RAJA MAHENDRA PRATAP SINGH UNIVERSITY
ALIGARH, UTTAR PRADESH

Proposed Titles for Theory and Practical Papers
U.G.(Honours), U.G. (Honours with Research) – 4th Year
& P.G. in ZOOLOGY – 5th Year

SUBJECT: ZOOLOGY

Syllabus Developed by:

S. No.	Name	Designation	Affiliation
Board of Studies			
1.	Dr. Vinay Kumar	Professor & Convenor of Board of Studies	Dharam Samaj College, Aligarh
2	Dr. Sheeba	Professor	Dharam Samaj College, Aligarh
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4	Dr. Manish Maheshwari	Professor	Dharam Samaj College, Aligarh
5	Dr. Harendra Kumar Gaur	Assistant Professor	Shri Varshney College, Aligarh
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7	Dr. Babu Ram Singh	Assistant Professor	Dharam Samaj College, Aligarh
8	Dr. Mohammad Amir	Professor	Aligarh Muslim University, Aligarh
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Semester-Wise Titles of the Papers in

U.G. (Honours), U.G. (Honours with Research) – 4th Year

SEMESTER WISE TITLES OF THE PAPER FOR U.G. (HONOURS), U.G. (HONOURS WITH RESEARCH) – 4th YEAR IN ZOOLOGY								
YEAR	**SEM.**	**COURSE CODE**	**PAPER TITLE**	**THEORY/ PRACTICAL**	**CREDITS**	**TOTAL**	**Evaluation**	
							CIE	**ETE**
4th Year	**VII**	RB050701T	BIOLOGICAL TECHNIQUES AND INSTRUMENTATION	THEORY	**4**	**20/16**	**25**	**75**
		RB050702T	MOLECULAR AND CELL BIOLOGY	THEORY	**4**		**25**	**75**
			CHOOSE BOTH FOR U.G. (HONOURS) AND ONE FOR U.G. (HONOURS WITH RESEARCH)				**25**	**75**
		RB050703T	i. SYSTEMATICS AND STRUCTURE AND FUNCTION OF NON-CHORDATES	THEORY	**4**			
		RB050704T	ii. MICROBIOLOGY AND IMMUNOLOGY	THEORY	**4**			
		RB050705P	PRACTICAL BASED ON THEORY PAPERS	PRACTICAL	**4**			**100**
	VIII	RB050801T	CHORDATE ANATOMY	THEORY	**4**	**20/24**	**25**	**75**
		RB050802T	GENETICS AND BIOTECHNOLOGY	THEORY	**4**		**25**	**75**
			CHOOSE BOTH FOR U.G. (HONOURS) AND ONE FOR U.G. (HONOURS WITH RESEARCH)				**25**	**75**
		RB050803T	i. ANIMAL PHYSIOLOGY AND BIOCHEMISTRY	THEORY	**4**			
		RB050804T	ii. ENVIRONMENTAL BIOLOGY AND TOXICOLOGY	THEORY	**4**			
		RB050805P	PRACTICAL BASED ON THEORY PAPERS	PRACTICAL	**4**			**100**
		RB050806R	RESEARCH PROJECT (SUBMISSION AND EVALUATION)		**8**			

Semester-wise Titles of the Papers in

P.G. in ZOOLOGY – 5th Year

SEMESTER WISE TITLES OF THE PAPER FOR POST GRADUATE COURSE – 5th YEAR IN ZOOLOGY								
YEAR	**SEM.**	**COURSE CODE**	**PAPER TITLE**	**THEORY/ PRACTICAL**	**CREDITS**	**TOTAL**	**EVALUATION**	
							CIE	**ETE**
5th Year	**IX**	RB050901T	BIOSTATISTICS AND COMPUTER APPLICATIONS	THEORY	**4**	**16**	**25**	**75**
		RB050902T	ANIMAL BEHAVIOUR	THEORY	**4**		**25**	**75**
			CHOOSE ANY ONE				**25**	**75**
		RB050903T	i. INSECT SYSTEMATICS, ECOLOGY AND APPLIED ENTOMOLOGY (ENTOMOLOGY PAPER 1)	THEORY	**4**			
			OR					
		RB050904T	ii. SYSTEMATICS, MORPHOLOGY AND PHYSIOLOGY OF FISHES (FISH AND FISHERIES – PAPER 1)	THEORY	**4**			
		RB050905P	PRACTICAL BASED ON THEORY PAPERS	PRACTICAL	**4**			**100**
	X	RB051001T	DEVELOPMENTAL BIOLOGY	THEORY	**4**	**24**	**25**	**75**
		RB051002T	EVOLUTIONARY BIOLOGY	THEORY	**4**		**25**	**75**
			CHOOSE ANY ONE				**25**	**75**
		RB051003T	i. INSECT MORPHOLOGY, ANATOMY, PHYSIOLOGY AND DEVELOPMENT (ENTOMOLOGY PAPER 2)	THEORY	**4**			
			OR					
		RB051004T	ii. FISH ECOLOGY, AQUACULTURE AND THEIR ECONOMIC IMPORTANCE (FISH AND FISHERIES - PAPER 2)	THEORY	**4**			
		RB051005P	PRACTICAL BASED ON THEORY PAPERS	PRACTICAL	**4**			**100**
		RB051006R	RESEARCH PROJECT (SUBMISSION AND EVALUATION)		**8**			

