity. 8thEd. Oxford&Ibh.
4. Mahajan, B. K. (2018). Methods in Biostatistics for Medical Students and Research Worker. (9th Ed.) Jaypee Brothers Medical Publishers.
5. Motulsky, H. (2015). Essential biostatistics: a nonmathematical approach. Oxford University Press.
6. P.S.S. Sundar Rao, P.H. Richard, J. Richard, (2003), An Introduction to Bio-statistics, Prentice Hall of India (P) Ltd., New Delhi.
7. Simpson, G. G. (1961). Principles of Animal Taxonomy. In: Columbia Biological Series Columbia University Press.
8. Terence Allen, (2015). Microscopy: A Very Short Introduction. Oxford University Press
9. Wilson and Walkers. (2018). Principles and Techniques of Biochemistry and Molecular Biology. 8thed. Cambridge University Press.

Course name: (Paper III) Environmental Biology and Bioinformatics (Credits 4)

Course Outcomes: After studying this course, the students will be able to-

1. Learn an idea about the basics of ecology such as population and their interaction.
2. Understand ecosystems and their features,
3. Know the effects of environmental pollutions and significance of biodiversity.

Unit 1: Ecosystem**Credit 1**

- i. Introduction to ecology, Habitat and Niche
- ii. Ecosystem, Productivity, Carrying Capacity, Food chain and food web, Energy flow through ecosystems.
- iii. Biogeochemical cycles
- iv. Biomes

Unit 2: Population Ecology & Community**Credit 1**

- i. Population: Concept, Characteristics and Growth
- ii. Population dynamics; r and k selection.
- iii. Ecological interactions (Mutualism, Protocooperation, Commensalism, Predation, Parasitism, Amensalism, Competition)
- iv. Community structure and its attributes; Levels of species diversity, edge and ecotone.

Unit 3: Environment**Credit 1**

- i. Environmental pollution: air, water, soil, microbial, noise and thermal pollutions
- ii. Global warming & Climate change, Acid rain, Ozone layer depletion
- iii. Environmental contaminants- their uptake and biotransformation, biomagnification
- iv. Bio-indicators and Biomarkers, Environmental monitoring/auditing
- v. Biodiversity- Assessment, conservation and management of biodiversity

Unit 4: Bioinformatics**Credit 1**

- i. Computer applications: MS-Office- Word, Excel, Power point presentation, precautions and safety measures.
- ii. Introduction and scope of Bioinformatics; Data archiving systems: FASTA format, Accession and GI-Number, Databases: NCBI, PDB, KEGG, and PubMed.
- iii. Concept of homology: BLAST, Clustal-W and their applications; Protein structural visualization tools.

Assignments:

1. What are the characteristics of population?
2. Differentiate between intra-specific and inter-specific competition.
3. Give an account of different biogeochemical cycles.
4. Writes short notes on-
 - a. Global warming
 - b. Pollution
 - c. Bio-indicators and bio-markers
 - d. Biodiversity

Suggested Readings:

1. Odum E.P. and Barrett, G W (2005). Fundamentals of Ecology (5th Edition). Thomson.
2. Singh, J.S. Gupta S. R. & Singh, S. P. (2015). Ecology Environmental Science and Conservation. S. Chand Publishing.
3. Thakur, A (2008). Environmental Biotechnology: Basic Concepts and Applications.
4. Wang, L.K., Ivanov, V., Tay, J.H and Hung, Y.T. (2010). Environmental Biotechnology.

Course name: Paper IV – Biochemistry (Credits 4)

Course Outcomes: After studying this course, the students will be able to-

1. Learn the concept of thermodynamics.
2. Understand the working of Enzymes, and metabolism of certain biomolecules such as carbohydrates, lipids and vitamins.
3. Students will also understand the basics of cancer biology and aging.

Unit 1: Bioenergetics**Credit 1**

- i. Elementary thermodynamics- First law and second law of thermodynamics
- ii. Cell as an open thermodynamic system
- iii. Calculation of free energy change during biological oxidation-reduction reactions

Unit2: Enzymes**Credit 1**

- i. Mechanism of enzyme action, Activation energy
- ii. Kinetics of enzyme action,
- iii. Enzyme inhibition- Competitive and non-competitive inhibitors, Lineweaver- Burk curve and its significance in prediction of type of inhibition,
- iv. Allosteric enzymes

Unit 3: Biomolecules & Metabolic Pathways Credit 1

- i. Carbohydrates- Classification, structure, general properties and biological significance
- ii. Lipids- Classification, structure, general properties and biological significance
- iii. Proteins structure and function, Isoelectric point, Sequencing of proteins: Sanger and Edman methods
- iv. Metabolic pathways- Glycogenesis and Glycogenolysis, Gluconeogenesis, HMP shunt, Oxidative phosphorylation, Beta oxidation of fatty acids, Nucleotide metabolism.

Unit 4:**Credit 1**

- (i) Classification and significance of Vitamins,
- (ii) Biology of Cancer- Neoplasia, Metastasis, Phases of cancer, Oncogenes and carcinogens
- (iii) Biology of Ageing

Assignments:

1. Describe the second law thermodynamics
2. What do mean by 'Cell as an Open Thermodynamic system'
3. Give an account of mechanism of enzyme action.
4. Derive the Michaelis-Menten Equation.
5. What do understand by enzyme inhibition? Describe Line-weaver Burk Curve.
6. Describe HMP shunt.
7. Write an essay on Biology of Cancer.
8. Describe different theories of aging.

Suggested Readings:

1. Bruce Alberts et al., (2008). Molecular Biology of the Cell, (5th Ed). Garland
2. Lehninger. A. L. (2013). Principles of Biochemistry (6thed.). New York, NY: Worth.
3. Stryer, L. (2006). Biochemistry (6th Edition). New York: Freeman.
4. Voet, D., & Voet, J. G. (2010). Biochemistry (4thed.). Hoboken, NJ: J. Wiley & Sons.

Course name: (Paper V) Lab Work Credit 4

Distribution of marks:

Particulars	Marks
Major Dissection-	20
Preparation-	10
Spotting (10) -	20
Environmental Biology exercise-	10
Biochemistry exercise-	15
Biostatistics exercise-	10
Bioinformatics	05
Class record, collection and viva	10
TOTAL	100

Major Dissections: Dissection of circulatory system and reproductive system of earthworm, Digestive system and Reproductive system of leech and other available lower non-chordates.

Preparations: Slide preparation of Euglena and Paramecium, sponge gemmules, Obelia colony and other available materials from lower non-chordates.

Museum study: General survey and classification of lower non-chordates

Protozoa: Prepared slides of Paramecium (conjugation and binary fission), Euglena, Vorticella, Ceratium, Noctiluca.

