Mahatma Gandhi University, Nalgonda.
(For Affiliated colleges)
M.Sc. Zoology CBCS Schema (with effect from 2023-24 A.Y.)

	SEMESTER- I				
PAPERS	Subject title with code	Workload/week	Credits	Internal exam marks+ Assignment+ Seminar	External exam marks
1	ZL_101T: STRUCTURAL BIOLOGY [SB] (core)	4	4	20+5+5	70
2	ZL_102T: ENVIRONMENTAL AND CONSERVATION BIOLOGY [ECB] (core)	4	4	20+5+5	70
3	ZL_103T: IMMUNOLOGY [IMM] (core)	4	4	20+5+5	70
4	ZL_104T: ADVANCES IN TAXONOMY AND FUNCTIONAL ANATOMY OF INVERTEBRATES [ATFAI] (core)	4	4	20+5+5	70
5	ZL_105P: **Practical – I:** SB & IMM	6 (+6@)	3	--	75
6	ZL_106P: **Practical – II:** ECB & ATFAI	6 (+6@)	3	--	75
	Total	28 (+12@)	22	120	430
	SEMESTER- II				
PAPERS	Subject title with code	Workload/week	Credits	Internal exam marks+ Assignment^+ Seminar	External exam marks
1	ZL_201T: TOOLS,TECHNIQUES AND BIOSTATISTICS [TTB] (core)	4	4	20+5+5	70
2	ZL_202T: ANIMAL PHYSIOLOGY [AP] (core)	4	4	20+5+5	70
3	ZL_203T: MOLECULAR GENETICS AND DEVELOPMENTAL BIOLOGY [MGDB] (core)	4	4	20+5+5	70
4	ZL_204T: EVOLUTION AND FUNCTIONAL ANATOMY OF VERTEBRATES [EFAV] (core)	4	4	20+5+5	70
	Add on paper: (a) Human Values and Professional Ethics / (b) Communicative Skills and Soft Skills	2	2	10+5^	35
5	ZL_205P: **Practical – I:** TTB & AP	6 (+6@)	3	--	75
6	ZL_206P: **Practical – II:** MGDB & EFAV	6 (+6@)	3	--	75
	Total	30 (+12@)	24	135	465
	SEMESTER -III				
PAPERS	Subject title with code	Workload/week	credits	Internal exam marks+ Assignment^+ Seminar	External exam marks
1	ZL_301T: SYSTEMS BIOLOGY [SMB] (core)	4	4	20+5+5	70
2	ZL_302T: RESEARCH METHODOLOGY [RM] (core)	4	4	20+5+5	70
3	ZL_303T:Elective-IA: Comparative Animal Physiology-I (CAP-I) / IB: Medical Entomology-I (ME-I) (optional)	3(+3$)	3	15+5+5	50
4	ZL_304T: Elective-IIA: Endocrinology (EN) / IIB: Agricultural Entomology-I (AE-I) (optional)	3(+3$)	3	15+5+5	50
	#Inter Disciplinary paper (ID paper) Evolutionary Biology and Population Genetics (EBPG)	2	2	10+5^	35
5	ZL_305P: **Practical – I:** SMB & RM	6 (+6@)	3	--	75
6	ZL_306P: **Practical – II:** Elective-IA/IB & Elective-IIA/IIB	6 (+6@)	3	--	75
	Total	28 (+6$) (+12@)	22	125	425
	SEMESTER -IV				
PAPERS	Subject title with code	Workload/week	Credits	Internal exam marks+ Assignment+S eminar	External exam marks
1	ZL_401T: ANIMAL BIOTECHNOLOGY [AB] (core)	4	4	20+5+5	70
2	ZL_402T: FISH BIOLOGY [FB] (core)	4	4	20+5+5	70
3	ZL_403T: Elective –IA: Comparative Animal Physiology-II (CAP-II) / IB: Agricultural Entomology-II (AE-II) (optional)	3(+3$)	3	15+5+5	50
4	ZL_404T: Elective – IIA: Applied Toxicology(AT) / IIB: Zoonotic Viral Diseases (ZVD) (optional)	3(+3$)	3	15+5+5	50
5	ZL_405P: **Practical-I:** AB & FB	6 (+6@)	3	--	75
6	ZL_406 P: **Practical – II:** Elective-IA/IB & Elective-IIA/IIB	6 (+6@)	3	--	75
7	ZL_407: Project	%	4	--	100
	Total	26 (+12@)	24	110	490

	Sem-I	Sem-II	Sem-III	Sem-IV	Total
No. of credits	22	24	22	24	92
Marks	550	600	550	600	2300
Total work load of Sem-I & Sem-III					*54 (+6$) (+24@)
Total work load of Sem-II & Sem-IV					*54 (+6$) (+24@)

Note *Work load without Add on paper, ID paper and seminars, #ID paper is offered by Dept. of Zoology and can be opted by other course students (not for M.Sc. Zoology course students), @ batches are made for practicals, if students' number increases more than 20, $=if two optionals are opted by different group of students, %1Hr/week workload for handling project work (individual/group) per faculty

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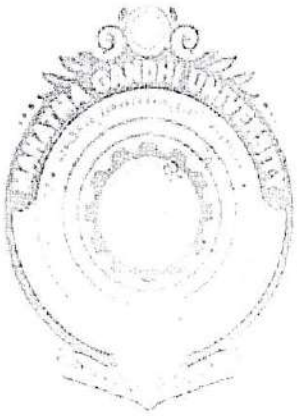
M.Sc. Zoology Syllabus

For Affiliated Colleges

With effect from 2023 - 2024 A.Y.



Mahatma Gandhi University

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. ZOOLOGY, Semester I
CORE PAPER-I: Structural Biology [SB]

UNIT I–Basic concepts of Biomolecules and Structural Biology **15Hrs**

1.1 Biomolecules and their significance – carbohydrates, proteins, amino acids, nucleic acids, and lipids.

1.2 Chemistry and structure of mono, oligo, and polysaccharides. Deoxy sugars, amino sugars, and glycosides.

1.3 Classification & structures of aminoacids(20 standard aminoacids structures) and proteins (primary, secondary, tertiary and quaternary)

1.4 Classification, structure and function of lipids, fatty acids, triglycerides; Phospholipids, cerebrosides and steroids.

1.5 Nucleic acids – Structure of DNA and RNA.Biological importance of free nucleotides, DNA polymorphism and types of RNA.

UNIT II–Enzymes and Metabolism **15 Hrs**

2.1 Classification, nomenclature and properties of enzymes – catalysis and energy of activation; Enzyme kinetics, Michaelis–Menten Constant (Km values) and LB plot; Mechanism of enzyme action and Regulation of enzyme activity.

2.2 Metabolism of carbohydrates –Biological oxidation; Glycolysis; TCA cycle; Role of respiratory chain in energy capture; ATP synthesis, Gluconeogenesis.

2.3 Metabolism of amino acids – Transamination, Deamination and Decarboxylation.

2.4 Oxidation and biosynthesis of fatty acids.

2.5 Metabolic disorders of different biomolecules (carbohydrates, proteins, lipids).

UNIT III–Cellular Organization **15 Hrs**

3.1 Molecular organization of cell membranes

3.2 Cell permeability – Transport across the cell membrane; transport of small molecules; Carrier proteins; Na^+-K^+ pumps and membrane bound enzymes.

3.3 Cell communications – Inter cellular communication and gap junctions; chemical signalling between the cells and strategies of chemical signalling.

3.4 Signalling mediated by intracellular receptors; signalling mediated cell surface receptors – second & third messengers and their importance; cAMP, G-proteins, Ca^{++}, Inositol Triphosphate (IP_3) and Prostaglandins.

3.5 Cell cycle; molecular events in cell cycle. Regulation of cell cycle.

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UNIT IV – Synthetic Biology **15 Hrs**

4.1 DNA replication – semi conservative method. Enzymes of DNA replication, replication of circular DNA, initiation, elongation and termination of replication process. Proof reading function of DNA polymerases.

4.2 Enzymatic synthesis of RNA; Genetic code-Wobble's concept, transcription in prokaryotes and eukaryotes and post transcriptional processing.

4.3 Protein synthesis – Translation in prokaryotes and eukaryotes andpost translational changes.
4.4 DNA repair mechanism – High fidelity of DNA sequence – Repair of damage caused by UV light. Eukaryotes repair systems:CRISPR-Cas9 definition and applications.
4.5 Synthetic genomics- Basic theoretical and computational modelling of the replication system.

PRACTICALS

1. Determination of proteins by Biuret method/ Folin phenol method.
2. Determination of glucose by nelson- somogyi/ Anthrone method.
3. Determination of lipids by Vanillin method
4. Determination of glycogen by Kemp's method
5. Estimation of cholesterol
6. Determination of enzyme activities of SDH and LDH
7. Effect of substrate concentration and pH on SDH activity
8. Protein fractionation using sodium sulphate
9. Estimation of DNA and RNA
10. Electrophoretic analysis of proteins/DNA
11. Feulgen reaction method for DNA localization.
12. Preparation and characterization of a synthetic molecule
13. **Submission of assignment on:** structure of Biomolecules-Carbohydrates, Amino acids, Proteins,

Lipids, Nucleic acid; mechanism of enzyme action, Metabolic cycles, DNA, RNA, protein synthesis.

[To be submitted at the time of Practical Examination – 10 Marks]

PRACTICAL EXAM MODEL (75M - duration of 3hrs):

Q1. Determination of concentration of protein/glucose/lipids/glycogen/Determination of SDH and LDH enzyme activity **20 Marks. (Major)**
Q2. Estimation of Cholesterol/DNA/RNA **15 Marks. (Minor-I)**
Q3. Spottings **(Minor-II)** **10 Marks.**
Q4. Submission of Assignment **10 Marks.**
Q5. Certified Practical record **10 Marks**
Q6. Viva-voce **10 Marks.**

Suggested Books

1 Textbook of Biochemistry by Harper.
2. Textbook of Biochemistry by Lehninger.
3. Textbook of Biochemistry by Stryer and Stryer.
4. Textbook of Biochemistry by Conn and Stumpf.
5. Textbook of Biochemistry by A.B.V. Rama Rao.
6. Cell and molecular biology by De Robertis and De Robertis, 8th ed.

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7. Molecular Biology by Friefielder.
8. Molecular cell biology by Darnell, Lodish and Baltimore (Scientific American Books).
9. Molecular biology by H. D. Kumar.
10. Biochemistry and molecular biology by W. H. Elliot and D.C. Elliot (OUP Press).
11. Molecular Biology of Cell by Bruce Alberts et al.
12. Cell by Karp.
13. Synthetic Biology - Tools and Application by Humin Zhao

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MAHATMA GANDHI UNIVERSITY, NALGONDA
M.Sc. ZOOLOGY, Semester I
CORE PAPER-II: Environmental and Conservation Biology [ECB]

UNIT I – Basic concepts of Ecology 15 Hrs

1.1 Types of ecosystem – freshwater, marine and terrestrial.
1.2 Laws of limiting factor, Laws of minimum, Laws of Tolerance and Tragedy of commons.
1.3 Micronutrients and macronutrients.
1.4 Population characteristics and dynamics – conceptual approach.
1.5 Growth curves and pyramids: sigmoid curve, J curve and hyperbola; logistic equation and concepts relating to growth.

UNIT II – Community Organization and Structure 15 Hrs

2.1 Community analysis, species diversity, ecotone concept and edge effect; interaction between environment and biota habitat and ecological niche and niche overlap; the concept of biome.
2.2 Concepts of productivity; eutrophication of lakes; biological indicator and water quality.
2.3 Ecosystem dynamics and management; stability and complexity of the ecosystem
2.4 Biogeochemical cycles; inorganic pollutants and their impact-SO_x, NO_x, CO, Phosphates, heavy metals (Arsenic, Lead and Mercury); radioactive nucleotides and their impact on the biological system.
2.5 Greenhouse effect, Ozone depletion, Fluorosis and microplastic pollution.

UNIT III - Biogeography of India, Habitats and Resources 15 Hrs

3.1 Classical concepts of biogeography – continental drift, endemism andrefugia.
3.2 Biogeographical regions of India and their salient features.
3.3 Classification, function and values of habitats – Freshwater wetlands, deserts, grasslands and forests.
3.4 Concepts of natural resources – renewable and non-renewable resources.
3.5 Overexploitation of resources – deforestation, water table depletion and land degradation.