Semester-wise Syllabus of Papers in

U.G.(Honours), U.G. (Honours with Research) – 4th Year

Semester VII Paper I

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VII	**Biological Techniques and Instrumentation**	**RB050701T**	**I**	Basic principles of microscopy, Principle, design, working, applications and limitations of following microscopes: Compound, Phase contrast, Interference, Polarized, Fluorescence, Transmission Electron, Scanning electron and confocal. Fixation and staining techniques for light and electron microscopy.	**4**
			II	Principle, design, working, applications and limitations of the following instruments: pH meter, centrifuge, spectrophotometer, autoclave, laminar flow, Chromatographic techniques-Paper, TLC, Gel Filtration, Affinity, Ion Exchange, Gas and HPLC Electrophoresis-Paper, Agarose Gel, Polyacrylamide gel, SDS PAGE and Isoelectric focusing.	
			III	**Blotting techniques**: Southern, northern, western and stee PCR and its types- Real time, Nested, Multiplex, Reverse Transcriptase, Asymmetric PCR **ELISA and its types**- Direct, Indirect, Sandwich and Competitive.	
			IV	Sanger DNA Sequencing, Protein sequencing, Different types of radioisotopes used in biology, Scintillation counter, GM counter, Autoradiography, Electrophysiological methods ECG, EEG, PET, MRI, FMRI, CAT.	

Suggested readings:

1. Wilson and Walkers: Principles and Techniques of Biochemistry and Molecular Biology 8Ed by Hoffman A & Cloakie S.
2. Molecular Biology of the Cell 5 Ed: by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff and Keith Roberts
3. Experimental Biochemistry by John M. Clark (Editor), Robert L. Switzer and Liam F. Garrity.
4. A text book of Molecular Biology, Bioinstrumentation and Biotechniques by Vikas Yadav and Parul Yadav.
5. Physical Biochemistry - Applications to Biochemistry and Molecular Biology by Freifelder David.
6. Physical Biochemistry: Principles and Applications by David Sheehan.

Semester VII Paper 2

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VII	**MOLECULAR AND CELL BIOLOGY**	**RB050702T**	**I**	**DNA replication**: Prokaryotic and eukaryotic DNA replication, enzymes and accessory proteins involved in replication, origin of replication, replication fork; initiation, elongation and termination of replication. **Transcription**: Transcription unit, RNA polymerases, transcription factors; initiation, elongation and termination of transcription in prokaryotes and eukaryotes, post transcriptional modifications (capping, polyadenylation, splicing and RNA editing).	**4**
			II	**Translation**: Genetic code; initiation, elongation and termination of translation in prokaryotes and eukaryotes. **Regulation of gene expression**: Regulation at transcription level (operon system, *lac* and *trp* operons), role of chromatin in gene expression, RNA interference.	
			III	**Cell structure and functions**: Structural organization and function of intracellular organelles: nucleus, mitochondria, Golgi bodies, endoplasmic reticulum and lysosomes. **Cellular membrane and cytoskeleton**: Lipid bilayer, Chemical composition of cell membrane, membrane proteins, movement of substances across cell membranes; Structure and organization of microtubules, intermediate filaments and microfilaments and their role in cell motility.	
			IV	**Cell signaling**: Signaling molecules and cell surface receptors, signaling through G-protein coupled receptors, second messengers. **Cell division and cell cycle**: Mitosis and meiosis, cell cycle and its regulation, apoptosis.	

Suggested readings:

1. Molecular Biology by Freifelder.
2. Genes XII by Lewin.
3. Molecular biology of the gene by Watson et al.
4. Molecular Biology of the Cell by Alberts et al.
5. Molecular Cell Biology by Lodish et al.
6. Cell: A Molecular Approach by Cooper.
7. Cell and Molecular biology by Gerald Karp
8. Cell and Molecular biology by De Robertis.
9. Genome 3 by T. A. Brown.
10. The World of Cell by Becker et al.
11. Cell Biology by Pollard et al.
12. A text book of Molecular Biology, Bioinstrumentation and Biotechniques by Vikas Yadav and Parul Yadav
13. Cytology, Genetics and Infectious Disease by Vikas Yadav and Parul Yadav (Unit III and IV)

Semester VII Paper 3

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VII	**Systematics and Structure and Function of Non-Chordates** **Note**: Choose both RB050703T & RB050704T for U.G. (Honours) and one for U.G. (Honours with research)	**RB050703T**	**I**	**Taxonomy** • Species concept; International Code of Zoological Nomenclature • Taxonomic procedures; New trends in Taxonomy • Taxonomy collections, preservations and curating of collection, process of identification • Preparation and use of different kinds of taxonomy keys; their merits and demerits • Cladistics and cladogram; • Brief knowledge of invertebrate characters (level of organisation, symmetry, coelom, metamerism, etc.) & classification of non-chordates	**4**
			II	**Locomotion and Respiration** • Amoeboid, Ciliary and flagellar locomotion; ultra structure of cilia and flagella • Hydrostatic locomotion in Cnidaria (Coelenterata), Annelida and Echinodermata; Flight mechanism in Insecta; Foot and its modification in Mollusca • Organs of respiration: Gills, lungs and trachea, Mechanism of respiration, Respiratory pigments	
			III	**Nutrition, Digestion, Excretion and Nervous system** • Patterns of Feeding and Digestion (Amoeboid, Ciliary, Filter feeding in Porifera, Polychaeta, Mollusca and Echinodermata, Parasitic feeding) • Excretory organs in Platyhelminthes (Flame cells), Aschelminthes, Annelida (Nephridia, Coelomoduct, Chloragogen Cells), Arthropoda (Green gland, Malpighian tubules) Mollusca (Renal chamber, Organ of Bojanus) • Primitive (Coelenterata and Echinodermata) and Advanced nervous system (Annelida and Mollusca)	
			IV	**Parasitic adaptations, Non-chordate larvae and Minor phyla** • Protozoan and Helminth Parasites • Larval forms of free-living non-chordates • Larval forms of parasitic non-chordates • Evolutionary significance of larval forms of non-chordates • Minor phyla - Concepts and Significance; General characters and examples of Rotifera, Ctenophora, Sipunculida and Onychophora	