Porifera: Museums of Euplectella, Spongilla, Euspongia Prepared slides of T.S. Sycon, L.S. Sycon, Spicules of sponges.

Coelenterata- Museums of Physalia, Corralium, Madrepora, Fungia, Pennatula, Metridium, Vellela, Porpita, Tubipora, Gorgonia, Prepared slides of Hydra, Obelia,

Helminths- Museums of Taeniasolium, Cysticercus larva of Taeniasolium, Schistosoma, Ascaris male, Ascaris female, Ancylostoma,

Prepared slides- Miracidium larva, Redia larva, Cercaria larva, Scolex of Taeniasolium, Mature proglottid and gravid proglottid of T. solium, T.S of Mature proglottid and gravid proglottid of T. solium, T.S. through body of male Ascaris, T.S. through body of female Ascaris.

Environmental Biology exercise: Study of different structural adaptations to ecological conditions
Study of micro and macro fauna of soil by froth-floatation method

Comparative study of physico-chemical eco-factors in different localities: temperature, pH,
Estimation of CO₂, O₂, carbonate in freshwater,
Study of plankton in a water body
Study of biological effects of certain pollutants.

Biochemistry exercise: Chromatographic separation of amino acids
Isolation and colorimetric determination of glycogen in animal tissues.
Kinetic assay of salivary amylase and study of the effects of time and temperature on urease activity
Biostatistics exercise: Experiments on probability, probability, t-test, Chi square test
Sampling of data for frequency diagram and calculation of mean, median and mode and standard Deviation, Anova.

Bioinformatics: Hands on Bioinformatics databases and tools

M. Sc. (Zoology)**II Semester**

Course name and code: (Paper I): Comparative Study of Higher Non-chordates Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn a comparative understanding about certain phylum-specific features among different animals of higher non-chordate phyla.
2. Understand the evolutionary aspects of higher non-chordates through the growing hierarchy of phyla.
3. Appreciate the significance of higher non-chordates in the economy and health issues of people.

Unit 1- Annelida:**Credit 1**

- i. General characters and Classification
- ii. Segmental organs,
- iii. Filter feeding.
- iv. Adaptive radiation in Polychaetes,
- v. Coelom and Metamerism.

Unit 2- Arthropoda:**Credit 1**

- i. General characters and Classification
- ii. Larval forms of Crustacea,
- iii. Parasitism in Crustacea,
- iv. Respiration in Arthropods,
- v. General characteristics, Organization and Affinities of Onychophora.

Unit 3- Mollusca:**Credit 1**

- i. General characters and Classification
- ii. Respiration,
- iii. Nervous system,
- iv. Torsion and detorsion in Gastropods.

Unit 4- Echinodermata:**Credit 1**

- i. General characters and Classification
- ii. Water vascular system,
- iii. Larval forms of Echinodermata
- iv. Affinities of Echinodermata

Assignments:

- i. Structure of nervous system in Pila and Unio.
- ii. Structure of water vascular system in echinoderms
- iii. Larval forms of Crustacea
- iv. Torsion in Mollusca





- v. General Organization of Onychophora
- vi. Larval forms of Echinodermata

Suggested Readings:

1. Brusca, R.C. and Brusca, G. J. (2003). Invertebrates. Sinauer Associates, Sunderland, Massachusetts.
2. Jenet Moore., (2006). An Introduction to the invertebrates. (2nd Ed.). Cambridge University Press.
3. Jordan, E. L. and Verma, P. S. Invertebrate Zoology. S Chand Publications
4. Kotpal, R. L. Modern Textbook of Zoology- Invertebrates. (12th Ed.), Rastogi Publication.
5. Parker & Haswell. Invertebrates, Invertebrates series- Protozoa – Echinodermata,
6. Richard Fox, Robert D. Barnes, Edward E. Ruppert. Invertebrate Zoology: A Functional Evolutionary Approach. 7th Ed. Brooks/Cole.
7. T Jeffery Parker, William A Haswell (2011). A Text-Book of Zoology. Nabu Press

Course name: (Paper II) Animal Physiology

Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn about the physiology of digestion, excretion and circulation.
2. Understand the nervous system and neuronal conduction and physiology of muscle contraction.
3. Additionally, this paper will also help students to understand the basics of immunity, antigens and antibody.

Unit 1-

Credit 1

- i. **Physiology of Digestion:** Digestion and Absorption of Proteins, Carbohydrates and lipids.
- ii. **Physiology of Respiration:** Gaseous exchange in terrestrial and aquatic animals, Respiratory pigments.

Unit 2

Credit 1

- i. **Physiology of Circulation:** Patterns of Circulation among different animals, Physiological categories of Heart, Haemodynamics.
- ii. **Physiology of Excretion:** Excretory products, Biosynthesis of Urea, Structure and functional mechanism of nephron.
- iii. **Concept of Homeostasis**

Unit 3

Credit 1

- i. **Physiology of Nerve Conduction:** Structure of neurons, Ionic basis of resting and Action potential, Synaptic transmission at molecular levels;

ii. **Physiology of Muscle Contraction:** Structure of skeletal muscle, Mechanism of Muscle Contraction

iii. **Physiology of Reproduction:** Male and female reproductive system of mammals

iv. **Sense organs:** Stato-acoustic system, Touch receptor, Thermoreceptor

Unit 4- Credit 1

i. **Physiology of Defense:** Innate and adaptive immunity, Types of Immune response, cells and organs of immune system.

ii. Antigens and antibodies, their interaction, generation of antibody diversity.

iii. Complement system. Vaccines: active and passive immunization, and types of vaccines.

Assignment:

1. Anatomy of alimentary canal
2. Circulatory system of human
3. Structure of neuron
4. Neuronal Synapse
5. Structure of antibody
6. Structure of muscles

Suggested Readings:

1. Chatterjees, C. C. (2019). Human Physiology.(13th Ed.).CBS Publishers & Distributors (P).
2. Guyton, A. C., & Hall, J. E. (2013). Medical physiology. (13th Ed.)
3. Saunders Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen (2018).
4. Kuby, Immunology. 8th Ed.

Course name: (Paper III) Cytology and Genetics (Credits 4)

Course Outcomes: After studying this course, the students will be able to-

1. Learn about structure and genomic architecture of different types of virus and bacteria,
2. Understand the animal cells and cell cycles.
3. Additionally, students will get a detailed idea about the basics of genetics and mutations.

Unit 1- Credit 1

- i. Fluid mosaic model and functions of Plasma membrane.
- ii. Membrane transport of small molecules,
- iii. Energy transduction in mitochondria,
- iv. Cell cycle and its control mechanism.

