



# DR. RAM MANOHAR LOHIA AVADH UNIVERSITY, AYODHYA

## Structure of Syllabus for the Program:

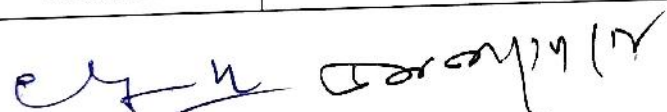



M.Sc. Subject: ZOOLOGY (NEP-2020)

Structure of Syllabus Developed by			
Name of BoS Convener/ BoS Member	Designation	Department	College/ University
Prof. C.K. Mishra,	Dean	Science	Dr. R.M.L. Awadh University, Ayodhya
Dr. Indu Singh	Convener	Zoology	KNIPSS, SULTANPUR
Dr. Mukul Sinha	Member	Zoology	L.B.S. P.G. College, Gonda
Dr. P.N. Tripathi	Member	Zoology	K.S. Saket P.G. College, Ayodhya
Dr. Ram Nayan Singh	Member	Zoology	KNIPSS, SULTANPUR
Prof. P.H. Pathak, (Retd.)	Member	Zoology	D.D.U. Gorakhpur

Course Code		Course Title	Credits	T/P	Evaluation	
					CIE	ETE
A	B	C	D	E	F	G
SEMESTER I (YEAR I)						
B050701T	CORE	Non-Chordates: General Account	5	T	25	75
B050702T	CORE	Biological Tools and Techniques	5	T	25	75
B050703T	CORE	Comparative animal Physiology	5	T	25	75
B050704T	FIRST ELECTIVE (Select any one)	Toxicology and Animal Behaviour	5	T	25	75
B050705T		Biostatistics, Computational Biology and Bioinformatics	5	T	25	75
B050706P	SECOND ELECTIVE (Select any one)	Practical Lab – IA	5	P	50	50
B050707P		Practical Lab – IB	5	P	50	50
SEMESTER II (YEAR I)						
B050801T	CORE	Chordates: General Account	5	T	25	75
B050802T	CORE	Systematics and Evolution	5	T	25	75
B050803T	CORE	Cell Biology	5	T	25	75
B050804T	THIRD ELECTIVE (Select any one)	Immunology	5	T	25	75
B050805T		Histology and Histochemistry	5	T	25	75
B050806P	FOURTH ELECTIVE (Select any one)	Practical Lab – IIA	5	P	50	50
B050807P		Practical Lab – IIB	5	P	50	50

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SEMESTER III (YEAR II)						
B050901T	CORE	Principles of Endocrinology	5	T	25	75
B050902T	CORE	Developmental Biology	5	T	25	75
B050903T	CORE	Principles of Ecology and Wildlife	5	T	25	75
B050904T	FIFTH ELECTIVE (Select any one)	Morphology, Physiology & Development of Fishes	5	T	25	75
B050905T		Insect Taxonomy, Morphology and Physiology	5	T	25	75
B050906P	SIXTH ELECTIVE (Select any one)	Practical Lab - IIIA / Project presentation	5	P	50	50
B050907P		Practical Lab - IIIB / Project presentation	5	P	50	50
SEMESTER IV (YEAR II)						
B051001T	CORE	Genetics and Molecular biology	5	T	25	75
B051002T	CORE	Biochemistry	5	T	25	75
B051003T	SEVENTH ELECTIVE (Select any one)	Applied Ichthyology	5	T	25	75
B051004T		Applied Entomology and Pest Management	5	T	25	75
B051005P	RESEARCH PROJECT/ DISSERTATION	Major Research Project/ Dissertation	10	P	50	50


  

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## Semester Courses of M.Sc. Zoology Based on CBCS

The course of M.Sc. Zoology will be spread in two years previous and final. Each of which will have two semester examinations and therefore will be four semester examinations.

### Programme Specific Outcomes of Zoology

1. Developing deeper understanding of key concepts of biology at biochemical, molecular and cellular level, physiology and reproduction at organismal level, and ecological impact on animal behaviour.
2. Developing the concept of animal adaptation by exploring the diversity of functional characteristics of various kinds of organisms which is closely related to evolutionary processes and environmental changes.
3. Understanding of Mendel's principle, its extension and chromosomal basis; chromosomal anomalies and associated diseases; developing concepts of regulation of gene activity in prokaryotes and eukaryotes of transcriptional and post transcriptional level.
4. Development of an understanding of animal science for its application in entomology, apiculture, aquaculture, agriculture and modern medicine.
5. Develop an information about and basic concept of developmental biology elucidation of early embryonic development and organogenesis of invertebrates and vertebrates, explanation of embryonic stem cells and their application.
6. To understand the basic components of computers, software (operating system) and application of software used in biological and statistical studies.
7. Development of theoretical and practical knowledge in handling the animals and using them as model organism.
8. By the theoretical project work is aimed to in calculate ability to develop a research question, organize relevant available literature and development of technical writing skill.
9. To understand the impact of chemicals on biodiversity of microbes, animals and plants; Bioindicator and biomarkers of environmental health. Biodegradation and bioremediation of chemicals; competition and existence; intraspecific and interspecific interactions.
10. Maintenance of high standards of learning in animal sciences.