Suggested readings:

1. Invertebrate structure and function.; Barrington. E. J. W. Thomas Nelson & Sons Ltd. London
2. The Invertebrates; Hyman. L. H.; McGraw Hill Co New York
3. Invertebrate Zoology, III edition. ; Barnes. R.D.
4. The invertebrates. Vol.1. Protozoa through Ctenophora, Hyman, L.H. McGraw Hill Co., New York.
5. Evolution of Metazon life cycle, Jagerstain, G. Academic Press, New York & London.
6. The Invertebrates. Vol.2. Hyman, L.H. McGraw Hill Co., New York.
7. The Invertebrates. Vol.8. Hyman, L.H. McGraw Hill Co., New York. and London
8. Invertebrate Zoology Barnes, RD. W.B. Saunders Co., Philadelphia
9. A Biology of higher invertebrates, Russel-Hunter, WD. McMillan Co. Ltd., London
10. The Invertebrates srnaller colomate groups, Vol.5. Hyman, L.H. McGraw Hill Co., New York.
11. Animal Parasitism. Cad. C.P.Prentice Hall Inc., New Jersey.

Semester VII Paper 4

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VII	**Microbiology And Immunology** **Note**: Choose both RB050703T & RB050704T for U.G. (Honours) and one for U.G. (Honours with research)	**RB050704T**	**I**	**Introduction to microbes**: Culturing bacteria in different media, purification of strains and various methods of short and long term storage; Mutations in bacteria and isolation of mutants; Ame's test; F-plasmids, their conjugation and role in gene mapping. Applications of microbiology.	**4**
			II	**Viruses and Phages**: Types of phages, Importance of bacteriophages in genetics and molecular biology, Fine structure of bacteriophage lambda; Life cycle of bacteriophages: lysogeny and lytic options; Transduction: generalized and specialized transduction; Complementation test; Retroviruses and their mechanism of replication, Structure and genomics of HIV.	
			III	**Immunology - I**: General concept of immune system: Innate and acquired immune system, cells and molecules involved in both type of immune systems; Active and passive immunity; Antigens, immunogens and haptens, antigenicity and immunogenicity; Immunogenic or antigenic response of B and T cells; Structure and function of antibody molecules; concept of epitopes and paratopes; Humoral and cell mediated immunity.	
			IV	**Immunology II**: Generation of antibody diversity: monoclonal and polyclonal antibodies, Hybridoma technology; antigen- antibody interactions, MHC molecules; Antigen processing and presentation; Activation and differentiation of B and T cells, B and T cell receptors; the complement system; Toll-like receptors; Hypersensitivity and autoimmunity; Cytokines (Interleukins, Chemokines, Interferons, Colony Stimulating Factors etc.); Vaccines.	
Suggested readings: 1. Kuby Immunology by Judy Owen, Jenni Punt and Sharon Stranford. 2. Roitt's Essential Immunology. 3. The Immune System by Peter Parham. 4. Cellular and Molecular Immunology 6th Edition by Shiv Pillai, Abdul K Abbas and Andrew H Lichtman. 5. Bailey & Scott's Diagnostic Microbiology. 6 Prescott's Microbiology by Joanne Willey, Linda Sherwood and Christopher J. Woolverton. 7. Gene technology, Immunology and Computational Biology by Vikas Yadav and Parul Yadav (Unit III and IV)					

U.G.(Honours), U.G. (Honours with Research) – 4th Year

Semester VIII – Paper 1

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VIII	**Chordate Anatomy**	**RB050801T**	**I**	**Chordate Origin**: Concepts of Protochordata, Nature of Vertebrate Morphology and classification to Vertebrate. **Vertebrate Integument**: General structure and function of skin. and their derivatives.	**4**
			II	**Circulatory system**: Blood, Evolution of Heart and Aortic Arches. **Digestive System**: Digestive Tract and Digestive Glands	
			III	**Respiratory System**: Respiratory Tissues characteristics and Different Respiratory Organs in Chordates. **Urinogenital System**: Male and Female urinogenital system in tetrapods. **Skeletal System**: skeletal elements of the body, Skull, Vertebral column, Limbs and Girdles (in Tetrapods)	
			IV	**Sense Organs**: Cutaneous Receptors, Chemoreceptors, Lateral line System, Stato-acoustic organs, Electroreception. **Nervous System**: Anatomy of brain in relation to its function, Spinal Cord and cranial nerves, peripheral and autonomous nervous system.	