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UNIT IV - Natural Resource Management 15 Hrs

4.1 Environmental Impact Assessment – principle, scope and purpose.
4.2 Role of ecological restoration in conservation; displacement and settlement of local communities.
4.3 Major conservation movements in India; NGOs in conservation efforts.
4.4 Community diversity resources use and management; conflict management and resolution.
4.5 National legislations for protecting biological resources – Biodiversity Act, 2002 and Biodiversity
Rules, 2004.

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PRACTICALS

1. Draw the biogeographical regions of India and provide in brief the salient features of each Biogeographical zone.
2. Estimation of total alkalinity of water and soil.
3. Estimation of phosphates in the water sample.
4. Estimation of nitrates and nitrites in the water sample.
5. Estimation of magnesium in the water sample.
6. Estimation of calcium in the water sample.
7. Biological indicators of water quality and their population dynamics – collection of the water sample.
8. Identification of zooplankton, and their ecological significance.
9. Enumeration and identification of the fresh water biodiversity of the local habitats.
10. Enumeration and identification of the terrestrial biodiversity of the local habitats.
11. Estimation of particulate matter in the air.
12. **Submission of assignment on:** Growth curve-pyramids: Productivity - Eutrophication: Biogeographical regions: Legislation: Population dynamics: Biogeochemical cycles: Lake status in the surrounding area: Overexploitation of resources-any resources study on any one-Biogeographical regions of India: Major conservation movements in India NGO in conservation. (To be submitted at the time of Practical Examination- 10 Marks)

Suggested Books

1. Caughley, G., and A. Gunn. 1996. Conservation Biology in Theory and Practice. Blackwell Science.
Cambridge, Massachusetts, U.S.A.
2. Cox, G. W. 2005. Conservation Biology: Concepts and Applications. McGraw-Hill, Dubuque, Iowa.
U.S.A.
3. Dasmann, R., 1981. Wildlife Biology, 2nd ed, John Wiley and Sons, NY
4. Dobson, A. P. 1996. Conservation and Biodiversity. Scientific American Library, New York.
New York,
U.S.A.
5. Jeffries, M. J. 1997. Biodiversity and Conservation. Routledge, New York, New York, U.S.A.
6. Mills, L. Scott 2006. Conservation of Wildlife Populations. Blackwell Science, Oxford, U. K.
7. Milner-Gulland, E. J., and R. Mace. 1998. Conservation of Biological Resources. Blackwell Science,
Oxford, U.K.
8. Morris, W. F., and D. F. Doak2002. Quantitative Conservation Biology: Theory and Practice of
Population Viability Analysis. Sinauer Associates, Sunderland, Massachusetts, U.S.A.
9. Sinclair, A. R. E., J. M. Fryxell, and G. Caughley2006. Wildlife Ecology, Conservation, and Management. Blackwell Publishing

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10. Soulé ME (ed) 1986. Conservation biology: the science of scarcity and diversity- Sinauer, Sunderland.
11. Bram F. Noble 2005. Introduction to Environmental Impact Assessment: A Guide to Principles and
Practice. Oxford University Press. London.
12. John A. Wiens and Michael R. Moss 2005. Issues and Perspectives in Landscape Ecology. Cambridge
University Press, London.
13. Aparna Sawhney 2004. The New Face of Environmental Management in India. Ash gate Publishing
Ltd., Sheffield.

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MAHATMA GANDHI UNIVERSITY, NALGONDA
M.Sc. ZOOLOGY, Semester I
CORE PAPER III: IMMUNOLOGY (IMM)

UNIT I – Introduction to Immunology
15 Hrs

1.1 Evolution of Immune system –invertebrates and vertebrates

1.2 Immune system – Innate and adaptive immunity.

1.3 Innate & Adaptive Immunity. Humoral mediated immunity and cell- mediated immunity

1.4 Cells involved in immune system: the role of macrophages in immunity, Major Histocompatibility complex (MHC).

1.5 The Lymphoid system – primary and secondary lymphoid organs, lymphatic traffic.

UNIT II – Immunoglobulins and Complement System
15 Hrs

2.1 Antigens nature, epitope, haptens, antigen presenting cells, adjuvants.

2.2 Immunoglobulins structure, function and classification of antibodies.

2.3 Monoclonal antibodies and their applications.

2.4 Immunological techniques - ELISA, FISH and GISH.

2.5 Complement system – Components of complement system, pathways - classical and alternative, biological consequences of complement activation and complement significance.

UNIT III –Disorders of Immune system
15Hrs

3.1 Hypersensitivity – Classification of hypersensitivity reactions: Type-I – Anaphylactic hypersensitivity: Type – II Antibody – mediated cytotoxic hypersensitivity.

3.2 Type-III – Immunocomplex mediated hypersensitivity:Type – IV Cell mediated (Delayed) hypersensitivity.

3.3 Autoimmune diseases – Organ specific auto immune diseases – Grave's disease, insulin–dependent *diabetes mellitus* (type I diabetes).

3.4 Autoimmune diseases – Systemic autoimmune diseases – Systemic Lupus Erythematosus (SLE), Rheumatoid arthritis.

3.5 Immunodeficiency disorders- Severe combined immunodeficiency (SCID), Chronic Granulomatous Disease (CGD), Leukaemia and Hepatitis.

UNIT IV – Transplantation and Tumour Immunology
15 Hrs

4.1 Transplantation – Barriers to transplantation.

4.2 Genetic predisposition for graft rejection, prevention of rejection.

4.3 Immunity to infection – Parasites- nature of interaction: immunopathological considerations

4.4 Immunity to infection – viruses, bacteria, fungi- nature of interaction: immunopathological considerations

4.5 Tumour immunology – Immunity to tumours, tumour specific antigens; and Immunosurveillance.

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PRACTICALS

1. Slide agglutination test- A, B, O blood groups.
2. HIV test (Tridot method)
3. RDT Kit for Malaria/ Dengue (Source for kit-NVBDCP).
4. RPR Test for Syphilis (Precipitation)
5. Widal Test for diagnosis of Enteric fever.
6. Blood smear preparation and identification of lymphocytes.
7. Identification of histological slides of lymphoid tissues - Spleen, thymus, lymphnode and bone marrow.
8. Single Radial immune diffusion for estimating the concentration of antibodies and antigens.
9. Immunization schedules and rising of antibodies.
10. Demonstration of Immunoelectrophoresis.
11. **Submission of assignment on:** structure of immune cells, antibodies, antigen-antibodies

Reactions, Immunological techniques (ELISA, RIA, Immunoprecipitation- FISH and GISH).

Monoclonal antibodies, MHC, Hypersensitivity types, Transplantation and Tumour immunology.

(To be submitted at the time of Practical Examination- 10 Marks)

Suggested Books

1. Immunology, Kuby, W.F.Freeman, U.S.A.
2. Fundamentals of Immunology,W.Paul.
3. Essential of Immunology,I.M.Roitt.
4. Immunology A Foundation Test, Basiro Davey.,
5. An introduction to Immunology, Ian R.Tizard.
6. Milstein, C .Monoclonal antibodies. Sci. Amer. 243: 66-74.
7. Immunology" by Dulsy Fatima and N Arumugam.
8. Cellular and Molecular Immunology, Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai.
9. Immunology Made Ridiculously Simple, Masood Mahmoudi.
10. Ahmed R., Gray D. Immunological memory and protective immunity: understanding their relation. Science. 1996; 272:54–60. [PubMed].

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ASST. PROFESSOR

MAHATMA GANDHI UNIVERSITY, NALGONDA
M.Sc.-ZOOLOGY, Semester-I
CORE PAPER-IV: Advances in Taxonomy and Functional Anatomy of Invertebrates
[ATFAI]

UNIT I – Advances in Taxonomy

15 Hrs

1.1 Basic concepts of biosystematics, taxonomy and classification; Branches of taxonomy Cytotaxonomy, Chemotaxonomy,
Numerical taxonomy and Cladistics taxonomy.

1.2 Taxonomic hierarchy of ranks; species concepts- Biological, Evolutionary and Phylogenetic.

1.3 Recent trends in biosystematics- Molecular taxonomy and Integrative approaches.

1.4 International Code for Zoological Nomenclature (ICZN) – Operative principles, interpretation and application of important rules.

1.5 Zoological Types; Scientific names and their basis.

UNIT II– Lower Invertebrates

2.1 Concepts of Prokarya and Eukarya; Concepts of Protostomia and Dueterostomia.

15 Hrs

2.2 Reproduction and development in Cnidaria.

2.3 Reproduction, development and larval forms of Platyhelminthes.

2.3 Host – parasite relationship and their interaction.

2.5 Filter feeding in invertebrates- Porifera, Polychaeta and Mollusca.

UNIT III - Higher Invertebrates

15 Hrs

3.1 Respiration in Annelida and Mollusca.

3.2 Shell and foot and their functions in Mollusca;

3.3 Evolutionary and phylogenetic significance of crustacean larval forms.

3.4 Evolutionary and phylogenetic significance of echinoderm larval forms.

3.5 Eusociality in insects; Autonomy and regeneration in echinoderms.

UNIT IV - Minor Phyla

15 Hrs

4.1 Systematic position, general organization and affinities of Ctenophora.

4.2 Systematic position, general organization and affinities of Nemertea.

4.3 Systematic position, general organization and affinities of Rotifera and Acanthocephala.

4.4 Systematic position, general organization and affinities of Bryozoa and Entoprocta.

4.5 Systematic position, general organization and affinities of Chaetognatha.

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PRACTICALS

1. Specimen studies- Salient characteristics, identification and classification of representative types of invertebrate groups from Protozoa, Porifera, Cnidaria, Ctenophora, Annelida, Mollusca, Arthropoda, Echinodermata and Hemichordata.
2. Collection and identification of invertebrates in pond water.
3. Preparation of permanent slides of Zooplanktons (minimum three different types of species).
4. Collection and identification of parasites from the cockroach.
5. Dissections –
   a. Minor – a) Reproductive system of cockroach, b) Mouth parts of cockroach.
   b. Major – a) Nervous system of prawn, b)Nervous system of Frog.
6. Submission of assignment on:1) International code for zoological nomenclature; 2) Molecular taxonomy; 3) Life cycle of *Aedes aegypti*;4) Foot in Mollusca; 5) Shell in Mollusca; 6) Social l of the bee, silk moth, and lac insect; 7) Identification mosquito species;8) Diagrams of larvae Crustacea; 9) Morphology of Ctenophora, Nemertea,Bryozoa,Entoprocta,Chaetognatha.
   [To be submitted at the time of Practical Examination- 10 Marks]

Suggested Books

1. Principles of Systematic Zoology (2nd Edition) by E.Mayr and P.D.Ashlock
2. Five Kingdoms-An illustrated Guide to the Phyla of Life on Earth by Lynn Margulis& M.J.Chapman
3. A Textbook of Zoology Vol.I by Parker and Haswell (Revised).
4. The Invertebrates Vol.I to Vol.VI by L.H.Hyman.
5 Invertebrate structure and byE.J.W.Barrington.
6. Invertebrate Zoology by P.A.Meglitsch(Oxford Press).
7. Life of Invertebrates by by Russel Hunter.
8. Invertebrate Zoology by Rupport and barnes(Saunders College Publishing Co.)
9. Life of Invertebrates by S.N.Prasad.
10. Evolutionary Biology by Eric C.Mitkoff.
11. Parasitology by Nobel and Nobel.
12. Regeneration by S.M. Rose-Appleton.
13. Worms and Man by D.W.T. Crompton

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. ZOOLOGY, Semester-II
CORE PAPER-I: Tools, Techniques and Biostatistics [TTB]

UNIT I - Tools and Separation Techniques **15 Hrs**

1.1 Principles and applications of microscopic techniques – Bright and Dark field microscopy; Fluorescent Microscopy; Electron Microscopy and Transmission Electron Microscopy (SEM & TEM).

1.2 Microtomy and staining procedures- Types of microtomes, Tissue fixation, Embedding, types of stains and mounting procedures of biological materials.

1.3 Centrifugation – basic principles centrifugation, types of Centrifugation, Preparative, analytical

principles of sedimentation, Svedberg Co-efficient; Cell separation by density gradient centrifugation; Cell separation by affinity adsorption; Cell separation by anchorage based techniques; principles and applications of Preparative, analytical ultracentrifugation.

1.4 Separation and Identification of materials- Concept of Chromatography; Adsorption chromatography, Ion-exchange chromatography, Gel chromatography,HPLC and Affinity Chromatography.