### M.Sc. Previous (Zoology)

(Effective from session 2022-23)

The M.Sc. Previous (Zoology) examination will consist of two semesters, called as first and second semesters. Their examinations will be held in the months of December and May respectively. In each of these semester examinations there will be three compulsory theory papers and two elective papers (out of which first elective will be of theory and second elective will be a practical paper) to be selected from each group of optional papers. So, in total there will be four theory papers and one practical paper. Each paper will be of three hours duration and 5 credit (maximum marks 75), except where stated otherwise. There will be 25% internal evaluation in each paper based on:

- |                          |          |
|--------------------------|----------|
| 1. Attendance            | 05 Marks |
| 2. Class Test/Assignment | 10 Marks |
| 3. Seminar               | 10 Marks |

### Format of the Question Paper:

There will be one compulsory question consisting of 4 parts of short answer type question based on the whole course, out of which all parts will have to be answered. Besides this, there will be 8 questions from four units (two from each unit), out of which 4 questions will have to be answered (one from each unit). Thus, in all 5 questions will have to be attempted and 9

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questions will have to be set. A question will carry equal marks, except stated otherwise.

### **M.Sc. Final Zoology**

**(Effective from session 2023-24)**

The M.Sc. Final Zoology will consist of two semesters, called as third and fourth semesters. Their examinations will be held in the months of December and May respectively. In each of these semesters examinations there will be three compulsory theory papers and two elective papers (out of which first elective will be of theory and second elective will be a practical paper) to be selected from each group of optional papers. So, in total there will be four theory papers and one practical paper. Each paper will be of three hours duration and of 5 credit (maximum marks 75), except where stated otherwise. There will be 25% internal evaluation in each paper based on:

1. Attendance 05 Marks
2. Class Test/Assignment 10 Marks
3. Seminar 10 Marks

#### **Format of the Question Paper:**

There will be one compulsory question consisting of 4 parts of short answer type question based on the whole course, out of which all parts will have to be answered. Besides this, there will be 8 questions from four units (two from each unit), out of which 4 questions will have to be answered (one from each unit). Thus, in all 5 questions will have to be attempted and 9 questions will have to be set. A question will carry equal marks, except stated otherwise.

### **ZOOLOGY: TWO-YEAR FULL-TIME PROGRAMME AFFILIATION**

The proposed programme shall be governed by DR RML Avadh University, Ayodhya.

#### **PROGRAMME STRUCTURE**

The M.Sc. Programme is divided into two parts as under. Each part will consist of two semesters as given below:

		<b>Semester Odd</b>	<b>Semester Even</b>
Part-I	First Year	Semester-1	Semester-2
Part-II	Second Year	Semester-3	Semester-4

Each semester would consist of four papers (course) and one practical course (based on all four papers, two credits for each paper). Semesters I and II (Part I) would have core papers (courses) to be studied by all students of the M.Sc. Zoology programme. Semesters III and IV (Part II) would comprise optional papers from which each student would have to select four papers in Semester III and three papers of his/her choice in Semester IV. Selection of papers in Semester III and IV would be based on merit (performance in the part I examiners), choice and other specific guidelines as outlined below. It is mandatory for each student to complete a dissertation, assigned at the end of semester II and goes on until Semester IV. It would be theoretical and not involve any laboratory components. The schedule of papers prescribed for various semesters shall be as follows.

<b>Part-I</b>		
<b>Semester-I</b>		
1.	Core	Non-Chordates: General account
2.	Core	Biological Tool and Techniques
3.	Core	Comparative Animal Physiology

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4.	First Elective (Select any one)	1-Toxicology and Animal Behaviour 2-Biostatistics, Computational Biology and Bioinformatics
5.	Second Elective (Select any one)	1-Practical/Field Visit/ Project Presentation 2-Practical/Field Visit/ Project Presentation
<b>Part-I Semester-2</b>		
1.	Core	Chordates-General account
2.	Core	Systematics and Evolution
3.	Core	Cell Biology
4.	Third Elective (Select any one)	1-Immunology 2-Histology and Histochemistry
5.	Fourth Elective (Select any one)	1-Practical/Industrial Training/Project Presentation 2-Practical/Industrial Training/Project Presentation

## SEMESTER-I

### PAPER-I NON- CHORDATA THEORY

**Unit-1:** Nutrition and reproduction in protozoa: origin of Metazoans; Structural organization, Canal system and affinities of Porifera; Polymorphism and Colony formation in Cnidaria; Coral reefs.