Unit 2- Credit 1

- i. Mendel's laws and their chromosomal basis,
- ii. Extension of Mendelism- Linkage and Crossing over. Incomplete and co-dominance, Expressivity, Penetrance, Pleiotropy,
- iii. Genetic interaction, Multiple allelism
- iv. Sex-determination,
- v. Inheritance- Autosomal, Sex-linked

Unit 3- Credit 1

- i. Human Chromosomes, Chromosomal banding, Karyotype, Pedigree analysis
- ii. Chromosomal aberration- Numerical and Structural,
- iii. Gene mutations
- iv. Genetic Drift
- v. Hardy-Weinberg Law

Unit 4- Credit 1

- i. A Brief introduction of Bacteriophages, Lytic and lysogenic cycles,
- ii. Animal viruses and Retroviruses, Lentivirus,
- iii. Structure of E. coli, Reproduction- Transformation and conjugation
- iv. Vectors: Plasmids- Structure, types and applications in gene cloning; Cosmid, Bacterial Artificial Chromosome (BAC), Yeast Artificial Chromosome (YAC)

Assignments:

1. Draw a well labelled diagram of plasmid.
2. Describe the structure of cell membrane
3. Prepare a well labeled chart showing Mitosis
4. Prepare a well labeled chart showing Meiosis
5. Draw a diagram showing crossing over
6. Give a Diagrammatic representation of structural aberration

Suggested Readings:

1. Bruce Alberts et al., (2008). Molecular Biology of the Cell, (5th Ed). Garland
2. Cooper GM. and Hausman RE., (2013). The Cell: a Molecular Approach, (6th Ed). Sinauer Associates Inc.
3. Gupta, P. K., (2009). Genetics, Rastogi Publication
4. Pierce B.A. (2013). Genetics: a Conceptual Approach, (5th Edition), Freeman Publications
5. Snustad, D. P. and Simmons M.J. (2015). Principles of Genetics, 7th Ed. John Wiley & Sons
6. Verma, P. S. and Agrawal, V. K. (2009). Genetics, (9th Ed.) S. Chand Publishing Group

Course name: (Paper IV), Molecular Biology Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Understand how gene functions and protein products are sorted during translation.
2. Learn about regulation of gene expression.
3. Moreover, students will also learn various signaling pathways and receptors.

Unit 1- Gene Action

Credit 1

- i. Chromosomal organization of genes, principal classes of DNA (A, B, and Z), Eukaryotic gene structure, Non-coding genes, Giant chromosomes
- ii. DNA replication, Transcription, Genetic code,
- iii. Polymerase chain reaction, DNA Sequencing- Sanger Sequencing and Next Generation Sequencing

Unit 2-

Credit 1

- i. Protein Architecture, Protein synthesis on free/bound polysomes.
- ii. Uptake into ER, Trafficking mechanism of proteins; regulation of intracellular transport; Post- translational modification of proteins.
- iii. Liposomes and drug targeting; DNA Fingerprinting.

Unit 3- Regulation of Gene Action Credit 1

- i. Regulation of Gene action in prokaryotes: Operon model- lac Operon and Trp Operon;
- ii. Gene regulation in eukaryotes at transcriptional and post-transcriptional levels (Britten-Davidson model);
- iii. Silencers and enhancers.

Unit 4- Cell Signaling

Credit 1

- i. Concept of cell signaling;
- ii. Types of Cell Signaling: Paracrine, autocrine, endocrine, synaptic; Combinatorial signaling
- iii. Intracellular receptors and Cell surface receptors: Ion channel linked receptors, G-Protein linked receptor;
- iv. Mechanism of signaling through G-Protein linked receptor, Enzyme linked receptors, Mechanism of action via enzyme linked receptor;
- v. Second messenger system, Mechanism of action of cyclic AMP;
- vi. Apoptosis.

Suggested Readings:

1. Becker WM et al., (2008). The World of the Cell, (7th Ed). Benjamin Cummings
2. Bruce Alberts et al., (2008). Molecular Biology of the Cell, (5th Ed). Garland
3. De Robertis & Robertis, (1987). Cell and Molecular Biology, (8th Sub Ed). Lippincott & Wilkins
4. Lodish H et al., (2007). Molecular Cell Biology, (6th Ed). W.H. Freeman & Company
5. Watson et al., (2013). Molecular Biology of the Gene, (7th Ed). Pearson Prentice Hall.

Course name: (Paper V) Lab work Credits 4

Particulars	Marks
Major Dissection-	20
Minor Dissection-	10
Preparation-	05
Spotting (10) -	20
Physiology exercise-	10
Molecular Biology exercise-	10
Cytology and Genetics exercise-	10
Class record and collection-	08
Comprehensive viva -	07
TOTAL	100

Major Dissection- Nervous system of Pila, Unio, Sepia, and other available materials of higher non-chordates

Minor Dissection- Nervous system of Prawn, Other minor dissections of available higher non-chordates

Preparation- Hastate plate of prawn, parapodia of Neries, Mouth parts and salivary glands of cockroach, Mouth parts of other insects, and of other available materials.

Museum and prepared slides study- General survey and classification of higher nonchordates

Annelida-Nereies, Heteroneries, Aphrodite, Chaetopterus, Arenicola, Terebella, Pheretima, Eutyphoeus, Dero, Branchellion, Bonellia, Sipunculus and other available museums T.S. Nereies through body segments, Parapodium of Nereies, etc.

Arthropoda- Museums and slides of major representatives of different classes of phylum Arthropoda

Mollusca- Museums and slides of major representatives of Mollusca

Echinodermata- Museums and slides of major representatives of Echinodermata.

Physiology exercise-

Total counts of erythrocytes, total leucocyte counts and differential leucocyte counts of fish, frog, bird and rat.

Estimation of hemoglobin content in fish, frog, bird and rat.

Rate of Oxygen consumption of aquatic animals and effects of different stresses upon it.

Determination of respiratory quotient of an air breathing animal

Study of functional properties of the cardiac muscles of frog using acetylcholine and adrenalin

Recordings of Electro cardiogram of frog.

Molecular Biology exercise-

Isolation and colorimetric determination of protein from fat bodies of cockroach and liver

Isolation and colorimetric determination of DNA from fat bodies of cockroach and liver. .

Cytology and Genetics exercise-

Demonstration of mitochondria in human buccal epithelium by supra vital staining

Study of mitosis in onion root tip and meiosis in testis of grasshopper with acetocarmine squash method

Study of salivary gland chromosomes of Drosophila and Chironomos

Study of the pattern of different hereditary traits in human beings, Karyotyping.

Gene Mapping exercise.



M.Sc. (ZOOLOGY) FINAL YEAR

III Semester

**Course name: (Paper I) Comparative Study of Proto-chordates and Lower Vertebrates
(Protochordates, Fish, Amphibia) Credits 4**

Course Outcomes: After studying this course, the students will be able to-

1. Learn the diverse classes of animals have adapted various ways according to their habitats and forms.
2. Understand the comparative physiological and anatomical aspects of lower vertebrates.
3. Analyze and evaluate the modifications/adaptations found in different physiological and anatomical systems of various organisms of class Protochordates, Fish, Amphibia.