Suggested readings:

1. Harvey et al: The Vertebrate Life (2006)
2. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002,Wiley - Liss)
3. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
4. Kenneth V. Kardong (2015) Vertebrates: Comparative Anatomy, Function, Evolution McGraw Hill
5. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
6. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Young: The Life of vertebrates (3rd ed 2006, ELBS/Oxford)
9. Weichert C.K and William Presch (1970). Elements of Chordate Anatomy, Tata McGraw Hills

Semester VIII – Paper 2

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VIII	**Genetics and Biotechnology**	**RB050802T**	**I**	**Gene Action**: From genotype to phenotype - Penetrance and expressivity, Gene interaction, Phenocopy, Genomic imprinting, Linkage and crossing over, Sex linked, Sex influenced, Sex limited characters, Pedigree analysis, Gene mapping; Extranuclear inheritance- Mitochondrial genes and Maternal effect.	**4**
			II	Sex determination in human, Drosophila and other animals; Dosage compensation of X-linked genes- Hyperactivation of X- linked gene in male Drosophila and Inactivation of X-linked gene in female Drosophila; Types of mutation, Mutagens, Mutant types (Lethal, conditional, Biochemical, loss of function, Gain of function, Germinal versus somatic, Insertional mutagenesis).	
			III	Tools and techniques of Biotechnology: Recombinant DNA technology, Restriction enzymes, Linkers/Adapters, Selection and screening of recombinants, Cloning vectors- Plasmid, Phages, Cosmids, Transposons, Shuttle and expression vectors, Gene library, C-value paradox.	
			IV	Application of Biotechnology: Industrial Biotechnology, Biofuels, Bioremediation, Biodegradation, Biofertilizers, Single cell Protein. Genetic manipulation of animal cells: Transgenic animals, Gene knockout, formation and selection of embryonic stem cells; Gene therapy: Human diseases targeted for gene therapy, vectors and delivery systems.	
Suggested readings: 1. Principles of Genetics by E. J. Gardener et al. Molecular biology of the gene by J. D. Watson. 2. Biotechnology by Satyanarayana. 3. Principles and techniques of biochemistry and molecular biology by Wilson and Walker. 4. Cytology, Genetics and Infectious Disease by Vikas Yadav and Parul Yadav (Unit I and II) 5. Gene technology, Immunology and Computational Biology by Vikas Yadav and Parul Yadav (Unit III and IV)					

Semester VIII – Paper 3

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VIII	**Animal Physiology and Biochemistry** **Note**: Choose both RB050703T & RB050704T for U.G. (Honours) and one for U.G. (Honours with research)	**RB050803T**	**I**	**Physiology of digestion**: Digestion and absorption of proteins, carbohydrates and lipids, Regulation of digestion and absorption. **Physiology of respiration**: Respiratory volumes and capacities, Mechanism of breathing, Transport and exchange of gases, Oxygen dissociation curve, Regulation of respiration. **Physiology of circulation**: Blood composition, blood coagulation, Structure and working of human heart, Cardiac cycle and its regulation. **Physiology of excretion**: Process of urine formation, Counter current mechanism, Regulation of excretion.	**4**
			II	**Neuro-physiology**: Generation and conduction of nerve impulse, Synaptic transmission, Physiology of sense organs. **Muscular physiology**: Types of muscles and muscle proteins, Molecular mechanism of muscle contraction. **Physiology of Endocrine system**: Overview of endocrine glands, Mechanism of hormone action.	
			III	**Biomolecules** Biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins), Stabilizing interactions (van der waals, electrostatic, hydrogen bonding, hydrophobic interaction etc.), Types and structure of amino acids, Secondary structure of Proteins (α-helix, β-sheet, motifs, folds, domains, Ramachandran plot), Tertiary and quaternary structure of proteins, Nucleic acids: DNA structure and forms of DNA, Types and structure of RNA. Oxidative phosphorylation and ATP synthesis.	
			IV	**Enzyme Kinetics and Bioenergetics** **Introduction to Enzymes**: Apoenzyme, Holoenzyme, Prosthetic Group, Cofactors, Coenzymes, Abzymes, Ribozymes. Immobilized Enzymes **Enzyme Kinetics**: Michaelis-Menten Equation, Enzyme Inhibition - Competitive & Non-Competitive **Enzyme Regulation**: Allosteric Regulation, Covalent Modification, Zymogens, Proenzymes, Isozymes.	

Suggested readings:

1. BRS Physiology by Linda S. Costanzo. Publisher: Lippincott Williams and Wilkins
3. Comparative Animal Physiology by CL Prosser and FA Brown. Publisher: W.B. Sanders Co.
4. Fundamentals of Human Physiology by Stuart Ira Fox. Publisher: McGraw-Hill Education - Europe
5. Ganong's Review of Medical Physiology by Brooks, Boitano and Barman. Publisher: McGraw Hill
6. Guyton & Hall Textbook of Medical Physiology by V Hall & R Kurpad. Publisher: Elsevier
8. Principles of anatomy and physiology by Derrickson and Tortora.
9. Principles of biochemistry, by Lehninger.
10. Biochemistry by Donald Voet and Judith Voet.
11. Biochemistry by Harper.
12. Biochemistry by Jeremy M. Berg, John L. Tymovzko, Lubert Stryer.

Semester VIII – Paper 4

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
VIII	**Environmental Biology and Toxicology** **Note**: Choose both RB050703T & RB050704T for U.G. (Honours) and one for U.G. (Honours with research)	**RB050804T**	**I**	**Ecosystem**: Concept of Ecosystem, Laws of limiting factors (Liebig's law, Blackmann's Law and Shelford's law), Energy flow, trophic levels, food chain, ecological niches. **Biotic community**: Structure, stratification and growth. **Population ecology**: Structure of population, population growth curves, R and K selection	**4**
			II	**Conservation of natural resources:** Wildlife conservation in India, National Action Plan (NAP). **Protection of endangered species of animals (*Ex situ* and *In situ* conservation):** Sanctuaries, National parks, Ramsar sites, Biosphere reserves and Biodiversity hotspots.	
			III	**Pollution**: Air, water, land, noise, and radiation pollution (sources, effects and control). **Principles of systematic toxicology:** Applications of toxicology, Different branches of toxicology, factors affecting toxicity.	
			IV	**Type of toxicants and their respective modes of actions:** Genotoxic agents and their toxicities, Nephrotoxic agents and their toxicities, Hepatotoxic agents and their toxicities, Methods of analyzing and estimating toxicity in vertebrates.	