1.5 Electrophoresis techniques – principles and applications of Agarose and Polyacrylamide gel electrophoresis.

UNIT II - Separation and Imaging Techniques **15 Hrs**

2.1. Spectroscopy: UV, Fluorescence, Visible, IR, ESR, NMR and Atomic Absorption Spectroscopy.

2.2 Mass Spectrometry (LC-MS, GC-MS), X-ray diffraction, MALDI-TOF.

2.3 Electrophysiological techniques – Single neuron recording, Patch clamp recording, ECG recording

2.4 PCR: Types of PCR: Primer design: Applications of PCR.

2.5 SDS-PAGE, 2D-Gel Electrophoresis.

UNIT III – Diagnostic techniques **15 Hrs**

3.1 Radioisotope techniques: Principles and applications of tracer techniques in biology: Radioactive isotopes and half-life periods of

isotopes: Autoradiography, principles and applications of Geiger-Muller and scintillation counter.

3.2 Imaging Techniques: PET, MRI, fMRI and CAT.

3.3 RT-PCR techniques for qualitative and quantitative analysis of DNA, RNA and Proteins.

3.4 Micro Array Technology: Principles and applications of Micro Array Technology.

3.5 Gene Editing Technologies: CRISPER/CAS9 Technology and applications..

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UNIT IV- Biostatistics- Descriptive Statistics **15 Hrs**

4.1 Introduction to biostatistics: Statistical data and its taxonomy: Organization and tabulation of data.

4.2 Frequency distribution: Concept of population and sample.

4.3 Measures of central tendency – Mathematical average (Mean – Arithmetic, Geometric & Harmonic Mean) and Positional Averages (Median and Mode); Measures of dispersion (or variability)– types, range, quartile deviation, mean deviation, variance, standard deviation, coefficient of variance

4.4 Sampling distribution of Mean, Standard error, Random variable concept, Expectation and variance of the random variable.

4.5 Basics of Probability- concept of probability, addition and multiplication laws of probability and application to the problems of biology.

PRACTICALS

1. To fix a tissue with Bouin's fixative and stain using haematoxylin – Eosin stain for Histochemical studies.
2. Separation of biological compounds by Paper Chromatography.
3. Separation of biological compounds by T.L.C.
4. To prepare a paraffin block of tissue for Microtomy for making sections of tissue for Histochemical studies.
5. Quantitative detection of total carbohydrates using Anthrone technique.
6. Quantitative detection of total lipids using sulpho-phospovanillin technique.
7. Quantitative detection of total proteins using Lowry method.
8. Graphic presentation of data – bar diagram, histogram, frequency polygon and pie chart.
9. Calculation of measures of central tendencies – mean, median and mode.
10. Calculation of measures of dispersions – range, mean deviation, standard deviation, variance and Coefficient of variance.
11. **Submission of assignment on**: principles and applications of centrifugation: Chromatographic techniques: Microtomy:

Microscopy and its applications in biology: Electrophoresis techniques and its applications: Spectroscopic techniques:

Radioisotope techniques: Electrophysiological techniques: Micro Array techniques: Statistical data and its taxonomy: Frequency

distribution: Concept of population and sample: Measures of central tendency: Measures of dispersion: Sampling distribution of

Mean: Standard error: Random variable: Concept of probability: Addition and Multiplication laws of probability.

[To be submitted at the time of Examination-10 Marks]

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Suggested Books

1. Principles and techniques of Practical Biochemistry Ed. B.L. Williams &amp: K. Wilson, Arnold Publishers
2. Practical Biochemistry by Plummer
3. Immunology – Roit

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4. Cell and Molecular Biology – DeRoberties
5. Cell and Molecular Biology – Ladish et al.
6. Statistical methods. Snedecor, G.W. and W.G. Cochran, Iowa State Univ. Press
7. Biometry by W. H. Freeman and Francisco
8. Fundamentals of Biometry by L.N. Balaram (1980)
9. Biostatistics by N. Gurumani
10. Techniques in life sciences – by Tembhare

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MAHATMA GANDHI UNIVERSITY, NALGONDA
M.Sc. ZOOLOGY, Semester-II
CORE PAPER-II: Animal Physiology [AP]

UNIT I – Digestion, Respiration and Circulation **15 Hrs**

1.1 Cellulose digestion –Ruminant and non-ruminant digestion; Absorption in mammals: Events of absorptive and post absorptive states and their regulation (Endocrine and neural regulation).

1.2 Respiration – Cascade of oxygen transport to tissues at high altitude; Adaptation to diving.

1.3 Responses to CO_2 and O_2 rich environment; Oxygen toxicity; Hypercapnia, control of respiration.

1.4. Circulation- Cardiac cycle and principles of hemodynamics; Haemoglobin buffering mechanism:

Blood coagulation, Haematome formation; Anti-coagulants.

1.5 Frequently occurring Cardiovascular diseases (Stroke and Congenital Heart Disease).

UNIT II– Osmoregulation, Excretion and Thermoregulation **15 Hrs**

2.1 Osmoregulation – Osmoregulatory problems in brackish water, fresh water and marine organisms; Osmotic problems in terrestrial animals; Hormonal control of osmoregulation.

2.2 Excretion – Urine formation, counter- current mechanism; Juxtaglomerular apparatus, rennin-angiotensin system; Hormonal regulation – ADH and aldosterone.

2.3 Detoxification of nitrogen products; Purine cycle and miscellaneous detoxification pathways.

2.4 Thermal physiology – temperature regulation in poikilotherms, homeotherms and heterotherms, and their mechanisms of survival; Central control of homeotherms.

2.5 Cold death, cold resistance, heat death; Torpor, hibernation and aestivation.

UNIT III– Muscle Physiology, Neurophysiology and Receptors **15 Hrs**

3.1 Comparative molecular structure and function of skeletal, smooth and cardiac muscles; Energy metabolism in skeletal muscle, muscle fatigue.

3.2 Types of neurons and glial cells.

3.3 Basis and significance of membrane potentials, equilibrium potentials, their change during stimulus, Na, K currents in action potential.

3.4 Types of synapses, synaptic transmission - Electrical and chemical; Synaptic inhibition and neurotransmitters.

3.5 Receptors – Receptor mechanisms, sensory coding; Mechanoreceptors, photochemical aspects of vision and phonoreception in mammals.

UNIT IV – Endocrinology, Bioluminescence and Stress Physiology

4.1 Detailed overview of invertebrate hormones.

4.2 Hormones in vertebrates-Biochemistry and physiological functions.

4.3 Mechanism of hormone action-Peptide and steroid hormones.

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4.4 Bioluminescence-Luminescent organisms-Neural control; Biochemistry and significance of luminescence.

4.5 Stress – Coping mechanism to stress:Role of hormones and sympathetic nervous system in stress.

PRACTICALS

1. Estimation of blood chlorides under hetero osmotic media.
2. Cold and heat stress on metabolic rate in tilapia fish/crab.
3. Effect of heat stress on glycogen levels in tilapia fish/crab.
4. Estimation of Acetylcholinesterase activity.
5. Estimation of phosphorylase activity.
6. Adrenalin and insulin induced changes in blood glucose levels in rat/mice.
7. Kymographic recordings of twitch, tetanus and fatigue.
8. Estimation of Hb, ESR, Blood clotting time and bleeding time.
9. Cell fragility.
10. **Submission of assignment on**: Ruminant and non-ruminant digestion. Absorption and post absorptive states and their regulation in mammals. Respiration – Cascade of oxygen transport to tissues at high altitude. Osmotic problems in aquatic and terrestrial animals. Rennin-angiotensin system and hormonal regulation – ADH and aldosterone, purine cycle, torpor, hibernation and aestivation. Types of neurons and glial cells. Synaptic transmission and Neurotransmitters. Receptor mechanism, photoreception and phonoreception in mammals. Endocrine glands of invertebrates. Biochemistry& significance of luminescence. Stress-hormones and the sympathetic nervous system in stress.

[To be submitted at the time of Examination-10 Marks]

Suggested Books

1. Principles of Animal Physiology by D.W. Wood.
2. Principles of Animal Physiology by Gordon.
3. Animal Physiology-Adaptations and environment by Schmidt-Nielson.
4. Principles of Animal Physiology by Wilson.
5. Text Book of Medical Physiology by Guyton.
6. General and Comparative Animal Physiology by William Hoar.
7. Comparative Animal Physiology by Florey
8. Comparative Animal Physiology by L.C.Prosser.
9. Human Physiology by Vander.

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MAHATMA GANDHI UNIVERSITY, NALGONDA
M.Sc. ZOOLOGY, Semester-II
CORE PAPER-III: Molecular Genetics and Developmental Biology

UNIT I - Introduction to Genetics — 15 Hrs

1.1 Mendelism. Mendelian inheritance; Modification of Mendelian inheritance.

1.2 Linkage studies, crossing over and extrachromosomal inheritance, multiple alleles, blood group antigens.

1.3 Chromosome structure (Prokaryote and Eukaryote): Identification, karyotype.

1.4 Genetic disorders – Chromosomal disorders; polygenic disorders; Environmental disorders.

1.5 Bacterial genetics – Transformation, transduction, conjugation, viral lytic and lysogenic cycle.

UNIT II – Molecular Genetics — 15 Hrs

2.1 Introduction of DNA technology – Restriction endonucleases, methods of ligation – DNA ligases, ligation of the fragment with cohesive and blunt ends.

2.2 Features of vectors – Cosmids, plasmids and shuttle vector with one example representing each class construction and characterization of new cloning vectors.

2.3 Applied molecular biology – DNA sequences – Maxam and Gilbert methods, Sanger's method. Application of recombinant DNA technology concerning the example of Insulin, Somatostatin, and interferon. DNA fingerprinting and its applications; Human Genome project.

2.4 Cloning strategies – Shotgun cloning, construction of gene libraries, genomic library and DNA library.

2.5 Hybridization techniques – Southern blot, Northern blot, R-loop mapping methods, *In-situ* hybridization.

UNIT III – Overview of Developmental Biology — 15 Hrs

3.1 Scope and importance of developmental biology.

3.2 Gametogenesis: Spermatogenesis, Oogenesis, vitellogenesis and chemo differentiation.

3.3 Fertilization, parthenogenesis and its significance.

3.4 Types of cleavage, mechanism of cleavage, chemical changes during cleavage.

3.5 Role of cytoplasm and nucleus during early development; Morphogenetic movements, Presumptive areas and fate maps.

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UNIT IV – Organogenesis — 15 Hrs

4.1 Gastrulation, metabolic events during gastrulation and rudimentary organs formation.

4.2 Concept of organizers and inducers; neural tubule formation.

4.3 Organogenesis: limb, central nervous system, heart, kidney and eye.

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4.4 Role of hormones in metamorphosis of insects and frog: regeneration in Cnidaria, Echinodermata, Amphibia (limb and tail regeneration), and Reptiles (Tail regeneration).

4.5Teratogenesis– Genetic and environmental: Developmental mechanisms of teratogenesis: Senescence.

PRACTICALS

1. Karyotyping of human chromosomes.
2. Isolation and estimation of DNA in tissues.
3. Isolation and estimation of RNA in tissues.
4. Estimation of RNA, DNA in tissues.
5. Estimation of soluble and structural proteins in chick embryo (any two durations)-24hrs, 48hrs, 72hrs & 96 hrs.
6. Estimation of SDH activity in chick embryo (any two durations)-24hrs, 48hrs, 72hrs & 96hrs.
7. Estimation of LDH activity in chick embryo (any two durations)-24hrs, 48hrs, 72hrs & 96hrs.
8. Estimation of calcium in egg shell by EDTA method (any two durations)-24hrs, 48hrs, 72hrs & 96hrs
9. Identification of chick embryo developmental stages (any two durations)-24hrs, 48hrs,72hrs & 96hrs.
10. Study of cleavage patterns in Lymnaea.
11 **Submission of assignment on**: Linkage: Crossing over: Multiple alleles: Blood group antigens:

Bacterial transformation, transduction, conjugation (only diagrams): Hybridization techniques –

Southern blot, Northern blot and Western blot: Features of vectors - Cosmids, plasmids and shuttle vector: DNA fingerprinting and its application: Gametogenesis (spermatogenesis & oogenesis): Fertilization and its significance: Parthenogenesis and its significance: Cleavage types:

Presumptive areas and fate maps: Concept of organisers and inducers: Role of hormones in the

metamorphosis of frog: Regeneration in Amphibia (limb and tail regeneration).

[To be submitted at the time of Examination -10 Marks]

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Suggested Books

1. General genetics by Winchester.
2. Molecular Biology of gene by Watson et al. Vol I & II.
3. Genetics by Strickberger.
4. Molecular Biology by Friefielder.
5. Genetics by P.K. Gupta.
6. Genes by Lewis.