Unit I Credit 1

- i. General organization, classification and affinities of Protochordates
- ii. Origin of Chordates
- iii. Origin of Tetrapods
- iv. General characteristics and classification of Cyclostomata, Fish and Amphibia

Unit II Credit 1

- i. Integument in fish and Amphibia.
- ii. General plan of digestive system in fish and Amphibia
- iii. General plan of circulation in fish and Amphibia

Unit III Credit 1

- i. Respiratory system in fish and Amphibia
- ii. Skeletal system in fish and Amphibia
- iii. Evolution and organization of Urinogenital system in fish and Amphibia

Unit IV Credit 1

- i. Nervous system in fish and Amphibia
- ii. Sense organs in fish and Amphibia.
- iii. Lateral line system in fish

Assignments:

1. Explain the Evolutionary history of protochordates.
2. Describe the Origin and body plan of chordates.
3. Give a Comparative chart of digestive systems in fish and amphibia.
4. Discuss the Evolutionary modifications in circulatory systems of fish and amphibia
5. Prepare the whole skeleton of Frog and a Bony/ Cartilaginous fish.
6. Comment upon the Lateral line system in fish.

Suggested Readings:

1. Beer, G. R. (1948). Vertebrate Zoology: Sidgwick & Jackson Kotpal, R. L. (2018). Modern Textbook of Zoology: Vertebrates, Rastogi Publications, 12th Edition Saxena, R.K. (2016). Comparative anatomy of vertebrates, M.V. Learning

2. Jordan, E. L.; Verma, P.S.(2002) Vertebrate Zoology, S. Chand, 14th edition
3. Kardong, K.; (2018) Vertebrate comparative anatomy function, Evolution

Course name: (Paper II) Developmental Biology Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn the various patterns and processes of embryonic development in different animal groups.
2. Understand the fundamental processes that underpin the fertilization of an egg cell and its step-by-step transformation into the fascinating complexity of a whole organism.
3. Analyze the correlation between evolutionary development of organisms with their embryonic development.

Unit 1. Gonads and Gametogenesis Credit 1

- i. Sex differentiation in vertebrates
- ii. Comparative account of differentiation of gonads in mammals,
- iii. Spermatogenesis in vertebrates
- iv. Endocrinology of Ovary, Oogenesis and Vitellogenesis in vertebrates, Superovulation.

Unit2. Fertilization and Embryogenesis Credit 1

- i. Fertilization: in vivo and in vitro, recognition of gametes and acrosomal reaction, prevention of polyspermy and gamete fusion, activation of egg metabolism.
- ii. Patterns of Cleavage
- iii. Patterns of Gastrulation in frog and chick: fate maps, cell movement and formation of germ layers.

Unit3. Organogenesis Credit 1

- i. Origin of anterior-posterior and dorsal-ventral polarity in Drosophila
- ii. Axis formation in amphibians: Nieuwkoopcentre and primary Organizer
- iii. Axis formation in birds.
- iv. Development of Brain in Amphibia.
- v. Development of Eye in Amphibia.

Unit 4 Credit 1

- i. Specification, determination and differentiation of cells during embryonic development
- ii. Mechanism of Induction during Organogenesis, Primary organizer
- iii. Development of limb in vertebrates: Involvement of Homeobox genes.
- iv. Regeneration and embryonic stem cells, its scope and applications.

Assignments:

1. Discuss the mechanisms of spermatogenesis and oogenesis.
2. Describe various Cleavage Patterns in Animals
3. Explain the process of Gastrulation in frog.
4. Describe the Primitive Streak formation in chick embryo.

5. Describe the Development eye in frog.
6. Discuss the Development of brain in vertebrates.

Suggested Books:

1. Gilbert, S. (2018). Developmental Biology. Sinauer Associates, Inc., Publishers, 11th Edition
2. Verma, P.S. (2006) Chordate embryology, S. Chand Publications
3. Balinsky, B. I. (2012) An Introduction to Embryology, Saunders Publications

Course name: (Paper III) Endocrinology (Credits 4)

Course Outcomes: After studying this course, the students will be able to-

1. Learn a deep understanding of endocrine physiology.
2. Understand various functions and regulatory roles of different hormones.
3. Analyze the role of hormones in homeostasis of body physiology.

Unit 1 Credit 1

- i. Endocrine system of vertebrates,
- ii. Hormones: Characteristics and types,
- iii. Nature of action of peptide and steroid hormones
- iv. Feedback mechanisms
- v. Biosynthesis and secretion of Hormones: apocrine, holocrine, and paracrine

Unit 2 Credit 1

- i. Neuroendocrine system: Hypothalamo-hypophyseal system; Neurosecretion
- ii. Structure and endocrinology of Pituitary
- iii. Hormones of Pineal gland and Kidney and their functions

Unit 3 Credit 1

- i. Phylogeny, structure and functioning of Thyroid.
- ii. Endocrine control of metamorphosis in insects and amphibians
- iii. Endocrinology of Parathyroid and Calcium regulation in body
- iv. Structure and endocrinology of Pancreas
- v. Structure and hormones of Adrenal.

Unit 4 Credit 1

- i. Endocrinology of Gonads and Placenta.
- ii. Reproductive cycle- Estrous and menstrual cycle
- iii. Hypothalamo-hypophyseal-gonadal axis
- iv. Gestation & Parturition

Assignments:

1. What do you understand by Endocrine glands?
2. Discuss the Biosynthesis of hormones.
3. Explain the Mechanism of action of various types of hormone.
4. What do understand by Neuroendocrine system?
5. Discuss the Hormonal effects on Behaviour of animals.

Suggested Books:

1. Hadley, M.E. (1992) Endocrinology, Prentice hall
2. Shastry, K. V. (2001) Endocrinology and Reproductive Biology, Rastogi Publication
3. Turner, C.D. and Bagnara J.T. (1976) General endocrinology, W. B. Saunders Company

Optional Papers:

(Note: The student has to select any one paper from IVA, IVB, and IVC.)

IVA. Fishery Biology

Course name: (Paper IVA) Taxonomy & Morphology of Fishes, Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn about diversity of fishes.
2. Understand their identification and biology.
3. Learn the commercial and industrial significance of fisheries science.