Suggested readings:

1. Ecology: Principles And Applications by JL Chapman and MJ Reiss.
2. Elements of Ecology by Smith & Smith.
3. Basic Ecology: Fundamentals of Ecology by Eugene P. Odum.
4. Ecology: Theories and Application by Peter Stiling.
5. Ecology and Environment by P.D. Sharma, Rastogi publications
6. Applied and Economic Zoology by Parul Yadav, KNRN publishers
7. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
8. Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). People & Wildlife, Conflict or Co-existence? Cambridge.
9. Bookhout, T.A. (1996). Res. & Manag. Techniques for Wildlife and Habitats, 5th ed. The Wildlife Society, Allen Press.
10. Sutherland, W.J. (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences
11. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.
12. Casarett & Doull's Toxicology: The Basic Science of Poisons by Klaassen Curtis, McGraw-Hill Education
13. Fundamentals of Toxicology: Essential Concepts and Applications by P.K. Gupta, BS Publications

Semester-Wise Syllabus of the Papers in

P.G. in ZOOLOGY – 5th Year

Semester IX – Paper 1

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
IX	**Biostatistics and Computer Applications**	**RB050901T**	**I**	Biostatistics: Applications of Biostatistics. Sample and Sampling techniques, Qualitative & Quantitative Variables, Presentation of Data (Pie charts, ogive, Histograms, Bar diagrams). Measures of central tendencies (Mean, Median, Mode), Measures of dispersion (standard deviation, variance), coefficient of variation.	**4**
			II	Tests of significance (chi square, t test, F test), Analysis of Variance, Type I and type II errors. Correlation & Regression analysis, Plotting of the regression line and calculations on regression equation.	
			III	Computer Applications: Internet basics, terminology, Introduction to power point presentation - image, data handling and graphical tools. MS word (Editing, copying, moving, formatting, table insertion etc). MS Excel tools for presentation of data, web hosting and web page designing.	
			IV	Bioinformatics: Biological Databases (Primary & Secondary Databases; Nucleic acid sequence database; protein sequence and structure database). Sequence alignment (pairwise and multiple sequence alignment), BLAST and its types. ClustalW, Phylogenetic analysis	

Suggested readings:

1. Jerrold H. Zarr: Biostatistical Analysis (Fourth edition), Pearson Education Inc., Delhi
2. W.W. Daniel and C.L. Cross: Biostatistics (Tenth edition), Wiley
3. John E. Havel, Raymond, E. Hampton and Scott J Meiners: Introductory Biological Statistics (Fourth edition)
4. Gene technology, Immunology and Computational Biology by Vikas Yadav and Parul Yadav
5. Bioinformatics for geneticists: Wiley (2003)
6. Lesk: Bioinformatics, Oxford (2003, Indian ed)
7. Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)

Semester IX – Paper 2

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
IX	**Animal Behaviour**	**RB050902T**	**I**	Introduction to animal behaviour, Patterns of behaviour, Reflexes, Types of reflexes, orientation, Kinesis (Orthokinesis and Klinokinesis); Taxis, types of taxis; Sun-compass orientation; motivation.	**4**
			II	Learning behaviour and Acquired behaviour: Non-associative learning (Habituation, Sensitization), Associative learning (Classical conditioning, Trial and Error learning), Latent learning, Insight learning (Reasoning, Intelligence, Cognitive thinking), Phase-specific learning (Imprinting), memory.	
			III	Parental care and migration; Types and causes of migration. Neuro-endocrine control of behaviour; Sexual behaviour, courtship, sexual selection; territorial behaviour.	
			IV	Patterns of communications (Chemical, visual, light, audio, tactile); infra sound and echo-location; Pheromones, Social behaviour with reference to insects.	

Suggested readings:

1. An Introduction to Animal Behavior by Aubrey Manning & Marian Stamp Dawkins. Publisher : Cambridge University Press
2. Animal Behavior: A synthesis of Ethology and Comparative Psychology by Hinde.Publisher: McGraw-Hill, NY
3. Animal behavior: An evolutionary approach by J Alcock. Publisher: Sinauer Assoc., Sunderland, Mass. USA
4. Behavioral Ecology by JR Krebs and NB Davies. Publisher: Blackwell, Oxford, U.K
5. Perspectives on Animal Behavior By Judith Goodenough, Betty McGuire, Elizabeth Jakob. Publisher: John Wiley & Sons.
6. Principles of Animal Communication by Bradbury & Verhrencamp. Publisher: Sinauer Assoc., Sunderland, Mass. USA
7. Sociobiology: The New Synthesis by EO Wilson. Publisher: Harvard Univ. Press, Cambridge, Mass. USA
8. The Evolution of Communication by M Hauser. Publisher: MIT Press, Cambridge, Mass. USA
9. The evolution of Parental Care by TH Clutton-Brock. Publisher: Princeton Univ. Press, Princeton, NJ, USA
10. The Mechanisms and Evolution of Behavior by JL Gould. Publisher: Norton.