**Unit-2:** Parasitic adaptations, General organization of Trematoda and Cestoda, Larva stages of Trematoda and Cestoda and Life cycle patterns in Platyhelminthic parasites; outlines of ecology of soil nematodes; segmental organs in Annelida; Adaptive radiations in Annelida.

**Unit-3:** Organization and affinities of Onychophora; Larval forms in Crustacea; Parasitism in Crustacea; Torsion in gastropods, its effect and significance.

**Unit-4:** Larval forms in Echinodermata; Water vascular system in Echinodermata; Affinities of Echinodermata and Hemichordata; Brief outlines of the structure and affinities of minor phyla with special reference to ctenophore, Rotifera, and Phoronida

#### Suggested Literature:

1. A life of invertebrates by W.D. Russel-Hunter, MacMillan Publishing Co. inc., New York.
2. Advances in invertebrates' reproduction by K.G. Adiyodi and R.G. Adiyodi, Peralam-Kenoth Kerivellur, Kerala.
3. Biology of the invertebrates by Jan Pechenik, William C. Brown Publishers, Dubuque, Iowa.
4. Invertebrates zoology by A. Kaestner, Interscience Publishers.
5. Invertebrates zoology by Alfred Kaestner, H.W. Levi & L.R. Levi, John Wiley & Sons Inc.
6. Invertebrates (Protozoa to Echinodermata) by Ashok verma, Narosa Publishing house, New Delhi.
7. Invertebrates Learning by W.C. Corning and J.A. Dayal.

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8. Invertebrates Structure and Function by E.J.W. Barrington, The Camolet Press, Great Britain.
9. Invertebrates Zoology by P.A. Meglitsch & F.R. Schram; Oxford University Press.
10. Invertebrates Zoology by R.D. Barnes, V Edition. Holt Saunders International edition.
11. Principles of Comparative Anatomy of Invertebrates by W.N. Bekiemishev, University of Chicago Press.
12. Principles of Comparative Anatomy of Invertebrates by Dr J.M. Mac Lennon; Z. Kabata, Oliver and Boyd Edinburgh.
13. Textbook of Invertebrate Zoology by G.S. Sandher; H. Bhaskar, Campus book International.
14. The Invertebrates by L.H. Hymen, McGraw-Hill Book Company.
15. The Invertebrates: A New Synthesis by R.S.K Barnes, P. Calow, P.J.W. Olive, D.W. Golding, and Spicer, J.I, III Edition, Blackwell Science.

**Course Outcomes-**After the course the students will be able to understand the basics of this course. Larval forms in Echinodermata; Affinities of Echinodermata and Hemichordata; Brief outlines of the structure and affinities of minor phyla. Get benefit of this course in various competitive examinations.

## **Paper-II BIOLOGICAL TOOLS AND TECHNIQUES THEORY**

**Unit-1:** Centrifugation; Principle, types and Applications; Principle and Uses of analytical instruments; Flame photometry and Spectrophotometry

**Unit-2:** Separation and identification of biomolecules by Chromatography: Paper and thin layer Chromatography, Gel exclusion Chromatography, High performance Liquid Chromatography (HPLC), Affinity Chromatography

**Unit-3:** Electrophoresis techniques: General principles, Support media; Electrophoresis of proteins and nucleic acid; capillary Electrophoresis, Principles of differential and density centrifugation.

**Unit-4:** Recombinant DNA techniques; Restriction Enzymes, Cloning Vectors, Preparation and Screening of cDNA and Genomic DNA libraries, Southern and Northern Hybridization, PCR; Principles and Applications. Detection of Proteins, DNA-Protein and Protein-Protein interaction; Western Blotting, DNA Foot Printing, EMSA

### **Suggested Literature:**

1. Essential Laboratory Techniques by S.R. Gallagher, E.A. Wiley.
2. An introduction to Practical Biochemistry by D.T. Plummer.
3. Techniques in Live Sciences by D.B. Tembhare.
4. Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition by Keith Wilson and John Walker, Cambridge University Press.
5. Light Microscopy in Biology: A practical Approach, 2nd Edition by Alan J. Lacey, Oxford University Press.
6. Electron Microscopy: Principles and Techniques of Biologist by John J. Bozzola, Lonnie D. Russell, Jones & Bartlett Publ.
7. Tools and Techniques of Biotechnology by Mousumi Debnath, Pointer Publishers.

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### Paper III COMPARATIVE ANIMAL PHYSIOLOGY THEORY

**Unit-2:** Excretion; Urine formation (Glomerular filtration, Tubular reabsorption and Secretion, Counter current mechanism and Hormonal regulation), acid-base balance and Homeostasis, Circulation; Blood- Composition, Blood Group and Coagulation; Heart-Structure, Origin and Conduction of heart beat and its regulation, cardiac cycle.