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7. General genetics by S. R. B. Owen.
8. Cell and molecular biology by De Robertis and De Robertis, 8th ed.
9. Molecular cell biology by Darnell, Lodish and Baltimore (Scientific American books)
10. Molecular biology by H. D. Kumar.
11. Biochemistry and molecular biology by W. H. Elliot and D. C.Elliot (OUPress)
12. Text book of molecular biology by K. S. Sastry et al. (MacMillan Ind. Pvt. Ltd.)

13.Developmental Biology - patterns, problems and principles by W. Saunders Jr.
14. Principles of Animal Developmental Biology by S.C. Goel.
15. Introduction to embryology by Balinsky.
16. Developmental Biology S. Gilbert.
17. Evolution.by Savage.
18. Process of organic evolution by Stebbings
19. Evolution of vertebrates by Colbert
20. Developmental Biology by Berryl.

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MAHATMA GANDHI UNIVERSITY, NALGONDA
M.Sc. ZOOLOGY, Semester-II
CORE PAPER-IV Evolution and Functional Anatomy of Vertebrates [EFAV]

UNIT I - Evolution of Life — 15 Hrs

1.1 Developments in Evolutionary Biology- Pre- Darwinian concepts, Darwinism and Neo-Darwinism.

1.2. Natural selection and adaptation: Mutation-its types, mutation rates, variation- gene mixing mechanisms.

1.3. Genetic drift; Speciation-Reproductive isolation (Pre-zygotic and Post-zygotic), Modes of speciation (Allopatric, parapatric and sympatric speciation).

1.4. Patterns of evolution – sequential, divergent, convergent, gradual, punctuated, monophyletic, polyphyletic and paraphyletic.

1.5. Origin and evolution of primates and human: Evolutionary significance of Bipedalism in no human and human primates.

UNIT II – Evolution of Vertebrates — 15 Hrs

2.1 Evolution of Agnathans- a) Extinct (conodonts, ostracoderms, and pteraspidomorphi) and living b) Extant (myxinoidea and Petromyzontiformes).

2.2 Evolution of Gnathostomes- a) Placodermi and b) Chondrichthes

2.3 Evolution of Teleostomi- a) Acanthodii and b) osteichthyes (Actinopterygii and Sarcopterygii)

2.4 Evolution of Tetrapods- a) Labyrinthodonts b) Lepospondyls and Lissamphibia (Urodela, Anura and Apoda)

2.5 Evolution of Amniotes- a) Reptilia (Mesozoic and living reptiles), b) Aves (paleognathae and neognathae and
c) Mammalia (prototheria and thermiforms).

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UNIT III – Functional Anatomy — 15 Hrs.

3.1 Integumentary system – Integument and its derivatives

3.2 Cranial Skeletal system – a) Basic plan of skull; b) Temporal fossae –its functions; c) Jaw suspension and its types.

3.3 Post-cranial skeletal system- a) Axial skeleton b) Appendicular skeleton; c) Joints (Axial and appendicular and their types).

3.4 Digestive system in Aves and Mammals- components and function: Dentition in mammals.

3.5 Respiratory system in vertebrates(Fishes to Mammals)- Gills, lungs and other respiratory structures.

UNIT IV – Functional Anatomy-II — 15 Hrs.

4.1 Excretory system in vertebrates (Fishes to Mammals)-Kidney and its structure: Mode of excretion.

4.2 Nervous system I vertebrates (Fishes to Mammals) – Brain, spinal cord and Peripheral nerves.

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4.3. Eye in vertebrates (Aves and Mammals)- Structure and function in different classes.
4.4. Amniotic egg – structure and its evolutionary sig
4.5 Evolutionary significance of internal fertilization: Placenta and its types.

PRACTICALS

1. Specimen Studies- Salient characteristics, identification and classification of representative types of vertebrate groups from Pisces, Amphibia, Reptilia, Aves and Mammalia
2. Collection and preparation of slides of scales of fishes.
3. Dissections –
   4. Minor – a) Weberian ossicles of Labeo, and b) Respiratory trees of Clarius.
   5. Major – a) Cranial nerves of Labeo (V, VII, IX & X cranial nerves).
6. **Submission of assignment on:** Diagrammatic representation with labelling of 1) Theories of Evolution: 2) Types of speciation: 3) Evolution of primates; 4) Evolution of human: 5) Adaptive radiation in amphibians, reptiles, birds and mammals: 6) Integument and its derivatives; 7) Types of axial and appendicular joints; 8) Sense organs- a) Eye in vertebrates; b) Ear in Tetrapods; 9) Structure of Brain, nervous system, respiratory system, digestive system, and excretory systems in fishes to mammals; 10) Different types of skulls basing on temporal fossae; 11) Structure of amniotic egg; 12) Placenta and different types of the placenta. (To be submitted at the time of practical examination- 10 Marks)

Suggested Books

1. Evolution of Vertebrates by E.H. Colbert
2. Evolutionary Biology by Mitkoff
3. Organic Evolution by Veer Bala Rastogi
4. Vertebrates - Comparative Anatomy, Function & Evolution (8th Ed.) by K.V. Kardong
5. Life of Vertebrates by J.Z. Young
6. A Textbook of Zoology Vol. II by Parker and Haswell (revised by Marshall)
7. Vertebrate Body by A.S. Romer
8. Chordates by Alexander
9. Comparative Vertebrate Anatomy by Hyman
10. Vertebrate Structure and Function by Waterman
11. Comparative Anatomy by Kent
12. Vertebrates by R.L. Kotpal
13. Chordate Zoology E. L. Jordan & P. S. Verma
14. Vertebrate Zoology & Evolution - Yadav B. N. & D. Kumar

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester – III
CORE PAPER-I: Systems Biology [SMB]

UNIT I - Introduction to Systems Biology — 15Hrs

1.1 History, concept, prospects and applications of systems biology.
1.2 Molecules to Organisms - Biomolecules, cell, tissue, organ and organisms.
1.3 Basic concepts of systems approach to biology.
1.4 Basic concepts of models and modelling, model behaviour, classification.
1.5 Basic concepts of networks; types of networks.

UNIT II - Systems Approach — 15 Hrs

2.1 Mammalian biological clocks, neuronal and humeral network mechanism.
2.2 Biochemical networks and metabolic cycles - Kreb's cycle, Electron Transport System.
2.3 Sustainable pest and disease management - Quantitative and qualitative models.
2.4 Apoptosis – Molecular modelling.
2.5 Bioremediation - Hydrocarbon bioremediation, radionuclide biotransformation, metals Bio-immobilization.

UNIT III - Predictive Modelling. — 15 Hrs

3.1 Continuous population models for single species.
3.2 Insect outbreak model - Aperiodic Dynamics.
3.3 Predictive ecology, game theory population models, predator-prey model.
3.4 Kinetic models of the biochemical system - Metabolic control analysis.
3.5 Data formats, simulation techniques, modelling tools.

UNIT IV - Systems Biology Applications — 15 Hrs

4.1 Networks in the nervous system: Integrative synaptic mechanism of the neural networks.
4.2 *Caenorhabditis elegans* model system for neurotoxicity.
4.3 Endobiogeny: An approach to systems biology, host-parasite interaction.
4.4 Evolutionary systems biology; approach to molecular phylogeny.
4.5 Nanoparticles in biological systems - Characterization and applications.

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PRACTICALS

1. Live-cell imaging through a fluorescent microscope. HBM
2. Estimation of predator-prey relationship using larvivorous fish. SIANS
3 Temperature-dependent enzymatic activity in metabolites.
4.In silico phylogenetic analysis.
5. Neurotransmitters- defined systems.
6. Estimation of parasitic load in infected fish/ chicken.
7. Bioassay of neurotoxicity.
8. Estimation of population growth under different environmental conditions.
9. Protein expression profiling using 2D electrophoresis.
10. **Submission of assignment on:** Types of networks in systems biology: Biochemical networks and metabolism (Kreb's cycle & electron transport) cycles: Mechanism of apoptosis :Insect outbreak, Bioremediation techniques; Predictive ecology - predator, prey model; *Caenorhabditis elegans* model system for neurotoxicity; Nanoparticles in biological systems & their applications.[To be submitted at the time of Practical Examination - 10 Marks]

Suggested Books

1. An Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon
2. Systems biology: A Text book by Edda Klipp.
3. Mathematical Biology: An introduction by Murray J
4. An Introduction to Mathematical Biology by Linda JS Allen.
5. Introduction to Systems Biology by Sangdun Choi.
6. Life: An Introduction to Complex Systems Biology. by Kaneko Kunihiko.
7. Systems biology. by Robert A. Meyer.
8. Systems biology: Principles methods and concepts by A. K. Konopka.
9. Systems biology: The challenges of complexity by Shigetada Nakashini.
10. A Model of Development of a Spontaneous Outbreak of an Insect with Aperiodic Dynamics by A. Yu. Perevaryukha. Entomological Review, 2015, Vol. 95, No. 3, pp. 397-405.

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester – III
CORE PAPER-II: Research Methodology [RM]

UNIT I - Research Design and Method 15 Hrs.

1.1 Research - definition, importance and application: Types - basic and applied research: Essential steps in research.

1.2 General methods in biological research - 1) Natural observation, 2) Field study, and 3) experimentations: Purpose Statement - definition and significance.

1.3 Experimental design - Basic principles & research hypotheses: Types of experimental design - 1) One Group & Two-group design, 2) Matched pair data analysis, 3) Factorial design & 4) Randomized block design.

1.4 Sampling method - Concept of population and sample: Sampling (random sampling and non-random sampling): Variables (random, independent and intervening variables).

1.5 Data collections: Methods for primary data (observation, interview, questionnaire methods, and experiments) & secondary data (scientific journals, books, reports, databases).

UNIT II - Computers in Research & Concepts of Probability and Hypothesis 15 Hrs.

2.1 Computers and their applications in biology: Word Processing –Introduction to MS Word, type setting, formatting, creating tables, inserting resources, and managing references.

2.2. Data Processing - Introduction to MS Excel, formatting, data management, and Understanding Formulas and data analysis tool

2.3.Probability distribution - Definition & Types: Properties and applications of 1) Normal Distribution, 2) Binomial distribution, and 3) Poisson distribution.

2.4 Statistical Inference, Statistical Model & Estimation: Hypothesis - types (null hypothesis, alternate Hypothesis): Basic approach to hypothesis testing: Hypothesis testing (one-tailed &two-tailed hypothesis tests): Test of significance.

2.4 Type I & Type II errors in hypothesis testing: Level of significance: Sample size estimation: Use of different statistical estimations depending on the type of data.

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UNIT III - Inferential Statistical Tools in Research 15 Hrs.

3.1 Single sample tests - Z test, Standard error of the mean, One-tailed and Two-tailed Z test and interpretation.

3.2 Student's test basic concepts: 1) Paired two sample for means, 2) Two-Sample assuming equal variances, & 3) Two-Sample assuming unequal variances.

3.3 ANOVA 1) One-way, and 2) Two-way ANOVA.

3.4 Chi-square test - Concept and application of 1) Goodness of Fit and 2) Test for independence.

3.5 Correlation and regression - Concepts and their applications.

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UNIT IV - Reporting Research 15 Hrs.

4.1 Literature collection - Need, review process, consulting source material, literature citation Components of research report - Text, tables, figures, bibliography.

4.2 Writing of dissertations, project proposals, project reports, research papers.

4.3 Intellectual Property Rights - Bio piracy, copyrights, patent and traditional knowledge and plagiarism.

4.4 Laboratory safety - Biohazardous agents, biosafety levels, lab acquired infections, other hazards Good Laboratory Practices.