Semester IX – Paper 3
Insect Systematics, Ecology and Applied Entomology (Entomology Paper 1)

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
IX	**Insect Systematics, Ecology and Applied Entomology (Entomology Paper 1)** **Note**: Choose any one out of RB050903T and RB050904T	**RB050903T**	**I**	**Introduction to Entomology:** Evolution of insects with special reference of fossil insects; causes of success of insects; Overview of insect classification and Collection and Preservation of insects. **Salient features of Apterygota orders:** Protura, Collembola, Diplura and Thysanura. **Salient features of Palaeopteran orders:** Ephemeroptera and Odonata.	**4**
			II	**Detailed Knowledge of the following Neopteran orders with their families:** **Plecoptera; Embioptera; Orthoptera** (Acrididae, Gryllidae, Tettigonidae, Locust and phase theory of locust); **Phasmida; Dermaptera; Blattaria; Mantoidea; Phithioptera** (Anoplura and Mallophaga)**; Psocoptera; Isoptera; Thysanoptera; Heteroptera** (Coreidae, Pyrrhocoridae, Reduviidae, Lygaeidae, Tingidae, Belostomatidae, Nepidae, Gerridae)**; Homoptera** (Membracidae, Jassidae, Aleurodidae, Psyllidae, Aphididae, Coccidae).	
			III	**Detailed knowledge of following Endopterygota orders with families:** **Coleoptera** (Carabidae, Dytiscidae, Darmestidae, Hydrophiliodae, Chrysomelidae, Meloidae, Coccinellidae, Burprestidae, Tenebrionidae, Cerambycidae, Scarabaeidae, Curculionidae); **Lepidoptera** (Noctuidae, Sphingidae, Pyrrilidae, Bombycidae, Papilionidae, Nymphalidae, Pieridae); **Hymenoptera** (Ichneumonidae, Braconidae, Chalcididae, Vespidae, Apidae, Formicidae); **Diptera** (Tipulidae, Psychodidae, Chironomidae, Simuliidae, Culicidae, Itonididae, Tabanidae, Asilidae, Syrphidae, Agromyzaidae, Muscidae, Trypetidae, Hippoboscidae, Drosophilidae); **Trichoptera; Aphinaptera**.	
			IV	**Insect life and their control:** Insect Parasitism**;** Entomophagous insects**;** Social life in Termites. Insect control by use of insecticides; Biological control and male sterility; and Integrated Pest management (IPM). **Life history, damage and control of major pests of:** Sugarcane crop, Fruit crops, Cotton crop, Paddy crop, and Stored grains. **Life cycle, transmission, pathogenesis, treatment and control of Insect born diseases** like Malaria, Dengue, Filariasis, Kala-azar, Yellow fever, Sleeping sickness and Loa-Loa. **Industrial Entomology:** Apiculture, Sericulture & Lac culture.	

Suggested readings:

1. Imms' General Textbook of Entomology 10th Ed by O.W Richards and R.G Davies.
2. Westwood, J. O. (1840). An introduction to the modern classification of insects: founded on the natural habits and corresponding organisation of the different families (Vol. 2). Longman, Orme, Brown, Green, and Longmans.
3. Principles of Applied Entomology by K.N. Ragumoorthy, M.R. Srinivasan and V. Balasubramani.
4. Applied Entomology (ICAR - JRF, SRF, ARS, SAUs Entrance Exams) by DS Reddy.
5. Modern Entomology by Tembhare.
6. Handbook of Entomology (4th Edition) by T. V. Prasad.

Semester IX – Paper 4

SYSTEMATICS, MORPHOLOGY AND PHYSIOLOGY OF FISHES (FISH AND FISHERIES – PAPER 1)

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
IX	**SYSTEMATICS, MORPHOLOGY AND PHYSIOLOGY OF FISHES (FISH AND FISHERIES – PAPER 1)** **Note**: Choose any one out of RB050903T and RB050904T	**RB050904T**	**I**	**Systematics and Morphology of fishes**: Salient features of fishes; Tools of fish classification-Classical and Modern; Berg's classification with its merits and demerits; Salient features and outline classification (upto orders with suitable examples) of Elasmobranchs and teleostomi; Integument structure, composition and function; Coloration; Types of fin and its modifications; Tail and its structural modifications; Structure and types of gills; Deep sea and hill stream adaptations in fishes.	**4**
			II	**Digestive, Respiratory and Circulatory Systems:** Structure and function of the alimentary canal and digestive glands; Adaptive modifications in the digestive tract of fishes; Blood supply and mechanism of respiration; Accessory respiratory organs; Structure of heart and blood vessels (arterial and venous system); Mechanism of blood circulation in fishes; Thermoregulation.	
			III	**Reproductive, Endocrine, Excretory and Osmoregulatory Systems**: Structure and function of reproductive organs, Reproductive cycles and maturation, spawning and development of fish; Endocrine glands and hormonal regulation; Structure of kidney and physiology of excretion; Osmo-ionic regulation in marine and freshwater teleosts; Parental care and Migration.	
			IV	**Lateral line system and specialized organs in fishes:** Structure and function of lateral line canal, relationship of lateral line system with internal ear and neuromast organs; Sense organs-mechanoreceptors, chemoreceptors, auditory organs, Weberian apparatus; Otolith organ; Sound and light producing organs; Electric organs; Poison glands in fishes.	