Unit 1. Fish Taxonomy Credit 1

- i. Classification of fish up to orders as proposed by **L. S. Berg (1940), Romers (1959), Greenwood (1966)** and **Pouget al. (1989)**
- ii. Systematic/Taxonomic study of freshwater and marine fish of following orders
 1. Order- Clupeiformes. Families- Clupeidae (including oil sardine), Notopteroidae.
 2. Order- Beloniformes. Families- Belonidae Hemiramphidae
 3. Order- Mastacembeliformes. Family- Mastacembelidae.
 4. Order- Mugiliformes. Family- Mugilidae
 5. Order- Perciformes, Family- Scombridae (Mackerel)
 6. Order- Tetraodontiformes, Family- Tetraodontidae (Tetradon)

Unit 2. Identification of Fish Credit 1

Study and preparation of identification key of the fish of following orders with suitable diagrams, fin formula, local and biological names,

- | | | |
|-----------------------|------------------|----------------|
| 1. Ophiocephaliformes | 2. Cypriniformes | 3. Perciformes |
|-----------------------|------------------|----------------|

Unit 3 Credit 1

- i. Study and preparation of identification key of the fish of following orders with suitable diagrams, fin formula, local and biological names,

1. Tetraodontiformes	2. Clupeiformes	3. Mastacembeliformes
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- ii. Scales in fish, Fins and their origin.
- iii. Tails in fishes

Unit 4. Morphology Credit 1

- i. Specialized organs (electric organs, poison glands, sound producing organs, light producing organs, the lateral line system, and Weberian ossicles)
- ii. Endocrine glands (Pineal, hypophysis, thyroid, adrenal, ultimobranchial body, corpuscles of Stannous, urophysis, liver, and kidney).

Assignments:**Write detailed notes on the following-**

1. Strategies for classification of fishes
2. Identification key for various group of fishes
3. Sense organs in fishes
4. Types of tail in fishes and their biological importance
5. Types of scale in fishes and their ecological adaptation

Suggested Readings:

1. Srivastava, G. (2014) Fishes of UP and Bihar, Vishwavidyalaya Prakashan
2. Khanna, S.S. and Singh H.R. (2014) A Text Book of Fish Biology & Fisheries
3. Lagler K.F. (1977) Ichthyology, JOHN WILEY & SONS
4. Parihar, R. P. (2014) A handbook of Fish Biology and Indian Fisheries, Central Publishing house, Allahabad

IVB. ENTOMOLOGY

Course name: (Paper IVB) Morphology, Physiology, Development and Ecology, Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn about structure and functions of different organs of Insects
2. Understand the development and hormonal control of metamorphosis.

Unit 1. Morphology

- i. Structure and nature of integument.
- ii. Morphology of head (antennae and mouth parts), thorax (legs, wings, venation and coupling mechanism) and abdomen (external genitalia)
- iii. Nervous system and sense organs.
- iv. Bioluminescence.

Unit 2. Physiology

- i. Anatomy of digestive system and nutritional physiology (nutritional requirement, feeding behaviour and food utilization)
- ii. Circulatory system and components of hemolymph. Excretory organs and physiology of excretion.
- iii. Respiratory organs, physiology of respiration and respiratory adaptations of aquatic and endoparasitic insects.

Unit 3. Development

- i. Reproductive organs and different modes of development.
- ii. Postembryonic/larval development, different type of larvae and pupae and hormonal control of diapause

Unit 4. Ecology

- i. Role of temperature, humidity and light in development and metamorphosis.
- ii. Origin and evolution of apterygotes and pterygotes and their interrelationships.

Suggested Reading

1. The Principles of Insect Physiology, Wigglesworth, Vincent B, Chapman & Hall Ltd. USA.
2. Entomology, C. Gillott. Springer. Germany
3. The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK
4. Physiological system in Insects, Klowden, M. J., Academic Press, USA
5. The Insects, An outline of Entomology, Gullan, P. J., and Cranston, P. S., Wiley Blackwell, UK
6. Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA

C. CELL BIOLOGY**Course name: (Paper IVC) Cytological and Molecular Biology Techniques**

Course Outcomes: After studying this course, the students will be able to-

1. Learn about basics of microscopy and other techniques which are used in life science.
2. Students will learn about the methods used for quantification and localization of biomolecules.

Unit I.

Elementary principles of phase, interference, polarization, electron and scanning electron microscope, confocal microscopy and live cell imaging.

Unit II.

Theory and application of freeze – drying, X-ray diffraction, radio autography, Fluorescent antibody techniques. Methods of tissue culture.

Unit III.

Theoretical basis of colorimetric and biochemical estimations of nucleic acid, proteins.
Chemical basis of fixation and cytochemical localization of proteins, lipids, glycogen, RNA, DNA, phosphatases, esterases and oxidases.

Unit IV.

Principles of Centrifugation, Chromatography, electrophoresis (Agarose, PAGE), Western Blotting, DNA and Protein isolation, Polymerase chain reaction, Southern Blotting, DNA finger printing, EMSA

Suggested Readings:

1. Bruce Alberts et al., (2008). Molecular Biology of the Cell, (5th Ed). Garland
2. Lehninger, A. L. (2013). Principles of Biochemistry (6thed.). New York, NY: Worth.
3. Boyer, Rodney F. (2012). Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edition. Pearson.
4. Terence Allen, (2015). Microscopy: A Very Short Introduction. Oxford University Press
5. Wilson and Walkers. (2018). Principles and Techniques of Biochemistry and Molecular Biology. 8thed. Cambridge University Press.

Course name: Paper V, Lab work (PART A): GENERAL Credits 2

Distribution of marks:

Major Dissection-	10
Minor Dissection-	05
Microtomy-	05
Developmental biology-	05
Endocrinology-	05
Spotting (05)-	10
Class record, collection and viva	10
Total-	50

Major Dissection-Dissection of cranial nerves of major representative types of fish and amphibian. Neck nerves of a mammal Afferent and efferent branchial arteries of Scoliodon

Minor Dissection- Eye muscles of Scoliodon, internal ear, urinogenital system of Scoliodon,

Preparation-Placoid scales of Scoliodon, Ampulla of Lorenzini; T.S. through liver, intestine, skin etc. offrog, Microtomy of tissues

Museum study- Study of museums and slides of representative types of Protochordates, Cyclostomata, Fish and Amphibia

Developmental Biology- Study of life stages of frog, mounting of eggs and embryo of frog, incubation and mounting of chick embryo, study of prepared slides of embryo of frog, chick and mammal, window formation.

Endocrinology- Study of prepared slides of different endocrine glands of fish and frog, dissection of vertebrate types to demonstrate different endocrine organs.

Course name: (Paper V) Lab work, (Part B) Credits 2

(Note: The student has to choose one of the following streams from A, B or C according to the theory paper opted for by him.)

Distribution of marks

A. Fishery Biology

Major Dissection-	10
Preparation-	05
Identification of two fish-	10
Spotting (05)-	10
Seminar-	05
Class record, collection and Viva-	10
Total -	50

Major Dissection- Cranial nerves of Wallago, Labeo and Scoliodon; Afferent and efferent branchial vessels of Scoliodon, Wallago, Eye muscles of Scoliodon and Wallago,

Preparation- Preparation of Placoid scales, Cycloid scales and Ctenoid scales

Identification- Identification of freshwater fishes of U.P and Bihar with the help of Identification key.