**Unit-4:** Thermoregulation; Thermoregulation based animal categories, mechanism of thermoregulation and thermal acclimatisation, Physiology of sense organs; Eyes and Ears

1. Animal Physiology by M. Brown, Apple Academic Press.
2. Animal Physiology by R.C. Sobte, Narosa Publishing House.
3. Animal Physiology by F.R. Haninsworth
4. Comparative Animal Physiology by C.L. Prosser, W.B. Saunders Company.
5. Comparative Physiology of Animal by R.W. Hill; P.D. Sturke.
6. Environmental Physiology of Animals by P. Willmer; G. Stone, Blackwell Science Ltd.
7. General and Comparative Physiology by W.S. Hoar, Prentice Hall of India Pvt. Ltd.
8. Marshall's Physiology of Reproduction by G.E. Lamming, Churchill Livingstone.
9. Neural and Integrative Animal Physiology by C.L. Prosser, Wiley India Pvt. Ltd.
10. Principles of Animal Physiology by J.A. Wilson.

**First Elective- Toxicology and Animal Behaviour**

**Unit-2:** Selective Toxicity, Biotransformation, Bioaccumulation and Biomagnification of Xenobiotics; Antidotal Therapy, Toxicity Tests, Biomonitoring of Toxic Chemicals, Bioindicators.

Bioindicators.

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**Unit-3:** Animal Behaviour; Introduction and Significance of Behaviour; Proximate and Ultimate causes of behavioural evolution; Patterns of behaviour; Communications and animal signals.

**Unit-4:** Reproductive behaviour in animals; Sexual selection, mating patterns and parental care; territorial behaviour, Social behaviour with special reference to insects and Primates; Biological rhythms.

**Suggested literature**

1. Toxicology, Earnest Hodgson.
2. Toxicology and risk assessment principles. Methods and application by Anna M Fan, Louis W Chang, Marcel Dekker, inc, New York.
3. Concept of Toxicology, Dr. Omkar
4. An Introduction to Animal Behaviour by Manning and MS Dawkins Cambridge University Press, UK.
5. Animal Behaviour by John Alcock, Sinaer Association, INC.
6. Animal Behaviour in the Laboratory by P. Silverman, London. Chapman and Hall.
7. Introduction to Animal Behaviour by Rishikesh and Niraj, Campus Bools.
8. Text Book of Animal Behaviour by FB Mannl PH learning Pvt.

**Course Outcomes-** Study is useful to physiochemical and bacteriological sampling and analysis of water quality. An introduction to behavior and mechanisms of behavior, various types of communications. This course also helpful for the study of learning and instincts, conditioning, habituation, sensitization. This course useful in various competitive exams like, UGC-NET, CSIR-NET, Civil service examinations etc.

**Second Elective- Biostatistics, Computational Biology and Bioinformatics**

**Unit-1:** Basic components of computer- hardware (CPU, input, output, storage devices), software (operating systems). Application software:: introduction to M S EXCEL use of worksheet to enter data, edit data, copy data, move data; use of inbuilt statistical functions for computation of mean, S.D., correlation, regression coefficients, etc, use of bar diagrams, histogram, scatter plots etc. graphical tools in excel for presentation of data; introduction to MSWORD word processor- editing, copying, moving, formatting, table insertion, drawing flowcharts, etc; Introduction to PowerPoint, image and data handling.

**Unit-2:** Sampling technique: methods of sampling, choices of sampling methods, sampling and non-sampling errors: tabulation and graphic representation of data; frequency distribution, tabulation, bar diagram, histogram, pie diagram; and their significance and limitations; Measures of Central tendency; Mean, Median, Mode, measures of dispersion: variance and standard variation, coefficient of variation, measures of skewness, coefficient of skewness, kurtosis; probability: theorems on probability, application of permutation and combination

**Unit-3:** Measures of dispersion: variance and standard variation, coefficient of variation, measures of skewness, coefficient of skewness, kurtosis; probability: theorems on probability, application of permutation and combination, Test of significance-t, F, Chi-square test; Correlation and Linear Regression

**Unit-4:** Bioinformatics; Introduction and scope of Bioinformatics, Archiving and retrieval of information; Search engines, databases (Nucleic acid sequences, genomes, protein sequence and structure, bibliographic), Access to molecular biology databases {Entrez, Sequence retrieval system (SRS), Protein identification resource (PRI)}, Sequence alignment and Phylogenetic tree.

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### Suggested literature:

1. Biostatistics by P N Arora and P.K Malhan, Himalaya publishing house
2. Principles of Biostatistics by Pagano M. Gauvreau, K (2000), Duxbury press, USA
3. Fundamental of Biostatistics by I A Khan and A Khanam, Ukaaz publication, Hyderabad
4. Barnes & Grey (ed): Bioinformatics for geneticists, Wiley (2003)
5. Lesk: Bioinformatics, Oxford (2003, Indian ed)
6. Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)

**Course Outcomes-** Introduction to basic components of computers, Software (operating systems) and application software used in biological and statistical studies. An overview of databank search data mining, data management and interpretation. An introduction and learning of Probit Log Analysis for interpretation of toxicity data.