Suggested readings:

1. Jhingran V.G. Fish and Fisheries of India, Hindustan Publishing Corporation,New Delhi.
2. Hoar W.S., Randall D.J. and Donaldson E.M. Fish Physiology. Academic Press, New York.
3. Jayaram K.C. Fundamentals of Fish Taxonomy. Todays and Tomarrow Publication,New Delhi.
4. Potts G.W. and Wootten R.J. Fish Reproduction: Strategies and Tactics, Academic Press.
5. Khanna S.S. and Singh H.R. Fish Biology and Fisheries. Narendra Publishing House, Delhi.

Semester X – Paper 1

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
X	**Developmental biology**	**RB051001T**	**I**	1. Basic concept of gamete 2. Gametogenesis: Spermatogenesis & Oogenesis 3. Types of eggs 4. Fertilization, Infertility, Artificial insemination.	**4**
			II	1. Cleavage 2. Blastulation 3. Fate map construction 4. Gastrulation 5. Determination 6. Differentiation 7. Regeneration 8. Competence	
			III	**Chick embryology:** 1. Structure of hen's egg 2. Copulation, ovulation and maturation and oviposition 3. Development of chick embryo up to the formation of primitive streak 4. Development of foetal membranes in chick 5. Placentation in Mammals	
			IV	**Organogenesis:** 1. Development of Eye 2. Development of Brain 3. Development of Heart. 4. Metamorphosis in Chordates. 5. Aging and Senescence 6. Stem cells and their types	

Suggested readings:

1. Developmental Biology: T. Subramaniam, (Reprint), Narosa Publishing House Pvt. Ltd., New Delhi (2013).
2. Essential Developmental Biology: Jonathan M. W. Slack, (3rd ed.), Wiley-Blackwell. (2012).
3. Developmental Biology: From a Cell to an Organism (Genetics & Evolution) eBook: Russ Hodge, Infobase Publishing. (2009).
4. Current Topics in Developmental Biology: Roger A. Pedersen, Gerald P. Schatten, Elsevier. (1998).
5. Developmental biology: Werner A. Müller, Springer Science & Business Media. (2012).
6. Human Embryology and Developmental Biology E-Book: Bruce M. Carlson, Elsevier Health Sciences. (2018).
7. Developmental Biology: Michael J. F. Barresi, Scott F. Gilbert, Oxford University Press. (2019).

Semester X – Paper 2

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
X	**Evolutionary Biology**	**RB051003T**	**I**	**Origin of life:** Origin of Universe and earth, Conditions on primitive earth (pre-biotic environment), Miller and Urey Experiment, Origin of Life, Coacervates, Eobionts (Protocells), Ribozymes and RNA world hypothesis, Origin of prokaryotes and eukaryotes (endosymbiotic theory) **Zoological time scale** **Evidences of evolution:** morphological, physiological, embryological and paleontological evidences. **Theories of evolution**: Lamarckism, Neo-Lamarckism, Darwinism, Neo Darwinism (Modern Synthetic Theory of Evolution), Punctuated equilibrium. **Types of selection**: Natural selection (Directional, stabilizing and disruptive), Artificial and Sexual Selection. Evolution by genetic engineering (*in vitro* molecular evolution).	**4**
			II	**Isolating Mechanisms**: Geographical and Reproductive isolation. Prezygotic (Ecological, seasonal, Ethological, Mechanical Isolation, Gametic mortality) and Postzygotic (Zygote mortality, Reduced Hybrid Viability, Hybrid Sterility, Hybrid Breakdown) mechanisms of isolation. **Concept of Species**: Biological, Morphological, Mate recognition, Ecological and Evolutionary species concept. **Speciation**: Allopatric, Sympatric, Peripatric, Parapatric **Adaptive Radiation:** Convergent and Divergent evolution, Coloration & Mimicry, Adaptation (Pre and Post Adaptation), Industrial melanism, Co-evolution.	
			III	**Genetic structure of populations:** Gene pool, Genotype Frequency, Allelic frequency, Fisher's Fundamental Theorem of Natural Selection, Genetic variability, Canalization, Genetic load, Genetic death. **Microevolution and macroevolution** **Hardy-Weinberg Law**: Conservation of gene frequency, Changes in gene frequency**:** Mutation, Migration, Selection, Non-random mating, Genetic drift (Bottleneck Effect and Founder Effect) and its consequences, Heterozygous advantage, Inbreeding depression.	

			IV	**Fossils and Fossilization:** Formation and Types of fossils, Dating of fossils; **Evolution of Human beings** **Interplay between ecological factors and evolutionary processes**: Bergmann's Rule, Allen's Rule, Island Rule (Foster's Rule) and Gloger's Rule. **Molecular phylogeny**: Concept and evidences of molecular evolution, Molecular divergence and Molecular clocks (origin of new genes and proteins, gene duplication and divergence), Construction of Phylogenetic trees, Phenetics and Cladistics.	
Suggested readings: 1. Barton, N.H., Briggs, D.E.G., Eisen, J.A. Goldstein, D.B. and Patel, N.H. (2007. Evolution. Cold Spring, Harbour Laboratory Press 2. Dobzhansky Th. et al. (1976): Evolution. Surjeet Publ. (34) 3. Futuyma D. J. (1998): Evolutionary Biology. Sinauer 4. Hall, B.K. and Hallgrimsson, B. (2008) Evolution, IV Edition. Jones and Barlett Publishers 5. Kimura M. (1984): The Neutral Theory of Molecular Evolution. Cambridge. 6. Li Wen-Hsiung and Dan Graur (1991): Fundamentals of Molecular Evolution. Sinauer 7. Ridley, M (2004). Evolution. III Edition. Blackwell publishing 8. Strickberger M. W. (2000): Evolution. Jones and Bartlett 9. White M. J. D. (1978): Modes of Speciation. Freeman 10. G.G.Simpson: Principle of animal taxonomy. 11. E.Mayer: Elements of Taxonomy					