4.5 Animal model systems; animal ethics- animal welfare guidelines for care and use of animals.

PRACTICALS

1. Preparation of charts (Frequency graphs, Scatter plots, Pie charts) using MS Excel.
2. Calculation of Mean and Standard Deviation, and preparation of the graph depicting mean and
3. Standard deviation using MS Excel.
4. Calculation of descriptive statistics of data in MS Excel.
5. Calculation of t-test for paired two samples for means using MS Excel.
6. Calculation of correlation for bivariate data using MS Excel.
7. Calculation of regression for bivariate data using MS Excel.
8. Calculation of one-factor ANOVA using MS Excel. 8 Calculation of two-factor ANOVA using MS Excel.
9. Literature review using online resources.
10. Preparation and documentation of research publication/dissertation.
11. Preparation of MS PowerPoint presentation on a topic of your choice.
12. **Submission of assignment on:** 1) Experimental design - Basic principles, hypotheses;2) Random and non-random sampling; 3) Data collection - primary & secondary data; 4) Graphical representation of data Column or Bar chart, Line chart, Scatter chart, & Pie chart;5) Probability distribution- Definition & Types; 6) Properties and applications of a) Normal distribution, b) Binomial distribution, and c) Poisson distribution; 7) Statistical hypothesis - null hypothesis & alternate hypothesis; 8) Student T-test; 9) Chi square test;
10) One way & Two way ANOVA; 11) Literature collection - sources; 12) Paper Dissertation writ Plagiarism tools; 14) Ethical considerations in Animal & human experimentation;
15) Good laboratory Practices.
[To be submitted at the time of Examination – 10 Marks]

Suggested Books:

1. Biostatistics by N. Gurumani.
2. Research Methodology by N.Gurumani.
3. Research Methodology by R.C.Kothari.
4. Research Methodology- A step by Step Guide by Ranjith Kumar.
5. Practical Statistics using Microsoft Excel by DibyojyotiBhattacharjee.
6. Next-generation Excel by I D Gottlieb.

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7. Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.) by John W.Creswell.
8. Fundamental of Research Methodology and Statistics by Yogesh Kumar Singh.
9. Introduction to Research Methods by Catherine Dawson.
10. Research Methods and Statistics by Sherri L. Jackson.

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Semester III & Semester IV

The candidate has to choose **one** out of **two** elective papers for **Elective-I and II** offered as **paper – III and Paper –IV** in **semester-III and semester-IV.**

The candidate will have a **project** in **semester IV.**

MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester – III
Elective IA
Paper III - Comparative Animal Physiology - I (CAP-1)

UNIT I – Comparative Aspects of Digestion and Respiration **15 Hrs**

1.1 Scope, principles and validity of comparative approach to physiology.
1.2 Origin of nutritive types - special dietary requirements (amino acids and vitamins). Feed and feeding mechanisms, comparative physiology of digestive enzymes.
1.3 Comparative aspects of carbohydrate pathways - Glycolysis and gluconeogenesis pathways; neural and hormonal regulation of digestion.
1.4 Uptake of oxygen and factors influencing uptake: Oxygen consumption by an intact animal, modifying agents.
1.5 Respiratory pigments in different phylogenic groups. Genes with reference to hemoglobin. Regulation of Respiration.

UNIT II – Osmoregulation, Excretion and Thermoregulation **15 Hrs**

3.1 Problem of osmoregulation and biological responses in different environments.
3.2 Comparative aspect of osmoregulation in different animal groups.
3.3 Excretory organs and general mechanisms of excretion in various animal groups.
3.4 Freezing, winter hardening, lethal limits and resistance adaptation: Behavioural and Locomotory adaptations: Heat regulation - Physical and Chemical.
3.5 Temperature regulation in homeotherms: Neural mechanism of thermoregulation.

UNIT III – Deranged metabolism and disorders **15 Hrs**

4.1 Effects of colonic bacterial flora (beneficial and harmful effect): Lactose intolerance, GERD.
4.2 Liver cirrhosis and its causative agents; Fatty liver.
4.3 Chronic obstructive pulmonary disease – Asthma, sleep apnoea, and snoring.
4.4 Electrolyte imbalance - Acidosis, alkalosis: Dialysis.
4.5 Heatstroke: thirst and its physiological mechanism.

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PRACTICALS

1. Estimation of levels of lactic acid and free amino acids levels.
2. Effect of Heterosmotic media on blood chlorides in any one animal- crustacean/fish.
3. Effect of acclimatization to hetero osmotic media on SDH, LDH in gills and muscle tissue of Crustacean/fish.
4. Effect of starvation on glycogen levels in fish/crab.
5. Effect of starvation on free amino acids in liver and muscles of fish/crab.
6. Starvation induced changes in aminotransferases in fish/crab.
7. Starvation induced changes in excretory products in fish.
8. Acclimatization to cold and high temp in fish/crab and its effect on oxygen consumption.
9. Effect of thyroid and anti-thyroid agents on oxygen consumption in fish.
10. **Submission of assignment on:** Comparative aspects of carbohydrate pathways: Comparative aspects of metabolic pathways: Respiratory pigments in different phylogenic Groups: Nitrogen excretion pattern as in different animal groups: Freezing: Winter hardening: GERD

[to be submitted at the time of Practical Examination – 10 marks]

Suggested Books

1. Comp. Animal Physiology by Ladd Prosser (Publ. W. B. Saunders. Philadelphia).
2. Comp. Animal Physiology by William Hoar. (Pub. E.E.E. IBH).
3. Animal Physiology – Adaption and function By F. Reed Hainswoth (Publ. by Addison – Wesley Publ. Company, California).
4. Animal Physiology by Kent Schmidt Nielson (Publ.E.E.E.IBH).
5. Animal Physiology and adaptation by David Gordaon.
6. Animal Physiology by Wilson.
7. Concise medical Physiology by SujitK.chaudari.
8. Textbook of medical Physiology by Arthur Guyton

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M.Sc. Zoology, Semester – III, Elective - IB
Paper III - Medical Entomology - I [ME-I]

15hrs

UNIT I – Overview of Entomology

1.1 Significance of Insects and Arthropods: Importance of insects to human society; Ecological role of insects in ecosystems; Success factors for insects - Adaptations and evolution

1.2 Classification of Insects and Arthropods: Insect diversity and classification; Medically important arthropods;
Morphological differences in Insects, Arachnids, and Acari

1.3 Insect Morphology: Exoskeleton and its functions; Head, Thorax, and Abdomen (Structural variations)

1.4 Insect Physiology - 1: Digestive system, Excretory systemand Respiratory system

1.5 Insect Physiology - 2:Circulatory system, Nervous system, Reproductive system and Endocrine system

15hrs

UNIT II – Medically Important Arthropods and Insect Ecology

2.1 Biology and life cycle of Culicidae and Phlebotomidae: *Anopheles*, *Aedes* and *Culex*species; Sandflies

2.2 Biology and life cycle of other medically important arthropods: Tsetse Flies; Fleas; Ticks and Mites

2.3 Impact of climate change on vector distribution; Altered habitat suitability for disease vectors; Mitigation Strategies

2.4 Insect Ecology - 1: Ecological Hierarchy (Individuals to Ecosystems); Trophic relationships and food webs in insect communities

2.5 Insect Ecology -2: Factors affecting insect population fluctuations; Density-dependent and Density-independent regulation; Insect behavior (Mating systems and dispersion)

15hrs

UNIT III – Community Ecology and Disease Vectors

3.1 Community Ecology: Classes of interaction; Predation (Insect predators and their impact); Competition (Resource utilization and Niche differentiation); Mutualism and Commensalism (Symbiotic relationships in insect communities)

3.2 Consequences of interaction and community structure: Keystone species and ecological significance; Measures of diversity; Ecological succession and insect community dynamics

3.3 Insect Behavior: Dispersal behavior (Migration and Colonization); Mating Behavior (Courtship, Mate selection, and Reproductive success); Social Behavior (Insect societies and Cooperative strategies)

3.4 Disease Vectors - 1:Bacterial Pathogens (Yersinia pestis and Rickettsiae); Arboviruses - Flaviviruses (DENV, JEV, TBEV) and Alphaviruses (CHIKV); Vector-Pathogen interactions and Transmission dynamics

3.5 Disease Vectors-2 & Venomous arthropods:Protozoan Parasites (*Plasmodium*, *Leishmania*, and *Trypanosoma*); Helminth infections (*Wuchereriabancrofti* and *Onchocerca volvulus*); Venomous Arthropods (Bees, Wasps, Ants, Spiders, Scorpions, and their impact)

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PRACTICALS

1 Insect collection and preservation of medically important insects.
2 Collection and identification of medically important insects, ticks, mites - up to genus level.
3 Collection and identification of venomous arthropods - up to genus level.
4 Identification of different mosquito breeding habitats.
5 Maintenance and study the stages of the life cycle of the mosquito.
6 Preparation of permanent mounts of mosquito larval mouthparts and respiratory siphon.
7 Preparation of permanent mounts of Insect leg and antennae.
8 Preparation of permanent mounts of wings of mosquito.
9 Preparation of permanent mounts of adult mosquito mouthparts.
10 Dissection of Mosquito salivary glands and Reproductive system.
11 Study of species diversity indices: Simpson's index, Shannon-Weiner index.
12 Study of permanent slides/specimens - *Plasmodium*, *Leishmania*, *Trypanosoma* and *Wuchereria*.
13 Maintenance of Insect / venomous arthropod collection box. Note: (**Submission of Insect / venomous arthropod collection box is must during the practical examination)
14 Submission of assignment on: Draw a well labeled external morphology of Anopheles mosquito; Draw a well labeled external morphology of Aedes mosquito; Draw a well labeled external morphology of Culex mosquito; Draw a well labeled lifecycle of Anopheles mosquito; Draw a well labeled lifecycle of Aedes mosquito; Draw a well labeled lifecycle of Culex mosquito; Draw a well labeled lifecycle of Sandfly; Draw a well-labelled lifecycle of Blackfly; Draw a well-labelled lifecycle of Tsetse fly; Draw a well-labelled lifecycle of Flea. Draw a well-labelled lifecycle of Ticks and Mites. Life cycle of Plasmodium, Life cycle of *Wuchereriabancrofti*. Life cycle of *Leishmania*.
[To be submitted at the time of Examination – 5 Marks]

Suggested Books

1 Biology of Disease Vectors, 2nd Ed., William C. Marquardt, 2004, Elsevier Academic Press.
2 Medical and Veterinary Entomology, 2nd Ed., Gary Mullen & Lance Durden.
3 Medical Entomology: A Textbook on Public Health and Veterinary Problems Caused by Arthropods - by Bruce Eldridge & John Edman.
4 Medical Toxicology by Richard C. Dart. Pub: Lippincott Williams & Wilkin.
5 Manual of Medical Entomology by Deane P. Furman & Paul Catts.
6 Infectious Diseases of Arthropods by Goddard.
7 Medical Entomology for Students 5th edition by Mike Service.
8 General and Applied Entomology by David and Ananthakrishnan.
9 Destructive and Useful Insects by R. L. Metcalf.
10 Ecology of Insects by Martin R. Speight Pub: Wiley-Blackwell.
11 Insect Ecology: An Ecosystem Approach - by Timothy D. Schowalter 3rd Edition. Pub: Elsevier, 2011.
12 Mosquito ecology field sampling methods 3rd edition by John B.Silver Pub: Springer.

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester – III, ELECTIVE- IIA.
PAPER-IV: Endocrinology

UNIT –I: Chemical, Neural Integration and regulation **15 Hrs**

1.1 Scope of endocrinology.

1.2 Concept of neurohumors and neurotransmitters.Characteristics of neural and hormonal integration, neuro-endocrine mechanism.

1.3 Hormones as chemical messengers: Regulation of hormone secretions

1.4 Concept of internal environment and homeostasis (glucose regulation)

1.5 Role of hormones and its metabolic complications – The role of Adipokines, Insulin resistance, Dyslipidemia and Obesity.

UNIT – II: Endocrine Glands, their Hormones and disorders **15 Hrs**

2.1 Invertebrate endocrine system – Hormones and their functions (Coelenterata and Annelida).

2.2 Invertebrate endocrine system – Hormones and their functions (Arthropoda and Echinodermata). Pheromones – Definition, types and their functions.

2.3 Vertebrate endocrine glands – Structure, hormones and functions of Hypothalamus and its secretions

2.4 Vertebrate endocrine glands – Structure, hormones and functions of pituitary, thyroid, parathyroid and thymus.

2.5 Vertebrate endocrine glands – Structure, hormones and functions of Adrenal, pancreas, pineal, gastro-intestinal tract and gonads.

UNIT –III: Chemistry of Hormones, Mechanism of Hormone Action and Applications **15 Hrs**

3.1 Classification of hormones.
Biosynthesis and release and transport of peptide, amino acid derivatives and steroid hormones.

3.2 Membrane bound and intra cellular receptors.

3.3 Mechanism of action of amino acid derivatives, peptide and steroid hormones.

3.4 Hormones in IVF, pregnancy testing, and Amniocentesis. Clinical disorders of male and female gonads.

3.5 Applications of endocrinology in Pisciculture, Sericulture and Apiculture.

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PRACTICALS:

1. In situ demonstration of endocrine glands of Rat.
2. Histology slides of Endocrine glands - Pituitary, Thyroid, Parathyroid, Thymus, Adrenal, Pancreas, Ovary &Testis, and Uterus.