## Semester-I Practical

**Distribution of Marks:**

**Time: 4 hours**

Dissection

Technique/ Instrumentations

Physiology Exercise

Toxicology and Animal behaviour

Spotting (10 spots)

Viva voce

**Total Marks: 100 (25, internal evaluation + 75, external examination)**

General characters and classification of the non- chordates phyla (Protozoa to Echinodermata) with the help of museum specimens and slides.

Protozoa: Vital staining and staining preparation of Paramecium; Permanent preparation of Ceratium, Noctiluca, Vorticella,

Study of prepared slides: Balantidium, Nyctotherus, Opalina. Paramecium conjugation / binary fission, Entamoeba histolytica, Giardia, Trypanosoma, Leishmania, Trichomona.

Porifera: Permanent preparation of gemmules, sponging fibres and different kinds of spicules, Study of museum specimens/models; Lecuosolania, Sycon, Grantia, Euplectella, Hyalonema, Oscarella, Chondrilla, Chliona, Chalina, Spongilla, Spongia, Hippospongia.

Cnidaria and Ctenophora: Permanent preparation of Hydra; Obelia and other hydrozoan colonies and Obelia Medusa ; Study of museum specimens/ models : Tubularia , Bougainvillia, Pennaria, Hydractinia, Sertularia, Campanularia, Millepora, Stylaster, Physalia, Porpita, Varella, Aurelia, Rhizostoma, Tubipora, Alcyonium, Gorgonia, Corallium, Pennatula, Zoanthus, Metridium, Adamsia, Cerianthus, Fungia, Madrepora, Cestum .

Helminths: Study of museum specimens/ whole mounts: Convoluta, Dugesia, Bipalium, Fasciola, Paramphistomum, Schistosoma, Taenia, Moniezia, Echinococcus, Trichuris,

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Trichinella, Heterodera, Enterobius, Ascaris, Ancylostoma, Dracunculus, Wuchereria; study of prepared slides: Scolex of tape worm, mature and gravid proglottid of tape worm; Study of cysticercus larva, hydatid cyst, larval stage of Fasciola.

Annelida: Study of museum specimens/models: Aphrodite, Tomopteris, Glycera, Chaetopterus, Arenicola, Sabella, Amphitrite, Serpula, Tubifex, Branchiobdella, Eisenia, Metaphire, Placobdella, pontobdella Branchellion, Polygordius,: Study of prepared slides: T.S. of body of leech passing through various places.

Arthropoda: Study of museum specimen: Limulus, Palamnaeus, Lycosa, Apus, Argulus, Balanus, Sacculina, Mysis, Gammarus, Squilla, Prawn, Lobster, true crab, hermit crab, Julus, Scolopendra, Scutigera, Lepisma, Mantis, stick insect, grass hopper, termites, Forficula, Pediculus, Ranatra, Dysdercus, Musca, Lady bird beetle, butterfly, wasp, Xenopsylla, life history of honey bee, lac insect and silk moth; Study of prepared slides: Mouth parts of mosquitoes, house fly, honey bee, butterfly, Sarcoptes, Ixodes, Cimex, Daphnia, Cypris, Cyclops, Pediculus, Pthirus.

Mollusca: Study of museum specimen/models: Chiton, Dentalium, Pila, Aplysia, Baccinum, Doris, Lymnaea, Mytilus, Patella, Pecten, Limax, pearl oyster, Teredo, Nautilus, Loligo, Sepia, Octopus. Study of prepared slide: Radula, T.S of shell of Unio, T.S of gill lamina of Unio, T.S of body of Unio passing through middle region; Larvae of molluscs.

Echinodermata: Study of museums specimen/ models: Astropecten, Asterias, Ophiothrix, Ophiura, Echinus, Clypeaster, Echinocardium, Thyone, Holothuria, Antedon; Study of prepared slides: Larvae of echinoderms: Aristotle's lantern. Hemichordata : Study of museum specimens: Balanoglossus, Cephalodiscus: Tornaria larva, Minor phyla: Representative specimens of Onychophora (Peripatus), Sipunculida (Sipunculus), Echiurida (Bonellia)

Dissection: Nervous system of Pila, Unio, Aplysia, Loligo, Palaemon, Squilla

Basic principles and functioning of Microtomy, Spectrophotometry, Paper chromatography, Centrifugation.

To identify different amino acids in a mixture using paper chromatography.

Bleeding and clotting time, Preparation of Haemin crystals, Determination of Haemoglobin percentage, Total count of Leucocytes, Differential Leucocyte Count, Blood group determination.

**First Elective Practical:** Effect of ammonia and mercury on rat, Study of geotaxis/phototaxis behavioural responses of the animal provided (*Musca domestica*).