Semester X – Paper 3

Insect Morphology, Anatomy, Physiology and Development (Entomology Paper 2)

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
X	**Insect Morphology, Anatomy, Physiology and Development (Entomology Paper 2)** **Note**: Choose any one out of RB051003T and RB051004T	RB051003T	I	**General organisation of the insect body; Head:** Orientation of insect head, Sutures and area of the cranium, tentorium, gnathal appendages (antenna and mouth parts). **Thorax:** pterothorax, thoracic appendages (legs and its modification; wing and wing coupling). **Morphology of male and female reproductive system.**	4
			II	**Digestive system:** General structure of digestive system and its modifications, salivary glands, cardiac and pyloric valves, peritrophic membrane and rectal pads. Nutritional requirements in insect, physiology of digestion of carbohydrates, fats and proteins; fat body. **Respiratory system:** General organisation of trachea and spiracles; type of spiracles; air sacs. Respiratory adaptations in aquatic, terrestrial and endoparasitic insects. **Circulatory system:** General structure of heart and its modifications, haemolymph and haemocytes. Physiology of circulation.	
			III	**Excretory system:** Malpighian tubules and other excretory organs. Physiology of excretion, metabolic pathways of synthesis of uric acid, urea and ammonia. **Sense organs:** Mechanoreceptors; chemo-receptors; auditory organs; sound and light producing organs. Production and reception of sound; mechanism of photoreception and light production. **Nervous system:** Structure of brain and nerve cord (CNS, PNS and SNS).	
			IV	**Reproductive system:** Anatomy of male and female Reproductive system; spermatogenesis; Oogenesis; yolk formation & diapauses; fertilization and embryonic development in insects. **Endocrinology:** hormones of neurosecretory cells, corpus cardiacum, corpus allatum and prothoracic gland, types of metamorphosis, hormonal control of metamorphosis and moulting/ecdysis; pheromones.	

Suggested readings:

1. Principles of Insect Morphology by R.E. Snodgrass.
2. Insects that Feed on Trees and Shrubs by W. T. Johnson & H. H. Lyon.
3. The Insects: Structure and Function (5th Edition) by R.F. Chapman.
4. Wigglesworth, V. B. (2012). The principles of insect physiology. Springer Science & Business Media.
5. Nation Sr, J. L. (2022). Insect physiology and biochemistry. CRC press.
6. Beutel, R. G., Friedrich, F., Yang, X. K., & Ge, S. Q. (2013). Insect morphology and phylogeny: a textbook for students of entomology. Walter de Gruyter.
7. Modern Entomology by Tembhare.
8. Handbook of Entomology (4th Edition) by T. V. Prasad.

Semester X – Paper 4

FISH ECOLOGY, AQUACULTURE AND THEIR ECONOMIC IMPORTANCE (FISH AND FISHERIES PAPER 2)

Sem.	Paper Title	Paper Code	Unit	Syllabus	Credits
X	**FISH ECOLOGY, AQUACULTURE AND THEIR ECONOMIC IMPORTANCE (FISH AND FISHERIES PAPER 2)** **Note**: Choose any one out of RB051003T and RB051004T	**RB05100ioin4T**	**I**	**Fish Ecology:** Physiochemical parameters of aquatic environment and their effects on fish life, factors affecting light penetration, classification and zonation of aquatic environment; Planktons and their role in fish life; Ecology and productivity of aquatic environment, algal bloom; Aquatic weeds and their control; Effect of water pollution on fish; Ecological significance of mangroves, corals and coral reefs.	**4**
			II	**Aquaculture and Pond Management:** Overview of aquaculture practices; Introduction to fish polyculture, cultivable fishes, special fish cultures (composite, sewage-fed and integrated fish culture); Induced breeding in fishes; fabrication and maintenance of aquarium; Construction of fish farm- selection of site, arrangement of fish farm, procurement of stocking material, maintenance of fish farm, harvesting.	
			III	**Capture Fisheries:** Riverine fisheries, Marine fisheries, Estuarine fisheries, Reservoir fisheries, Cold water fisheries, Lacustrine Fisheries, Crustacean fisheries (prawn and crab), Molluscan fisheries; Methods of fishing- Various types of fishing nets, gear and crafts and their uses.	
			IV	**Fish Products and Fish Pathology:** Economic importance of fishes, nutritive value, fish by products, common edible fishes, larvicidal fishes, harmful fishes; Fish pathology- Methods of fish preservation and processing, fish spoilage, rigor mortis, rancidity, enzymatic spoilage, microbial spoilage, fish diseases and their control (bacterial, fungal, viral and protozoan).	

Suggested readings:

1. Reid G.R. Ecology and Inland waters and Estuaries. Rein Hold Corp., New York.
2. Pandey K. and Shukla J.P. bFish and Fisheries, Rastogi Publication, Merrut UP.
3. Lagler K.F., Bardach, J.E., Miller, R.R., Passino, D.R.M. Freshwater Fishery Biology by Ichthyology. John Wiley & Sons, New York.
4. Walter K. Dodds, Matt R Whiles. Freshwater Ecology: Concepts and Environmental Applications of Limnology