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3. Effect of Eye Stalk ablation on Blood Glucose levels in Crabs.
4. Identification of Gonadotrophin in Human urine samples.
5. Effect of thyroxin and Thiourea (Anti thyroid agent) on oxygen consumption in fish.
6. Effect of Parathormone on serum calcium levels in Rat.
7. Effect of insulin and adrenalin on blood glucose levels in Rat.
8. **Submission of assignment on:** Diagram of endocrine glands; Flowchart of HCG; Classification of hormones; Hormones as chemical messengers; Flow chart diagram of steroid, peptide hormonal biosynthesis.

[To be submitted at the time of examination- 10 Marks]

Suggested Books

1. Comparative Endocrinology of Invertebrates by Highman and Hill.
2. Comparative Vertebrate Endocrinology by P.J.Bentley. Cambridge Univ. Press.
3. General and Comparative Endocrinology by E.J.W. Barrington, Oxford Clarendon Press
4. Endocrinology Vol.1-3 by DeGroot L.J.et.al.
5. Text Book of Endocrine Physiology by C.R.Martin. Oxford Univ.Press. New York.
6. Text Book of Endocrinology by Turner and Bangnara (W.B.Sanders).
7. Vertebrate Endocrinology by Mc.Hadley.
8. Text Book of Comparative Endocrinology by Gorbman A. and Bern H.A., John Harley and Sous. New York.
9. Essential Endocrinology by JoenLaycock and Peter Loise Oxford Univ. Press.
10. A Text Book of Medical Physiology by Arthruma C.Guyton.
11. Text Book of Endocrinology by R.H.Williams (W.B.Saunders).

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, SEMESTER – III, Elective - IIB
Paper IV: Agricultural Entomology - I [AE-I]

UNIT I Introduction and Oil Seed pests **15 Hrs**

1.1 Scope and Importance of Agricultural Entomology.
1.2 Insect - outline classification and emphasis on identification of phytophagous insects.
1.3 Oil seed pests: Life history, hosts, nature of damage and control measures – I
1.3.1 *Aphis craccivora, Bemesiatabaci.*
1.3.2 *Lipaphiserysimi, Asphondyliasesame.*
1.3.3 *Dichocrocispunctiferalis, Euproctislunata.*

UNIT II - Commercial crop pests: Life history, hosts, nature of damage and control measures **15 Hrs**

2.1 *Nilaparvata lugens: Nephotettixnigropictus.*
2.2 *Chrotogonustrachypterus, Atherigonaaqvii.*
2.3 *Chilopartellus, Spodopterafrugiperda.*
2.4 *Sesamiainferens, Pyrillaperpusilla.*
2.5 *Helicoverpaarmigera, Spodopteralitura.*

UNIT III - Vegetable & Stored Grains pests: Life history, hosts, nature of damage and control measures **15 Hrs**

3.1 *Urentiussentis, Plusiaorichalcea, Dysdercuskoenigii, Plutellaxylostella.*
3.2 *Scirtothrips dorsalis, Euzopheraperticella, Earias vitelli.*
3.3 *Tanymecusindicus, Exelastisatmosa, Amsactamoorei.*
3.4 Major Stored Grain Pests - Khapra beetle, Rice weevil, Rice moth, Pulse beetle.
3.5 Minor Stored Grain Pests – Lesser grain borer, Indian meal moth, Saw-toothed beetle.

PRACTICALS

1. Collection, Preservation and identifications of insect pests of agricultural and stored products importance.
2. Study of permanent slides of different parts of insects.
3. Preparation of permanent slides of different parts of insects and their stages of the lifecycle.
4. Study of museum specimens of agricultural importance.
5. Rearing of pests of agricultural importance in the laboratory.
6. Dissection of the digestive system of Grasshopper or any suitable pest.
7. Dissection of the reproductive system of Grasshopper or any suitable pest.
8. Dissection of nervous systems of Grasshopper or any suitable pest.

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9. **Submission of assignment on**: General body plan of a typical insect, types of phytophagous insect mouthparts, antennae, legs, wings, external genitalia, types of phytophagous insects, Pests of paddy, wheat, sorghum, maize, pulses, Stored grain pests.

[To be submitted at the time of Examination – 10 Marks]

Suggested Books

1. Metcalf, C. L. & Flint, W.P: Destructive and useful insects. Their habits and control, 4th Edition, McGraw Hill, New York.
2. Pradhan, S. Insect pests of Crops, National Book Trust, New Delhi.
3 K. P. Srivastava: A Text Book of Applied Entomology Vol. I & II, Kalyani Publishers, New Delhi.
4. H. S. Pruthi: Text Book of Agricultural Entomology, ICAR Publication, New Delhi.
5. Alwal, A. S. Agricultural Pests of India and South East Asia, Kalyani Publishers, New Delhi.
6. B. V. David & Kumara Swamy: Elements of Economic Entomology
7. Pedigo, L.P. Entomology and Pest Management, Prentice-Hall, New Delhi.

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester III, ID paper
EVOLUTIONARY BIOLOGY & POPULATION GENETICS (EBPG)

Unit I: Evolution and Natural selection: **15 hrs**

1.1 Darwinian fitness, Genetic burden or load, Polymorphism and balancing, Natural Selection; Emergence of Non-Darwinism, Molecular clock.

1.2 Genome Evolution: i) Evolution of Multigene Family ii) Acquisition of new genes: Mechanisms and Exon Theory; Concerted Evolution and Molecular Drive, Molecular evolution and Phylogenetics.

1.3 Genetic variation in population (Morphological, Chromosomal and biochemical); Patterns and Mechanisms of reproductive isolation; Genetic basis of Reproductive isolation

1.4 Speciation: Biological and Phylogenetic species concept; Models of Speciation: Allopatric, Parapatric and Sympatric; Hardy–Weinberg equilibrium – Testing population samples; Assumption, Derivation.

1.5 Molecular Population genetics- concept and significance: Emergence of land vertebrates; Origin and evolution of primates and man.

Unit II: Mutation and Population Genetics **15 hrs**

2.1 Mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Molecular basis of Mutation.

2.2 Mutations in human, Cystric fribrosis, Inbreeding: Measures of inbreeding, inbreeding depression, Heterosis.

2.3 Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

2.4 Quantitave genetics: Polygenic inheritance concept, heritability and its measurements, QTL (quantitave trait loci) mapping.

2.5 Human genome project: Methodologies, Strategies and applications; Ethics and social implications. Molecular population genetics – concept and significance.

Suggested readings:

1. Evolutionary Biology : D. J. Futuyma
2. Evolution of vertebrates: E. H. Colbert
3. Introduction to Evolution: P. A. Moody
4. Evolution: Strickberger
5. Evolution and the diversity of life: E. Mayer
6. Genes & Evolution: Jha
7. Evolution & Genetics: Merrel
8. Evolutionary Genetics: M. Smyth
9. Molecular Evolution: Li & Graur
10. Species Evolution: Max King
11. Organic Evolution: V. B. Rastogi
12. Molecular Evolution: A Phylogenetic Approach: Blackwell Science Ltd (2nd Reprint, 2001.
13. Principles of Genetics. (5th ed.). Tata McGraw-Hill. Publ. Co. Stearns, S. C. & Hoeksstra, R. I (2005).

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14. Karp, G. (2008). Cell and Molecular Biology: Concepts and experiments.5th edn., John Wiley.
15. Clark, D. P. (2005). Molecular Biology. Elsevier.
16. Cooper, G. M. (2004). The Cell. 3rd edn. ASM Press.

MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology Semester IV
Core Paper - I: Animal Biotechnology

UNIT –I: Introduction and Animal Improvement **15 Hrs**

1.1 Introduction to biotechnology - scope, importance and its applications.
1.2 Mammalian reproductive systems and gametogenesis.
1.3 *In vitro* fertilization and embryo transfer; ICSI, and sperm sexing.
1.4 Cryopreservation, cryoprotection and gamete banking.
1.5 Biotechnology in improvement of livestock herds and breeding selected traits.

UNIT – II: *In vitro* culture of cells and tissues **15 Hrs**

2.1 Cell culture - Equipment and materials for cell culture technology, the principle of sterile techniques and cell propagation, primary and established cell line cultures.
2.2 Mammalian cell lines & their characteristics.
2.3 Basic techniques of mammalian cell culture *in vitro*, disaggregating of tissue and primary culture, maintenance of cell culture, and cell separation.
2.4 Tissue culture system – cell tissue fragment, organ and embryo cultures, merits and demerits.
2.5 Scaling-up of animal cell culture, cell synchronization, and cell cloning, micromanipulation, and cell transformation.

UNIT –III: Production of recombinant organisms and transgenic animals **15 Hrs**

3.1 Cloning of mammals.
3.2 Transgenic animals; creation of transgenic mice, retroviral vector method, Microinjection, embryonic stem cell method – short gun, electroporation, lipofection, microinjection.
3.3 Production of other transgenic animals – cattle, sheep, pigs and fish.
3.4 Large scale culture and production from genetically engineered animal cell culture.
3.5 Large scale culture and production from recombinant microorganisms –Downstream processing.

UNIT -IV: Applications of Biotechnology **15 Hrs**

4.1 Medical biotechnology – Application of RFLP in forensic science, Hybridoma technology and production of monoclonal antibodies.
4.2 Environmental Biotechnology - Bioassay, biosensors in Eco toxicological screening; Bioleaching of metals by microorganisms; Bio absorption of metals by bacteria.
4.3 Insecticide development – biopesteide; *Bacillus thuringiensis* – mode of action of toxin, toxin gene isolation and engineering of *B. thuringiensis*.
4.4 Biotechnology of aquaculture - sex reversal in fish and sterile fish culture.
4.5 Use of animals as bioreactors; Knock out model systems and their utility.

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PRACTICALS

1. Preparation of culture media:
   a) Bacteria; b) Animal cells
2. Methods of cultivating Bacteria and Animal cells.
3. Isolation and characterization of microbes useful in fermentation.
4. Staining Techniques for microbes:
   b) Gram's staining; b) Spore & Capsule staining:
   c) Acid-fast stain; d) fungal stains
5. Determination of microbial Growth Curve.
6. Antibiotic sensitivity test.
7. Yield estimation in fermentations products:
   c) *Aspergillus niger*-citric acid; b) *Lactobacillus* – Lactic acid from curd; and
   c) *Saccharomyces cerevisiae* (Yeast) Alcohol
8. Microbial evaluation of stored foods from plant/animal origin for contaminants/toxins.
9. Visit to Quality Control Labs.
10. **Submission of assignment on**: In vitro fertilization and embryo transfer: ICSI, sperm sexing Cryopreservation, cryoprotection, Primary and established cell line cultures, Scaling-up of animal cel culture, cell synchronization, cell transformation. Transgenesis - methods involved transgenicanimals: sho gun, electroporation, lipofection, microinjection and embryonic stem cell method. Production of transgeni animals, cattle, sheep, pig and fish. Application of RFLP in forensic science. Hybridoma technology Bioleaching of metals by bacteria. Bio pesticides - Bacillus thuringiensis, mode of action of toxin, toxi gene. Sex reversal in fish - isolation of engineering of Bt. Use of animals as bioreactors.

[To be submitted at the time of Examination - 10 Marks]

Suggested Books

1. Culture of Animal Cells. R. IanFreshney, Wiley Liss.
2. Animal Cell culture - Practical Approach - Ed. John R W Masters, Oxford.
3. Animal Cell Biotechnology, 1990 - Speir, RE and Griffith, JB, Academic Press.
4. Molecular Biotechnology - Glick &Pasternock.
5. Gene manipulation - Old & Primrose.
6. Biotechnology - S. Mitra.

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester- IV
Core Paper- II: FISH BIOLOGY

Unit – I: Introduction and Diversity of Fishes **15 Hrs.**

1.1. Introduction, general characteristics, evolutionary succession and fossil history of fishes.
1.2. The early evolution of fishes; Chondrichthian fishes - Sharks, Skates and Rays.
1.3. Characterization and classification of: Ostracoderms, placoderms, acanthodians, holocephali, and elasmobranchs.
1.4. Characterization and classification of cyclostomes, sarcopterygii, dipnoi, and actinopterygii.
1.5. Integumentary system - basic structure of skin, dermal and epidermal pigments, fins, and scales.