Study of specimens, slides and bones of fishes- Specimens of both freshwater and marine water fishes

Seminar- Seminar presentation for 15 minutes compulsory for each student

Fish collection- Collection of at least ten different types of fish available in local habitats.

(B) Entomology

Dissection major-	10
Dissection minor	05
Physiology exercise	05
Identification of two insects	10
Seminar-	05
Spotting (5)	10
Class record, collection and viva	05
Total-	50

Entomology Practical Syllabus

1. Major Dissection: Nervous system of Cockroach, Grasshopper, Honey bee etc
2. Minor Dissection: Sting apparatus of Honey bee, wasp, House Fly. Alimentary canal of Grasshopper, Cockroach, and Spiracle of Grasshoppers. Mouth parts of Cockroach, house fly. Grasshopper testes and ovaries.
3. Permanent Mounting: Wings of some insects, halteres, antennae and mouth parts.
4. Field studies of insects to understand their habit, habitat environmental impact, beneficial and harmful activities etc.
5. Taxonomic Identification: upto families of some insects.
6. Identification and Studies of some insect larva
7. Insect Collection collection of locally available insects.

(C) Cell and molecular biology techniques

Cytological localization-	10
Vital staining	10
Microtomy	10
Seminar	05
Spotting (5)	10
Class record and viva	05
Total	50

Cell Biology Practical Syllabus

1. Studies of various mitotic stages in onion root tips
2. Studies of various meiotic stages in testes of Grasshopper
3. Settings and demonstration of various microscopes
4. Demonstration of Fluorescent immunostaining of proteins
5. Cell freezing and thawing
6. Quantitative assay of nucleic acid and proteins
7. Localization of proteins, lipids, RNA, DNA, phosphatases, esterases and oxidases in cells
8. Isolation of DNA and Proteins from blood and tissue

9. Electrophoresis and detection of DNA and Proteins

**M.Sc. (ZOOLOGY) FINAL YEAR
IV Semester**

Course name: (Paper I) Comparative Study of Higher Vertebrates(Reptiles, Birds and Mammals)

Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn the diversity of higher vertebrates.
2. Understand the various ways of their adaptation according their habitats and forms.
3. Analyze the comparative physiological and anatomical aspects of lower vertebrates.
4. Understand the modifications/adaptations found in different physiological and anatomical systems of various organisms of the classes- Reptiles, Birds and Mammals.

Unit 1. Reptiles and Birds Credit 1

- i. Characteristics and classification of Reptilia and Aves.
- ii. Origin, and evolution of Reptiles; Extinct reptiles.
- iii. Origin of Birds,
- iv. Flightless birds

Unit 2. Mammals Credit I

- i. Origin, characteristics and classification of class Mammalia,
- ii. Structural peculiarities and phylogenetic relations of Prototheria and Metatheria,
- iii. Dentition in mammals.
- iv. Adaptation in Aquatic mammals

Unit 3. Circulation and Respiration Credit I

- i. General plan of circulation in reptiles, birds and mammals
- ii. General plan of respiration in reptiles, birds and mammals

Unit 4. Urinogenital and Skeletal system Credit I

- i. General plan of urino-genital system in reptiles, birds and Mammals
- ii. Skeletal system in reptiles, birds and Mammals.

Assignments:

1. Evolutionary history of Reptiles
2. Fossils: Types, formation and their importance in Evolution
3. Origin and body plan of Birds
4. Origin and Evolution of Mammals
5. Types of teeth in different classes of animal and their function
6. Circulatory system in Birds, Reptiles and Mammals
7. Comparative aspects respiration in reptiles, birds and mammals
8. Urinogenital system in reptiles and birds

Suggested Readings:

1. Beer, G. R. (1948). Vertebrate Zoology: Sidgwick & Jackson,
2. Kotpal, R. L. (2018). Modern Textbook of Zoology: Vertebrates, Rastogi Publications, 12th Edition,
3. Saxena, R.K. (2016). Comparative anatomy of vertebrates, M.V. Learning
4. Jordan, E. L.; Verma, P.S.(2002) Vertebrate Zoology, S. Chand, 14th edition

Course name: (Paper II) Animal Behaviour Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn various aspects of behaviour of animals.
2. Understand how the behaviour of animals permits flexibility that allows them to respond rapidly to environmental changes.
3. Analyze the theories and evidences for a broad range of behavioural aspects of animals.

Unit 1. Learning and Communication Credit 1

- i. Innate and Learning behavior; Memory
- ii. Communication (chemical, visual, audio) among animals
- iii. Biological clocks: Circadian, Lunar and Annual Rhythms
- iv. Physiology and molecular biology of Biological Rhythms

Unit 2. Reproductive Behaviour Credit 1

- i. Courtship and mating behavior;
- ii. Mating systems: Polyandry and Polygyny
- iii. Sexual selection, pre-copulatory & post copulatory,
- iv. Last male precedence, Sperm competition & cryptic female choice

Unit 3. Migration and Parental Care Credit 1

- i. Migration in fish
- ii. Migration in birds
- iii. Parental care in fish
- iv. Parental care in amphibians

Unit 4. Orientation and Social Behaviour Credit 1

- i. Orientation in animals,
- ii. Altruism and evolution- Group selection, Kin selection, Reciprocal altruism
- iii. Social behavior in insects and mammals, Eusociality

Assignments:

1. Types of learning Behaviours
2. Senses in animals

3. Mating behaviours in animals
4. Migration in fishes and birds
5. Social behaviours in insects
6. Parental care in different animal groups

Suggested Readings:

7. Agrawal, V. K.; (2012), Textbook of Animal Behaviour, S. Chand
8. Alcock, J.(2005)Animal Behavior. SinauerAssociates, Inc. Publishers
9. Dugatkin, A. L. (2003) Principles of AnimalBehavior. W. W. Norton & Co
10. Mandal, F.B. (2010), Text book of Animal behavior, PHI Learning Pvt. Ltd
11. Prasad, S. (2004), Animal Behaviour, Ahead Publications

Optional Papers

(Note: The student has to choose any one stream from the following three streams)

STEAM A: Fishery Biology

Course name: Paper III, Applied Ichthyology and Development of Fish Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Gain a detailed knowledge of Applied Ichthyology.
2. Understand various techniques of fish farming.
3. Learn about the industrial applications of ichthyology.
4. Learn the maintenance of fish farm, fish preservation and storage etc.