**Second Elective Practical:** Measure the pre and post clitellar lengths of earthworms and calculate mean, median, mode, standard deviation etc. Measure the height and weight of all students in the class and apply statistical measures. To learn the basics of computer applications. To learn sequence analysis using BLAST. To learn Multiple sequence alignment using CLUSTALW. To learn about Phylogenetic analysis using the programme PHYLIP.

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## **SEMESTER-II**

### **PAPER-I CHORDATES: GENERAL ACCOUNT THEORY**

**Unit-I:** Protochordates and Pisces: General organization and affinities of Hemichordata, Urochordata and Cephalochordata, Characteristic features and affinities of Cyclostomes, General organization of fishes: General organization and affinities of Ostracoderms, Dipnoi and Coelocanth.

**Unit-II:** Amphibia: Origin of Tetrapods, General organization of Anura, Neoteny and Parental care. Reptilia: Origin and Evolution, Adaptive radiation, Dinosaurs, Crocodilia, Poisonous snakes and their venom

**Unit-III:** Aves: Origin and Evolution, Flightless birds, Adaptations for flight, Migration in Birds

**Unit-IV:** Mammalia: Origin of Mammals, Adaptive radiation in Eutheria, Uterus modifications, Aquatic mammals

#### **Suggested literature:**

1. Harvey et al: The Vertebrate Life (2006)
2. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backbone animals through time (5th ed 2002, Wiley - Liss)
3. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
4. Kenneth V. Kardong (2015) Vertebrates: Comparative Anatomy, Function, Evolution McGraw Hill
5. McFarland et al: Vertebrate Life (1979, Macmillan Publishing)
6. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)
9. Neilsen (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford

#### **Course outcomes:**

The student at the completion of the course will be able to:

- demonstrate comprehensive identification abilities of chordate diversity
- explain structural and functional diversity of chordate
- explain evolutionary relationship amongst chordate

### **PAPER-II SYSTEMATICS AND EVOLUTION THEORY**

**Unit-I:** Definition and basics concept of biosystematics & Taxonomy: Historical aspects of systematic and its importance and applications in biology; Trends in biosystematics: concepts of different conventional and newer aspects – chemotaxonomy, cytotoxonomy, ethotaxonomy, molecular taxonomy, numerical taxonomy.

**Unit-II:** Dimensions of speciation and taxonomic characters: type of lineage changes, production of additional lineage, species concepts – species category, different species concepts, subspecies and infraspecific categories, theories of biological classification, hierarchy of categories, taxonomic and non-taxonomic character

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**Unit-III:** Procedures in taxonomy: collection, preservation and identification, taxonomic keys- different kinds of taxonomic keys their merits and demerits, systematic publications. Different kinds of publications, type concept – different zoological types, international code of zoological nomenclature (ICZN) –its operative principles, interpretation and application of important rules, zoological nomenclature, formation of scientific names of various taxa.

**Unit-IV:** Darwinian and pre-Darwinian concepts of evolution : Birth of concept of organic evolution; Lamarckian theories , Darwin's theory of natural selection : merits and demerits , Neodarwinian concepts and sources of variation : post – Darwinian concepts of evolution: Gradualistic vs. Non-gradualistic theories, Mayr's Founder Principle , Gould's punctuated equilibrium theory , Kimura's neutral theory , Endo-symbiotic theory of Margulis, contemporary views ; Neo- Lamarckism, Neo – Darwinism, Modern synthetic theory of evolution. Isolation and speciation; Genes in population; Hardy Weinberg Law and Sewell Wright effect, micro evolution, macro evolution and mega evolution, Evolution in action.

**Suggested Literature:**

1. Biology Systematics by A. Mielli, Chapmon and Hall
2. Evolution by Hall and Hallgrimsson , johnsn and Bartlett publisher
3. Evolution by mark ridley. Blackwell science
4. Evolution by barton N.H. briggs, D.E.G., Eisen J.A., Goldstein, A.E. Ptel, N.H., cold spring Harbor Laboratory press New York, U.S.A.
5. Evolution by futuyma, D.J., sinauer associates inc., sunderland , USA
6. Evolution by Hall, B.K. and Hallgrimsson, B. Jones and Bartlett publisher, Sudbury, USA
7. Evolution analysis by Freeman and Herron, Person /prentice hall
8. Methods and principle of systematic Zoology by E.Mayer , E.G.Linsley , R.L. vsinger, McGraw – Hill Book Company , ICN
9. Numerical Taxonomy by joseph felsentein, springer – verlag Berlin Heidelberg New York
10. Procedure in Taxonomy by E.T.Schenk and J.H.Mc.Masters , Standford University Press Standford , California
11. Taxonomy ; A text and reference book by r.e,blackwelder , john wiley and sons , INC
12. What evolution is by mayr E. Basic Books , new York , USA

**Course outcomes:**

The study of the DNA fingerprinting & Molecular markers for detection evaluation of polymorphism, RFLP, PAPD etc and numerical taxonomy, for useful to student for research methodology and further study of research work in different topics. This course is useful in various competitive exams like CSIR-NET etc.