Unit – II: Fishes habits and habitats **15 Hrs.**

2.1. Buoyancy – Dynamic lift and static lift; swim bladder- structure and function.
2.2. Locomotion – Myotomal muscles and caudal fin oscillation mechanisms.
2.3.Feeding mechanisms – Food habits and feeding, fish as predators and prey; Food chains and food webs.
2.4. Osmoregulation and ion balance – Freshwater, brackish water and marine teleosts; kidney and salt balance.
2.5. Fish migration, migratory mechanisms, mating, and parental care.

Unit – III: Fish Biology **15 Hrs.**

3.1. Skeletal system - skull, splanchnocranium, jaw suspension and vertebral column.
3.2. Digestive system – Digestive tract, enzymes and digestion.
3.3. Respiratory mechanism – Respiratory gills and lungs.
3.4. Circulatory system – Heart and accessory pumps.
3.5. Excretory system – Excretory organs and excretion.

Unit – IV: Fish biology and Embryogenesis **15 Hrs**

4.1. Nervous system- Central nervous system, brain and peripheral nervous system.
4.2. Sense organs – Olfactory, taste buds, touch receptors, photoreceptors, lateral line and internal ear.
4.3. Endocrine system – Pituitary gland, urohypophysis, adrenal, gonads, and thyroid gland.
4.4. Reproductive system- Male and female reproductive organs; role of hormones.
4.5. Embryogenesis - Early development and post embryonic development.

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PRACTICALS

1. Morphometric identification of fishes.
2. Meristic characters of fishes.
3. Dissection and preparation of permanent slides of scales.
4. Isolation of pituitary gland.
5. Identification of fish developmental stages - egg, spawn, fry fingerling and adult.
6. Dissection of Weberian ossicles.
7. Dissection of digestive system.
8. Dissection of reproductive system.
9. Sexual differentiation of fishes.
10. Determination of chlorides in heterosmotic media.

Submission of assignment on: Digestive system; Respiratory system; Circulatory system; Excretory system; Nervous system; Endocrine system; Reproductive system; Osmoregulation system

[To be submitted at the time of Examination – 10 Marks]

Suggested Books:

1. Textbook Of Fish Biology & Indian FisheriesRahul P Parihar
2. A Text Book of Fish Biology and Fisheries by S S Khanna and H R Singh.
3. Handbook of Fish Biology and Fisheries.(Vol I & II) by Paul J. B. Hart and John D. Reynolds
4. Fish Biology by, C B L Srivastava.
5. Fauna of British India, including Ceylon & Burma – by Francis Day.
6. Indian Fishes and Fisheries – Jhingran.
7. Introduction to Fish Physiology – Dr. Lynwood S. Smith
8. An Introduction to fishes – S. S. Khanna
9. Ichthyology- K.F. Lagler, John F. Bardach, R.R Miller and D.R. May Passino.

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester-IV, Elective - IA
Paper III: Comparative Animal Physiology - II [CAP-II]

UNIT 1 - Responses and Adaptation of Animals to their Environment 15Hrs

1.1 General receptor characteristics, receptor potentials and sensory coding.
1.2 Central nervous system – Insect to vertebrate comparison.
1.3 Integration for effective behaviour - spinal reflex: Learning and memory and its genetic basis.
1.4 Adaptations in organ systems for reception – Chemo, thermo, mechano, and electro- receptors.
1.5 Influence of environmental factors on chromatophore system: Biological rhythms –circadian – circumlunar and circannual rhythm

UNIT II - Effectors and Responses 15Hrs

2.1 Gland effectors for secretion - mechanism of target tissue activation and mechanism of secretion.
2.2 Types of muscle fibres slow, fast and asynchronous flight muscle. Mechanism and chemistry of muscle fibre contraction
2.3 Accessory movements - skeletal levers, elastic movements.
2.4 Effectors for movement - Cyclosis, amoeboid, ciliary, flagellar movements, and control of movement.
2.5 Stress biology and related disorders

UNIT III - Circulation and Control of Reproduction 15Hrs

3.1 Major types of body fluids - fluid compartments. Classification and regulation of circulatory systems.
3.2 Types of vertebrate hearts, heart rate, regulation and cardiac output, chemical and nervous control of heart rate.
3.3 Invertebrate hearts - annelids, scorpion, insect, crustacean, molluscan, and tunicate hearts.
3.4 r -selected and k- selected reproductive patterns: timing with respect to environmental variables, photo periods.
3.5 Hormones and development; Hormonal control of insect growth and reproduction; sexual behaviour in vertebrates; pregnancy and parental care.

PRACTICALS (All experiments involving live animals are for demonstration only)

1 Maze behaviour studies in rat.
2. Metabolic distinction of slow and fast muscles.
3. Kymographic studies of muscle properties.
4. Effect of temperature on heartbeat of crab.
5. Effect of AchE and adrenaline on heartbeat in crab.
6. Effect of oestrogen on serum calcium levels of rat.
7. Pregnancy testing by using HCG kit.
8. Dissection of nervous system of cockroach and crab, and their comparison.

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9. Dissection of male and female reproductive systems of cockroach and crab, and their comparison.
10. **Submission of assignment on**: General receptor characteristics, receptor potentials and sensory coding. Adaptations in organ systems for reception - chemo -, thermo -, mechano -, and electro-receptors. Central nervous system-Insect to vertebrate comparison - diagrams. Stress biology and related disorders. Types of muscle fibres slow, fast and asynchronous flight muscle. Invertebrate hearts - annelids, scorpion, insect, crustacean, molluscan, and tunicate hearts - diagrams. r -selected and k- selected reproductive patterns; timing with respect to environmental variables, photoperiods. Hormonal control of insect growth and reproduction. Biological rhythms with examples.
[To be submitted at the time of Examination - 10 Marks]

Suggested Books

1. Comp. Animal Physiology by Ladd Prosser (Publ. W. B. Saunders, Philadelphia).
2. Comp. Animal Physiology by William Hoar, (Pub. E.E.E. IBH).
3. Animal Physiology - Adaptation and function. By F. Reed Hainsworth (Publ. by Addisoncompany, California).
4. Animal Physiology by Kent Schmidt Nielson (Publ. E.E.E. IBH).
5. Animal Physiology and adaptation by David Gordon.
6 Animal Physiology by Wilson.

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology Semester – IV, Elective - IB
Paper III - Agricultural Entomology - II [AE - II]

UNIT – Introduction **15 Hrs**

1.1 Introduction - Antiquity of pest problem.
1.2 Reasons for insects turning into pest, reasons for pest outbreaks.
1.3 Economic injury level; Economic threshold level.
1.4 Climatic factors and natural barriers.
1.5 Pest monitoring and methods of survey.

UNIT II - Insect Pest Control Methods **15Hrs**

2.1 IPM - Definition, necessity of IPM; Tools of IPM, Ecology versus IPM.
2.2 Cultural, Physical, Chemical, Mechanical, Biological and Genetic control methods.
2.3 Synthetic Pyrethroids; Pesticide formulations - Dust, Sprays, Emulsions, Aerosols, Fumigants, Seed dressers or Seed treatment chemicals etc.
2.4 Synergists, Repellents, Baits, Toxicants, Anti feedants, Attractants, Chemosterilants;
2.5 Pesticide application methods and Safety parameters in pesticides application.

UNIT III - Pesticide Resistance and Advances in IPM **15 Hrs**

4.1 Chitin Synthesis Inhibitors; Insect growth regulators; Pheromones.
4.2 Pesticide resistance - Definition and types of resistance; Mechanism of resistance, Genetics of resistance.
4.3 Regulatory methods - Insecticides and Plant Quarantine Acts.
4.4 Modern trends in pesticide research; Biotechnological advances in IPM.
4.5 Pesticide applications and their adverse consequences on environment; Concepts of organic farming

PRACTICALS

1. Collection, Identification and Preservation of insect pests of agricultural, medical and veterinary importance.
2. Usage of light traps for insect collection.
3. Usage of pheromone traps for insect collection.
4. Bird perches and their utility.
5. Bioassay of insecticides using different methods of exposure.
6. Calculation of LD50 using probit analysis.
7. Study of antifeedant activity in Spodoptera or any suitable pest.
8. Culturing of NPV.
9. Visit to ICRISAT Hyderabad Telangana State.
10. **Submission of assignment on:** IPM definition, necessity of IPM, Ecology versus IPM; Reasons for insectsturning into pests ,Economic threshold level.

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Pest monitoring and Methods of Survey. Types of pest control .Pesticide Resistance and Regulatory methods. Biotechnological advances in IPM. Safety parameters in pesticides application.

[To be submitted at the time of Examination - 10 Marks]

Suggested Books

1. Introduction to General and Applied Entomology by V.B. Awasthi.
2. Integrated pest management principles and practices byAbrolD.P.CABIpublications.
3. Integrated pest management principles and applications vol. 1 by Singh. CBSpublication.
4. Applied Entomology by P.G.Fenemore and Alka Prakash.
5. Biodiversity and insect pestsmanagement S. Ignacimuthu, S.Jayaraj.
6. Integrated pest management principles and applications Amerika Singh, O.P. Sharma, D.K.Garg.
7. Handbook of Integrated pest management by ICAR.
8. Pest management principles and practices by Rajesh Ravi.
9. Theory and practices of integrated pest management by A.K. Dhawan& Ramesh Arora.
10. A textbook of Applied Entomology, Vol. I & II. By K.P. Srivastava.

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MAHATMA GANDHI UNIVERSITY, NALGONDA

M.Sc. Zoology, Semester-IV, Elective –IIA
Paper – IV: Applied Toxicology [AT]

UNIT I: Toxicity of Pesticides and Heavy metals — 15 Hrs

1.1 Classification of Pesticides, Bioaccumulation and Biomagnifications of Pesticides: factors affecting Bioaccumulation and Biomagnification.

1.2 Environmental problems by organochlorine and organophosphate pesticides, case studies of DDT, Endosulphan and Malathion.

1.3 Pesticide toxicity– Haematotoxicity Reproductive and developmental effects, Carcinogenicity, Immunological effects.

1.4 Eco-toxicology of heavy metals – Mechanism of heavy metal toxicity, case studies of Arsenic, Mercury and Cadmium.

1.5 Toxicity of Food Additives- Polycyclic hydrocarbons, Hydrocyclic-amines, Nitrosamines and synthetic carcinogens.

UNIT II: Occupational and Industrial Toxicology — 15 Hrs

2.1 Occupational hazards- physical, chemical, biological and mechanical hazards.

2.2 Occupational diseases: Pneumoconiosis, Silicosis, Asbestosis, Anthracosis.

2.3 Occupational Cancer – Skin cancer, Lung cancer, Bladder cancer and Leukaemia: Prevention of Occupational diseases.

2.4 Industrial toxicology – Industrial hygiene, Risk assessment and management of industrial chemicals.

2.5 Introduction, Legislation and Regulation – Federal government, State government.

UNIT III: Applied toxicology — 15 Hrs

3.1 Toxicology of chemical Warfare agents – chemical weapons, classification of chemical Warfare Agents and their Management

3.2 Veterinary toxicology – common toxicity in Dog, Cat and Poultry by herbicides, house hold chemicals, heavy metals and Mycotoxins etc.

3.3 Wild life toxicology –Susceptibility of wild life to chemicals, acute ecological hazards, toxicology of chemicals in birds and mammals, integrated approach to wild life toxicology.

3.4 Cosmetic toxicology – toxicity of shampoos, conditioners, bleachers and Dyes.

3.5 Laboratory animals – animal care and maintenance: CPCSEA guidelines.

PRACTICALS: (All experiments involving live animals are for demonstration only)

1 Determination of LC50/LD50 of selected toxicant (bioassay method).
2. Determination of LPO activity by TBRAS method.
3. Effect of toxicant on glycogen, glucose and amino acids.
4. Hepato-toxicant effect on Total Bilirubin Content (direct and indirect method).
5. Estimation of SGOT and SGPT as a marker enzyme for hepatotoxity.
6. Estimation of serum creatinine activity as a marker enzyme for renal toxicity.
7. Micronuclei test.
8. Estimation of Haemoglobin and RBC in Lead exposed experimental animals.
9. Estimation of AchE activity as a marker of pesticide poisoning.

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10 Industrial visit.

11 Submission of assignment on: Dose effect and dose-response relationship; Oxidative stress: Effect of toxic agents on neurons, lesions of neural tissue: Occupation disease - pneumoconiosis, silicosis, asbestosis; Legislation & Regulation involved in environmental toxicology; Detoxification Mechanisms /Biotransformation of xenobiotic.