Unit 1 Credit 1

- i. Fisheries of India: Brief study of Marine, fresh water, estuarine and cold water fishery, ornamental fishes.
- ii. Fish Farming: Type of fish farming, fish ponds, construction of fish ponds, physico-chemical and biological characteristics of ponds, fishing methods.
- iii. Fertilization and management of fishery pond (spawning, hatching, rearing, stocking); transport and mortality of fish fry.
- iv. Composite culture and cage culture; integrated fish farming

Unit 2 Credit 1

- i. Principle and importance of fish preservation: traditional and advanced methods of fish preservation: sun-drying, salting, pickling, smoking, chilling, frying and canning etc.
- ii. Fish products (Fish oil, Fish sauce, Fish Glue etc.) and their importance.

Unit 3 Credit 1

- i. Application of genetics in aquaculture: sex manipulation, chromosomal manipulation.
- ii. Transgenic fish.
- iii. Production of mono-sex and sterile fish and their Significance in aquaculture.
- iv. Induced breeding

Unit 4 Development and Growth of Fish: Credit 1

- i. Cleavage and Gastrulation.
- ii. Neurulation.
- iii. Organ formation.
- iv. Larval development.
- v. Metamorphosis.
- vi. Growth and age.

Assignments:

Write detailed notes on the following-

1. Maintenance and Development of Fish Pond
2. Production of Seed
3. Maintenance hatchery
4. Fish Preservation and Storage
5. Transgenic Fish Production
6. Fish Products
7. Developmental stages of Fish

Suggested Books:

1. Gupta, S.K. (2006) General and Applied Ichthyology, S. Chand Publications
2. Sandhu, G.S. Applied Ichthyology, Dominant Publishers
3. Khanna, S.S. and Singh H.R. (2014) A Text Book of Fish Biology & Fisheries
4. Parihar, R. P. (2014) A handbook of Fish Biology and Indian Fisheries, Central Publishing house, Allahabad
5. Gilbert, S. (2018). Developmental Biology. Sinauer Associates, Inc., Publishers, 11th Edition

Course name: Paper IV, Fish Physiology and Fish Ecology Credits 4

Course Outcomes: After studying this course, the students will be able to-

1. Learn two important aspects of fish farming: Fish Physiology and Fish ecology.
2. Understand that the alterations in these conditions may lead to devastating effects on fish farming.
3. Analyze and evaluate certain pathological threats to fish industry.

Unit 1 Credit 1

- i. Nutrition- Alimentary canal, associated glands, food and feeding habits, digestion
- ii. Excretion - Kidney structure and modifications, nitrogenous and excretory products, urine formation.
- iii. Osmoregulation- Definition, osmoregulation in freshwater, marine and migratory fishes.

Unit 2 Credit 1

- i. Respiration- Structure and function of gills, process of respiration in a typical fish, accessory respiratory organs.
- ii. Circulatory System - Heart structure and function, fish blood and blood vessels, arterial and venous system.

Unit 3 Credit 1

- i. Fish nervous system
- ii. Reproduction- Gonads structure, spermatogenesis, oogenesis, gonadal steroids, endocrine control of reproduction, and fertilization.
- iii. Common enemies and symptoms, etiology and treatment of disease of food fishes.

Unit 4 Fish Ecology: Credit 1

- i. Abiotic factors: density, pressure, temperature, salt content in water, light, sound, electric currents, bottom deposits, particles suspended in water.
- ii. Biotic factors: inter-specific interactions among fishes and with other organisms; intra-specific interactions among fishes.
- iii. Pollutants affecting fishes, with special reference to oil spills, domestic pollutants, industrial water, radioactive wastes and sewage fed fisheries. Effects of pesticides and heavy metals on fishes; bioaccumulation and bio-magnification; dose response relationship and toxicity curve, LC50.
- iv. Plankton in relation to fish production.
- v. Larvivorous Fish

Assignments:

1. Fish digestive system
2. Fish Excretory System
3. Respiratory System of Fishes
4. Reproductive System of Fishes
5. Nervous System of Fishes
6. Abiotic factors affecting fish farming
7. Biotic factors affecting fish growth
8. Effects of pollutant on fish
9. Viral Diseases of Fishes
10. Bacterial Diseases of Fishes

Suggested Books:

1. Khanna, S.S. and Singh H.R. (2014) A Text Book of Fish Biology & Fisheries, Narendra Publishing house
2. Parihar, R. P. (2014) A handbook of Fish Biology and Indian Fisheries, Central Publishing house, Allahabad
3. Bone, Q. and Moore, R.H. (2021) Biology of Fish, Taylor and Franchis, 3rd Edition.
4. Malik, A. ((2017) Physiology of Fishes, Oxford Book Company
5. Lagler K.F. (1977) Ichthyology, JOHN WILEY & SONS
6. Evans, D. (2013) Physiology of Fishes, CRC PRESS

STREAM (B) ENTOMOLOGY

COURSE NAME: (PAPER III B) Evolution and Taxonomy

Unit I

Origin and evolution of apterygotes and pterygotes and their interrelationships

Unit II

Thysanura: Machilidae; Lepismatidae Dictyoptera: Blattidae; Mantodea: Mantidae Orthoptera : Tettigoniidae; Acrididae; Gryllidae; Gryllotalpidae Isoptera : Termitidae; Kalotermitidae Siphunculata : Pediculidae; Haematopinidae Hemiptera : Cicadidae; Jassidae; Lacciferidae Coccidae; Cimidae; Pyrrhocoridae Belostomatidae

Unit III

Lepidoptera : Pyralidae; Saturniidae; Bombycidae; Pieridae; Papilionidae; Lymantriidae Diptera : Culicidae; Simuliidae; Chironomidae; Tabanidae; Drosophilidae Tachinidae; Muscidae; Hippoboscidae.

Unit IV

Hymenoptera : Ichneumonidae; Aphidiidae; Formicidae; Vespidae; Apidae; Bombycidae Coleoptera : Cicindellidae; Carabidae; Hydrophilidae; Scarabaeidae; Lampyridae; Tenebrionidae; Meloidae; Chrysomelidae; Curculionidae.

Suggested Reading

1. Entomology, C. Gillott. Springer. Germany
2. The Principles of Insect Physiology, Wigglesworth, Vincent B, Chapman & Hall Ltd. USA.
3. 2. The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK
4. 3. Physiological system in Insects, Klowden, M. J., Academic Press, USA
5. 4. The Insects, An outline of Entomology, Gullan, P. J., and Cranston, P. S., Wiley Blackwell, UK
6. 5. Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA

COURSE NAME: (PAPER IV B) Economic Entomology

Unit 1

Pests of stored grains: Sitophilus oryzae; Tribolium castaneum; challosobruchus chinensis; Corcyra cephalonica Pests of cotton : Dysdercus spp; Earias vitella; Pectinophora Gosaypiella Pests of cereal – crops ; heliothis armigera; Chilozonellus; Leptocorysa Varicornis; Hieroglyphus spp.