**PAPER-III CELL BIOLOGY  
THEORY**

**Unit-I:** Structure and function of Membrane & Cytoskeleton: Biomembranes and architecture: lipid bilayer and protein components • Microfilaments: actin structures, myosin powered cell movements • Intermediate filaments: Organization & function • Microtubules: Organization and dynamics, Kinesin and dynein powered movements

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L. Singh, 25.1.23, and other illegible signatures.



**Unit-II:** Endomembrane system and intracellular trafficking; Compartmentalization in eukaryote cells • Gated transport between nucleus & cytosol • Structure of nuclear pore complex • Signal sequences & sorting transporters • Role of monomeric GTPases in protein sorting • Protein sorting to ER and mitochondria. • Vesicular trafficking, secretory pathways, receptor mediated endocytosis

**Unit-III:** Cellular communication; General principles of cell communication • Extracellular matrix and Cell adhesion, Cell signalling • Signalling molecules and cell-surface receptors (G-protein coupled receptors, Ion-channel linked receptors, Enzyme linked receptors • Second messengers • Regulation of signalling pathways, JAK-STAT pathway, MAP Kinase pathway

**Unit-IV:** Cell cycle and Cell division; Cell cycle overview and control • Checkpoints in cell-cycle regulation • Regulation of Mitosis and Meiosis • Cancer and apoptosis

**Suggested literature:**

1. Lodish et al: Molecular Cell Biology: Freeman & Co, USA (2004).
2. Alberts et al: Molecular Biology of the Cell: Garland (2002).
3. Cooper: Cell: A Molecular Approach: ASM Press (2000).
4. Karp: Cell and Molecular Biology: Wiley (2002). Pierce B. Genetics. Freeman (2004).
5. Lewin B. Genes VIII. Pearson (2004).
6. Watson et al. Molecular Biology of the Gene. Pearson (2004).

**Course outcomes:**

The course will lay down the foundation of biochemistry among students where they will develop a deep understanding of structure of biomolecules like proteins, lipids and carbohydrates and how simple molecules together form complex macromolecules. They will be able to understand the thermodynamics of enzyme catalysed reactions and mechanisms of energy production at cellular and molecular levels.

**First Elective- Immunology**

**Unit-I:** Types of Immunity (Innate, Adaptive, humoral, cell-mediated), Cells of Immune system (B & T lymphocytes, Phagocytes, Granulocytic cells, Mast cells, NK Cells, Dendritic cells), Organs of Immune system- (Primary and secondary lymphoid organs- Thymus, marrow, Bone lymph nodes, spleen, MAST), Generation of B & T cell responses

**Unit-II:** Immunoglobulins (structure, Types/Classes & functions) Epitopes Maturation, differentiation and activation of BCR and TCR Monoclonal and polyclonal antibodies Antibody diversity Organization & Expression of Immunoglobulin genes

**Unit-III:** Antigen antibody interactions (Agglutination Reactions, Precipitation Reactions, cross reactivity, Antibody affinity and avidity, immune florescence, flow cytometry, western blotting, immune electron microscopy, RIA, ELISA and it's types)

*Devi Singh*  
*Ramesh*  
*25.1.23*  
*Deep*

**Unit-IV:** Antigen: types, processing & presentation, Major Histocompatibility complex: classes, structure, expression, immune responsiveness, and disease susceptibility (HLA) Complement system—classical, alternative, lectin pathways, Vaccine

**Suggested literature:**

1. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby (2007) Kuby Immunology. W H Freeman
2. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. (2017). Roitt's Essential Immunology, 13th Edition. Wiley Blackwell
3. Immunology by Ian. R. Tizard Saunders college Publishing Chicago, New York.
4. Nandini Shetty (2005) Immunology Introductory Textbook. New Age International.

**Course outcomes:**

The student at the completion of the course will be able to understand:

- the scientific reasoning exhibited in experimental life science.
- an in depth understanding about Immune System & it's elaborate mechanisms.
- state of art information about recent trends in Immune therapy in case of several diseases like cancer, hepatitis etc

**Second Elective- Histology and Histochemistry**

**Unit-I:** Fixation and Fixatives. Types of fixatives. Chemistry of fixation. Choice of Fixatives. Tissue processing. Dehydration. Clearing and Embedding.

**Unit-II:** Microtomy. Types of microtomes. Sectioning paraffin blocks. Staining of paraffin sections. Principle and methods of staining. Histological stains. Haematoxylin and Eosin.