[To be submitted at the time of Examination - 10 Marks]

Suggested Books

1. Principles of ecotoxicology- 3rd edition 2006, C H Walker, S P Hopkin, R N Sibly and D B Peakall (Eds.), Taylor and Francis, New York, NY.
2. Introduction to Environmental toxicology -3rd edition 2003, W.G.Landis and M.H.Yu. Lewis publishers, Florida.
3. Text Book of Modern Toxicology 2000 edition, Ernst Hodgson and Patrica Levi, McGraw – Hill, International edition, Singapore.
4. Principles of toxicology 2010 edition, Anju Agarwal and Krishna Gopal, ibdc publishers India.
5. Essentials of Toxicology 2011 edition, Vijay Kumar Matham, New India Publishing Agency, New Delhi, India.
6. Principles of Biochemical Toxicology- Jatimbrell; Taylor and Francis Ltd, London.
7. Basic Environmental Toxicology – LorrisG. Cockerham, Barbara S Shane; CRC Press, London.
8. Hand book of Toxicology – Thomos J Haley, Willan O Berndt; Hemisphere Publishing cooperation, Washington.
9. Modern Toxicology (3 Volumes)- P K Gupta and Salunkha; B V Gupta Metropolitan Book Co., Pvt. Ltd, New Delhi.
10. Encyclopaedia of Toxicology – O P Jasra.

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M.Sc. Zoology, Semester – IV, Elective -IIB
Paper IV - Zoonotic Viral Diseases [ZVD]

UNIT I - Principles of Zoonosis & Viral Diversity 15Hrs

1.1 Classification of viruses: Principles and significance of zoonosis; Emerging and Re-emerging viral diseases.

1.2 Zoonotic viral diseases: Alpha viral Zoonosis - Pathogenesis and pathology of Chikungunya.

1.3 Flaviviruses Zoonosis - Complexes of the Flaviviridae with clinical importance: Pathogenesis and pathology of Japanese Encephalitis.

1.4 Bunya virus Zoonosis - Pathogenesis and pathology of some important haemorrhagic fever caused by Hantavirus.

1.5 Filovirus Zoonosis - Pathogenesis and pathology of Ebola Haemorrhagic Fever (EHF).

UNIT II - Zoonosis caused by major viruses 15 Hrs

2.1 Coronavirus Zoonosis-Pathogenesis and pathology of SARS-CoV-1, SARS-CoV-2 (COVID-19), MERS and other Coronaviruses.

2.2 Retrovirus Zoonosis- Pathogenesis and pathology of SIV, HIV 1 and HIV2.

2.3 Herpesvirus Zoonosis - Pathogenesis and pathology of Herpesvirus hominis type 1 & 2 (HSV-1 and HSV-2) and Varicella-zoster virus.

2.4 Rhabdovirus Zoonosis – Paramyxo viruses, Nipah Virus Encephalitis, Picorna viruses, Hepatitis.

2.5 Orthomyxoviruses Zoonosis -Influenza Viruses (H5N1, H1N1, H7N7, H7N9 and H9N2).

UNIT III - Virus Diagnostics, Vaccines and Treatment 15 Hrs

3.1 Diagnostic Virology – Scope and History, viral detection methods and their significance.

3.2 Virus detection and discovery: Diagnostic Techniques: Serological and molecular approaches. Electron Microscopy. Next Generation Sequencing.

3.3 Immunization against Viral Diseases - Antigenicity and immunogenicity of viral proteins; Viral antigens recognized by the immune system: Vaccine-induced immunity against Viral Diseases.

3.4 Viral Vaccine Development - Virus vaccines - Active/Live, Inactivated. Virus-like particle; Other Vaccine Approaches. Vaccine Formulation and Delivery.

3.5 Antiviral Agents - Overview, mechanisms of specific antiviral drugs; Principles of antiviral therapy; Monoclonal antibody therapy.

PRACTICALS

1 Standard Operational Procedures and biosafety (BSL-2, BSL-3, BSL-4) precautions in Viral Lab.

2. Glassware decontamination, washing, sterilization, packing and sterile handling.

3. Operational procedures of Laminar Flow.

4. Sample collection and preservation for virus detection.

5. Extraction & isolation of DNA & RNA of a virus.

6. PCR amplification and testing of amplicons through electrophoretic techniques.

7. In silico phylogenetic analysis.

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8. ELISA antibody test for viral infections.
9. Lymphocyte separation.
10. **Submission of assignment on:** Evolution of viruses; Virus-Like Particle Vaccines; Monoclonal Antibody Therapy; Next Generation Sequencing; Antigenic Variation; Virus Discovery; Influenza Viruses; Haemorrhagic fevers; Flaviviruses; Kyasanur Forest Disease; SARS-CoV; SARS-CoVII; MERS.

[To be submitted at the time of Examination - 10 Marks]

Suggested Books

1. Handbook of Zoonosis: Identification and Prevention by J. L. Colville and D. L. Berryhill. 2007
2. Human-Animal Medicine: Clinical Approaches to Zoonosis, Toxicants and Other Shared Health Risks by Rabinowitz and Conti. 2009 u
3. Fields Virology Volume 1 & 2 by David M. Knipe
4. Rolf Bauerfeind et al.Zoonosis Infectious Diseases Transmissible from Animals to Humans.2016
5 Encyclopaedia of VIROLOGY 3rd Edition by Dr.Brian J Mahy, Dr Marc H V Van Regenmortel. 2008
6 Basic Immunology: With Student Consult Access.Abul K. K. Abbas. Andrew H.Lichtman. 2004.
7 Immunology. David A.Goldsby, Janis Kuby, Thomas J. Kindt, Barbara A. Osborne Latest edition December 2002
8 Immunology. Ivan Roitt, Jonathan Brostoff. David Male, David K. Male (Editor). 2001.
9 Cellular Interactions and Immunobiology (Biotol S.) 1993
10 Defence Mechanisms. Biotol Series, Butterworth/Heinemann, Oxford, UK.
11 Antiviral Agents, Vaccines, and Immunotherapies. Stephen K. Tyring. 2004.
12 Antiviral Drug Discovery for Emerging Diseases and Bioterrorism Threats. Paul F. Torrence (Editor). 2005
13 Chimeric Virus like Particles as Vaccines. Wolfram H. Gerlich, Detlev H. Krueger & Rainer Ulrich. 1996.
14 Vaccines. Stanley A. Plotkin, Walter A. Orenstein. 2003.
15 CRC Handbook of Viral and Rickettsial Hemorrhagic Fever by James H.S. Gear

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M.Sc. ZOOLOGY QUESTION PAPER PATTERN

(w.e.f. 2023-24 A.Y.)

(4 units paper -EXTERNAL EXAM-70Marks)

Section–A: Answer any five questions 5x4=20M

1
2
3
4
5
6
7
8

Section-B: Answer all the Questions 50M

(Note: Out of four questions, any two questions carry 12 marks each (24M) and another two questions carry 13 marks each (26M))

9. a (or) b
10. a (or) b
11. a (or) b
12. a (or) b

(4 units paper -Internal Exam – 20Marks)

Part-A: 10 Multiple choice Questions 10x1=10M

Part-B: 10 fill in the blanks 10x1=10M

Assignment 5 Marks

Seminar 5 Marks

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M.Sc. ZOOLOGY QUESTION PAPER PATTERN

(w.e.f. 2023-24 A.Y.)

(3 Units paper- EXTERNAL EXAM - 50 Marks) Elective paper (Optional)

Section–A: Answer any four Questions 4x4=16M

1
2
3
4
5
6

Section-B: Answer all the Questions 34M

(Note: Out of three questions, any two questions carry 11 marks each (22M) and the remaining one question carry 12 marks)

7. a (or) b
8. a (or) b
9. a (or) b

(3 Units paper - Internal Exam - 15Marks)

Part–A: 8 Multiple choice Questions 8x1=8M

Part–B: 7 fill in the blanks 7x1=7M

Assignment 5 Marks

Seminar 5 Marks

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M.Sc. ZOOLOGY QUESTION PAPER PATTERN

(w.e.f. 2023-24 A.Y.)

I D paper

(2 Units paper- EXTERNAL EXAM-35Marks)

Section –A: Answer any two Questions 2x5=10M

1

2

3

4

Section-B: Answer all the Questions with internal choice 25M

(Note: Out of two questions, any one question carries 12 marks and another question carries 13 marks)

5. a (or) b

6. a (or) b

(2 Units paper- Internal Exam -10Mrks)

Part –A: 5 Multiple choice Questions 5x1=5M

Part –B: 5 fill in the blanks 5x1=5M

Assignment 5 Marks

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Minutes of the Zoology BOS committee meetings, MGU, Nalgonda.

Members in the Board of Studies committee, Zoology:

1	Dr. M. Thirumala	Assistant Professor	Chairperson, BOS in Zoology (UCS, MGU, Nalgonda)
2	Dr.C. Srinivasulu	Associate Professor	Member (UCS, Osmania University, Hyderabad)
3	Dr.A.V.Rajashekhar	Associate Professor	Member (UCS, Osmania University, Hyderabad)
4	Dr.S.Padmaja	Associate Professor	Member (UCS, Osmania University, Hyderabad)
5	Dr. Nageswara Rao Amanchi	Assistant Professor	Member (UCS, Osmania University, Hyderabad)
6	Dr.Apka Nageswar Rao	Assistant Professor	Member (Nizam College, Osmania University, Hyderabad)
7	Dr.K.Y.Chitra	Assistant Professor	Member (UCS,Osmania University, Hyderabad)
8	Dr. Meenakshi	Assistant Professor	Member (UCS,Osmania University, Hyderabad)
9	Mr. Srinath Patel	Assistant Professor	Member (NG College, Nalgonda)
10	Mr. J.Swamy	Assistant Professor	Member (GDC (W), Nalgonda)
11	Dr. Sanjay Dwivedi	Lead, QC	Member (Sanofi healthcare India Private Limited, Medchal-Malkajgiri)
12	Dr. P.Pavan Kumar	Scientist	Member (Asian Institute of Gastroenterology, Hyderabad)

Agenda:

As per Mahatma Gandhi University (Nalgonda) administration directions of forming schema and syllabi with 92 credits for M.Sc. lab courses, BOS committee meetings (3) were conducted. Two BOS committee meetings through online mode (Zoom) on 19.6.2023 (Monday) at 4PM (for M.Sc. Zoology [w.e.f. 2023-24 A.Y.] schema finalization with 92 credits and to discuss workload of M.Sc. Zoology course) and on 19.8.2023 at 3.30PM (for M.Sc. Zoology [w.e.f. 2023-24 A.Y.] syllabus discussion) in MGU. Third BOS committee meeting through offline mode at OU, Zoology department on 6.9.2023 at 11.30 AM for further discussions and getting final approval of M.Sc. Zoology [w.e.f. 2023-24 A.Y.] schema and syllabus.

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The following resolutions were made in M.Sc. Zoology schema and syllabus w.e.f 2023-24 A.Y.

1. Credits are reduced from 112 to 92.
2. In all 4 semesters, four practical papers in each semester (with each practical paper of 2 credits and 4 instruction hours) are clubbed into two, hence every semester in the modified schema consists of only 2 practical papers instead of 4 practical papers (earlier).
3. In every semester, for each practical paper, 3 credits are proposed and accepted (marks are also changed from 50 to 75 accordingly (each practical paper workload is 6hrs/week in modified schema)
4. Add on paper is removed in I sem; only one Add on paper is retained, i.e. in II sem
5. Seminar credits were removed completely
6. In sem III and sem IV, 3rd and 4th papers are optional papers with only 2 electives proposed each.
7. For optional papers, credits are decreased from 4 to 3, marks are also reduced from 100 to 75 accordingly.
8. In sem IV, earlier three practical papers and one project was there, but new schema consists of 2 practical papers and project work (only one hour per week workload for handling project work per faculty)
9. ID paper (III sem) subject title is Evolutionary Biology and Population genetics (EBPG) and made to 2 credits from 4 credits, another ID paper (in IV sem) is removed.
10. Practical Exams model is proposed and accepted.

The chairman, BOS thanked all the members for making it convenient to attend the BOS committee meetings.

1. Chairperson, BOS in Zoology, Mahatma Gandhi University, NALGONDA-508 254. (T.S.)
2. 6/9/23
3. —
4. 6/9/23
5. 6/9/2023 Dr. NAGESWARA RAO AMANCHI Assistant Professor Ecotoxicology Lab. Department of Zoology Osmania University, Hyderabad-500 007
6. —
7. K.Y. Chitra 6/9/2023
8. Meenakshi 6/9/2023
9. 6/9/2023
10. 6/9/23
11. —
12. —