Unit 2

Pests of fruits: Idiocerus atkinsoni; Dacus cucurbitae; Papilio Demoleus Pests of oil-seeds: Bagrada cruciferarum; Athalia proxima; Lipaphis Erysimi

Unit 3:

Different methods of insect management: Cultural; Mechanical; Biological chemical. Integrated pest management (IPM). Properties, formulations, methods of application and mode of action of insecticides. Physiology of insect resistance to insecticides.

Unit 4**Life – history of beneficial insects.**

Life – history and biology of silk – worm and its products. Life – history and biology of honey – bee and its products. Life – history and biology of lac – insect and its products.

Suggested Readings

1. Insect Plant Biology, Schoonhoven, L. M., van Loon, J.A., & Dicke, M., Oxford University Press, USA
2. Entomology, C. Gillott, Springer, Germany
3. Interrelationship between insects and Plants, Jolivet, P., CRC Press, USA
4. Entomology & Pest Management, Pedigo, L. P., Prentice Hall, New Jersey, USA
5. Concepts of IPM, Norris, Caswell-Chen and Kogan, Prentice-Hall, USA
6. Agricultural insects pests of the tropics and their control, Hill, D. S., Cambridge University Press, UK
7. Medical and Veterinary Entomology Mullen, G., Durden, L., Academic Press, USA
8. Medical and Veterinary Entomology, Kettle, D. S., Cabi Press, USA
9. Medical Entomology for students, Service, M. Cambridge University Press, UK

STREAM C: CELL BIOLOGY**COURSE NAME: (Paper III C) Ultrastructure and Morphodynamics of Cell****Unit 1**

- (i) Morphodynamics of Cell.
- (ii) Ultrastructure and functions of the following : Cell membrane, Nuclear membrane

Unit 2.

Cellular Organelles: Ultrastructure and Functions (i) Mitochondria. (ii) Golgi complex (iii) Endoplasmic reticulum (iv) Ribosomes (v) Lysosomes.

Unit 3.

The Chromosomes (i) Morphodynamics of chromosomes and the achromatic apparatus in cell division. (ii) Mechanism of chiasma formation.

Unit 4.

Cell Physiology (i) Physiology of a dividing cell. (ii) Chromosomal changes caused by ultraviolet and ionizing radiations (iii) Carcinogenesis: Cytopathology; Possible somatic and viral causes

COURSE NAME: (Paper-IV C) Cell Regulation and Principles of Biotechnology**Unit 1**

1. Regulation of cellular functions;
2. Hormone action: Hormone receptor Interaction;
3. Membrane receptors; Steroid, thyroid and epinephrine receptors;

4. Second messengers (cyclic AMP: Cyclic GMP);
5. Interferon.

Unit 2

1. Genetic code
2. Genetic recombination.
3. Transformation.
4. Conjugation and transduction

Unit 3.

1. Application of genetic engineering and its prospects
2. Microbes and human welfare

Unit 4

1. Thermodynamic principles and steady-state conditions of living Organisms
2. Organization and methods to study metabolism
3. Degradation of glucose and nucleotides in animals.
4. Energy metabolism and high energy compounds.
5. Redox potentials, Mitochondrial electron transport chain and Oxidative phosphorylation
6. Nature of enzymes
7. Classification and nomenclature of enzymes.
8. Kinetic analysis of enzyme catalyzed reactions

Course name: Paper V, Lab Work (A. GENERAL) Credits 2

Distribution of Marks

Dissection major	10
Dissection minor	05
Preparation	05
Animal Behaviour Exercise	05
Spotting (5)	10
Class record and collection-	08
Viva-voce -	07
Total-	50

B. OPTIONAL**A. Fishery Biology**

Dissection major-	10
Dissection minor-	05
Preparation-	05
Ecology exercise-	05
Seminar	05
Spotting-(5)	10
Class record, collection and viva-voce-	10
Total-	50

Major Dissection: Digestive system, Urinogenital system, Cranial nerves of Wallago, and Scoliodon.

Minor Dissection: Scroll valve of Wallago and Scoliodon, Accessory respiratory organs of Heteropneustes fossilis, Weberian ossicles,

Preparation: Scales of fish, internal ear

Ecology Exercise-

Ecological adaptation in fishes

Preparation of fish feed

Study of pond ecology: measurement of pH, hardness, transparency, dissolved oxygen, dissolved CO₂, Qualitative study of plankton

Seminar presentation for 15 minutes by every student.

Study of Specimens, slides and bones of fishes belonging to different orders

Collection-Collection of fishes available in local habitats; Collection of skull bones of Labeo and Wallago.

Suggested Books:

1. Bone, Q. (2007). Biology of Fishes. Taylor & Francis Group
2. Khanna, S.S. and Singh H.R. (2014). A Text Book of Fish Biology & Fisheries
3. Lagler K.F. (1977) Ichthyology, JOHN WILEY & SONS
4. Srivastava, G (2014) Fishes of UP and Bihar, VishwavidyalayaPrakashan
5. Evans, D. (2013) Physiology of Fishes, CRC PRESS

(B) Entomology

Dissection major-	10
Dissection minor-	05

Preparation-	05
Physiology exercise-	05
Seminar	05
Spotting (5)	10
Class record, collection and Viva	10
Total	50

Entomology Practical Syllabus

1. Major Dissection: Dissection / demonstration of insect organ systems (nervous, digestive, reproductive, neuroendocrine) in insects like grasshopper, cricket, cockroach, wasp, honey bee, insect larvae
2. Minor Dissection: Studies and preparation of W.M and section of various organ in insects.
3. Identification and classification of representative insect families in theory syllabus.
4. Study of beneficial insects, benefits derived from them and useful products
5. Study of destructive insects, damage caused by them and damaged products
6. Study of insecticidal formulations and insect control appliances, IPM

(C) Cell Biology

Quantitative estimation-	10
Cytological preparation-	10
Microbial exercise-	05
Seminar-	05
Spotting (5)	10
Class record and Viva -	10
Total	50

Cell Biology Practical Syllabus

1. Study of ultrastructure of cell organelles
2. Metaphase Chromosome preparation
3. Microscopic analysis of chromosomes at various stages of cell division
4. Structural comparison of normal and cancerous cells
5. Extraction of DNA from blotting paper.
6. Familiarity with laboratory instruments and usage of micropipettes; preparation of laboratory reagents (1M Tris of pH 8 and making different dilutions from the same, 0.5M EDTA).
7. Ligation of insert and vector.
8. Competent cell preparation and transformation.
9. Clone screening.
10. Plasmid isolation from positive clones.

Singh
(Ram Singh)

Amal
(Anand)

Seema
(Seema Verma)

Online consent
Prof. V.B. Upadhyaya
(External expert)

Online consent
Dr. Dinker
(External expert)