**Unit-III:** Principles and methods of histochemical localization and identification of the following: Carbohydrate moieties Glycogen and glycoproteins with oxidizable vicinal diols by Periodic acid Schiff method Glycoproteins with carboxyl groups and/or O-sulphate esters by Alcian blue methods  
Protein end groups General proteins by Bromophenol blue method-NH<sub>2</sub> groups by Nihydrin-Schiff method - SS groups by Performic acid -Schiff and performic acid- alcian blue methods

**Unit-IV:** Principles and methods of histochemical localization and identification of the following: Lipid moieties General lipids by Sudan black B method Neutral lipids by total Sudan III and Sudan IV methods Nucleic acids Methyl green pyronin for DNA and RNA Feulgen reaction for DNA Enzymes: Acid and alkaline phosphatases by Metal precipitation and Azo dye methods. Immunocytochemistry: Basic principles. Fluorescence histochemistry: Basic principles

**Suggested literature:**

1. Bancroft, J.D. & Stevens, A. Theory and Practice of Histological techniques, ChurchillLivingstone, 2002
2. Casselman, W.G.B. : Histochemical techniques, John Wiley, 1959
3. Pearse, A.G.E.: Histochemistry; Theoretical and Applied (Vol. I, II & III), (4th ed.), ChurchillLivingstones, 1980-1993

*Handwritten signatures and notes:*  
A large signature on the left, possibly "Devi".  
In the center, "Alcane" is written above "25-1.23".  
On the right, there is a signature that looks like "George" followed by a checkmark and another signature.



### Course outcomes:

The student at the completion of the course will be able to understand:

- the basic histological tools and techniques.
- use of various histo-chemicals to perform a variety of experiments.
- the methods to design and perform experiments on their own.

## Semester-II Practical

### Distribution of Marks:

Time: 4 hours

Dissection

Systematics and Evolution

Cell Biology Exercise

Immunology

Histology and Histochemistry

Spotting (10 spots)

Viva voce

**Total Marks: 100 (25, internal evaluation + 75, external examination)**

General character and classification of chordate phyla. Urochordata : study of museum specimens/ whole mount : oikopleura, Herdmania, Ascidia, pyrosoma, doliolum, salpa. Cephalochordate: study of museum specimen: Branchiostoma. Cyclostomata : study of museum specimens /models : peltromyzon, Myxine; Ammocoete larva. Pisces: study of museum specimens/ models : sphyra (hammer-headed shark), Trygon, (string-rays), pristis, Raja (skate), Torpedo (electric-rays), chimaera, polypterus, Acipenser, polydon, Amia, Lepidosteus, hilsa, harpodon, notopryer, labeo, catla, cyprinus, cirrhina, ariys, heteropneustes, clarias, wallago, mystus, Anguilla, exocoeteus, hippocampus, channa, amphiprion, anabas, synaptura, echeneis, neoceratodus, protopterus, lepidosiren; study of disarticulated bone of carp. Amphibia: Study of museum specimen /models : Ichthyophis, uraeotyphlus, cryptobranchus, ambystoma, axolotl, larva, salamandra, amphiuma, triturus, proteus, Necturus, siren, alytes, bufo, hyla, rhacophorus, study of disarticulated bone to frog. Reptilia : Study of museum specimen/models chelone, kachuga, sphenodon, hemidactylus, calotes, draco, phrynosoma, iguana, heloderma, varanus, ophisaurus, typhlops, python, natix, ptyas, dendrophis, bungarus, naja, russle's viper, pit viper, hydrophis, cerotatus, crocodilus, alligator, gavialis, ichthyosaurus, dromaeon, brontosaurus, tyrannosaurus, stegosaurus, study of disarticulated bones of varanus. Aves : Study of museum specimens / models : Archaeopteryx, Milvus (kite), gyps (vulture), Pavo (peacock), Columba (pigeon), eudynamis (koel), psittacula (parrot), bubo (owl), coracias (nilkanth), dinopium (woodpecker), house sparrow, corvus (crow); study of disarticulated bones of fowl. Mammalians : study of museum specimens / models : echidna, ornithorhynchus, macropus, erinaceus, shrew, pteropus, bat, loris, manis, hystrix, funambulus, rattus, oryctolagus or lepus, herpestes, lutra, (otter), civet cat, macaca, study of disarticulated bones of rabbit, skull of dog.

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To study different cell types such as buccal epithelial cells, neurons, striated muscle cells using Methylene blue. To study the different stages of Mitosis in root tip of onion. To study the different stages of Meiosis in grasshopper testis.

**Immunology lab:** Examination of Peripheral blood smears for blood cells, demonstration of Western Blot Analysis and ELISA, Immunofluorescence staining of B and T Cells

**Histology and Histochemistry lab:** Microtomy and staining: Hematoxylin-eosin – Demonstration, Histopathology: Study of histopathological changes (permanent slides) – gastric ulcers, cirrhosis of liver, breast tumors, cystic follicles of ovary, pancreas in diabetics, cryptorchid testis and leukemia. Histochemistry: Histochemical localization of glycogen in rat/mouse liver by Bauer Feulgen technique.

Adm L.H

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Rendk  
25-1-23