PROF. RAJENDRA SINGH (RAJJU BHAIYA) UNIVERSITY, PRAYAGRAJ

Course Structure with Credit Distribution for the

Programme: M.Sc. Subject: ZOOLOGY

Structure of Syllabus Developed by			
Name of BoS Convener/BoS Member	**Designation**	**Department**	**College/ University**
Prof. Shri Prakash (Convener)	Professor	ZOOLOGY	K A P G College, Prayagraj
Dr. Girijesh Shukla (Member)	Associate Professor	ZOOLOGY	HNB Govt. P.G. College Naini, Prayagraj
Dr. Neelam Bajpai (Member)	Assistant Professor	ZOOLOGY	Mahamaya Govt. DegreeCollege Kaushambi
Prof. K. P. Singh (Subject Expert)	Professor	ZOOLOGY	Allahabad University, Allahabad
Dr. Anuradha (Subject Expert)	Assistant Professor	ZOOLOGY	C M P College, Prayagraj
Dr. Anurag Tripathi (Special Invitee)	Associate Professor	ZOOLOGY	K A P G College, Prayagraj
Dr. Brijesh Kumar Mishra (Special Invitee)	Assistant Professor	ZOOLOGY	HNB Govt. P.G. College Naini, Prayagraj

Course Code		**Course Title**	**Credits**	**T/P**	**Evaluation**	
					CIE	**ETE**
A	**B**	**C**	**D**	**E**	**F**	**G**
UG SEMESTER VII / PG SEMESTER I						
B050701T	**Core**	Non-Chordates and Biostatistics	3	T	25	75
B050702P	**Core**	Lab on Non-Chordates and Biostatistics	1	P	25	25
B050703T	**Core**	Cytogenetics	3	T	25	75
B050704P	**Core**	Cytogenetics Lab	1	P	25	75
B050705T	**Core**	Research Methodology	4	T	25	75
B050706T	**Discipline Centric Elective (Select any one)**	Toxicology	4	T	25	75
B050707T		Immunology				
B050708T	**Discipline Centric Elective (Select any one)**	Developmental Biology	4	T	25	75
B050709T		SustainableDevelopment and Waste Management				

UG SEMESTER VIII / PG SEMESTER II (For lateral entry)

B050801T	**Core**	Chordates and Comparative Anatomy	3	T	25	75
B050802P	**Core**	Chordates and Comparative Anatomy Lab	1	P	25	75
B050803T	**Core**	Animal Physiology and Biochemistry	3	T	25	75
B050804P	**Core**	Lab on Animal Physiology and Biochemistry	1	P	25	75
B050805R	**Research Project**	Research Project	12	R	-	100

OR

P.G. SEMESTER II (FOR TWO YEAR PG PROGRAMME)

B050801T	**Core**	Chordates and Comparative Anatomy	3	T	25	75
B050802P	**Core**	Chordates and Comparative Anatomy Lab	1	P	25	75
B050803T	**Core**	Animal Physiology and Biochemistry	3	T	25	75
B050804P	**Core**	Lab on Animal Physiology and Biochemistry	1	P	25	75
B050805T	**Discipline Centric Elective (Select any one)**	Parasitology	4	T	25	75
B050806T		Environmental Biology				
B050807T	**Discipline Centric Elective (Select any one)**	Entomology and Economic Zoology	4	T	25	75
B050808T		Molecular Endocrinology				
B050809T	**Ability Enhancement Course (Select any one Theory +Practical)** **A**	Vermiculture & Vermicomposting	3	T	25	75
B050810P		Practical on Vermiculture	1	P	25	75
B050811T	**B**	Mushroom Culture	3	T	25	75
B050812P		Practical on Mushroom Culture	1	P	25	75

SEMESTER III

B050901T	**Core**		Cell Biology	3	T	25	75
B050902P	**Core**		Cell Biology Lab	1	P	25	75
B050903T	**Core**		Biotechnology and Molecular Biology	3	T	25	75
B050904P	**Core**		Lab on Biotechnology and Molecular biology	1	P	25	75
B050905T	**Discipline Centric Elective (Select any one)**		Biological Tools and Techniques	4	T	25	75
B050906T			Fish and Fisheries				
B050907T	**Discipline Centric Elective (Select any one)**		Evolutionary Biology and Animal Behaviour	4	T	25	75
B050908T			Ecology and Wildlife Conservation				
B050909T	**Ability Enhancement Course (Select any one, Theory+Practical)**	**A**	Computational Biology and Bioinformatics	3	T	25	75
B050910P			Practical on Computational Biology and Bioinformatics	1	P	25	75
B050911T		**B**	Aquaculture	3	T	25	75
B050912P			Practical on Aquaculture	1	P	25	75

SEMESTER IV

B051001R	**Core/MRP**	**MASTER DISSERTATION**	20	R	-	100

1. **CIE** in Column-F stands for **'Continuous Internal Evaluation'** and depicts the maximum internal marks. Respective examinations will be conducted by subject teacher.
2. **ETE** in Column-G stands for **'External Evaluation'** and depicts the maximum external marks. Respective Examination will be conducted by the University.
3. Column-B defines the nature of course/paper. The word **CORE** herein stands for **Compulsory Subject Paper**.
4. **Master Dissertation:** (As per the spirit of NEP2020, Dissertation is a training of research and innovation, hence at the end of semester it will be submitted in printed form which will be evaluated by the external examiners appointed by the University. The supervisor and the topic for Dissertation shall be allotted in first semester. At the end of semester, the Dissertation will be evaluated by an external examiner appointed by the University from the list of examiners approved by the BOS.
5. **This syllabus has been framed by experts and approved by BOS.** Any alteration or modification in syllabus or change in the rules of examination as mentioned in the syllabus will require the approval of BOS constituted by PRSU.

M.Sc. Zoology Semester I

Core Paper 1: **Non-Chordates and Biostatistics**

Unit I

Protozoa:Locomotion, nutrition and reproduction, protozoans and human diseases

Porifera: Affinities of Porifera, Skeleton and canal system

Coelenterata (Cnidarians): Polymorphism, Coral and coral reefs

Unit II

Platyhelminthes: Evolution of Parasitism, Host-parasite relationship, Parasitic adaptations.

Annelida: Adaptive radiation in Polychaeta, Segmental organ in Annelida, Metameric segmentation.

Unit III

Arthropoda: Mouth parts of insect and mode of feeding habits, Larval forms inCrustaceans, Insect metamorphosis and its hormonal control, Basic concepts of Insect Pest Management

Mollusca: Archimollusca (Ancestral Mollusca), Respiration in Mollusca, Torsion and Detorsion in Gastropods

Unit IV

Echinodermata: Affinities of Echinodermata, Water vascular system, Larval form and its significance, Hemichordata: Affinities of Hemichordata, Larva of *Balanoglossus*.

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Unit-V

Data: types and collection of data, Diagrammatic and graphic representation of data and their significance,

Sampling techniques: methods of sampling, choice of sampling methods, sampling and non-sampling errors

Unit VI

Measures of Central Tendency: Mean, Median, Mode

Measures of dispersion: Range, Mean Deviation, Variance and Standard deviation

Unit VII

Probability: Theory and application, Probability distribution: normal, binomial and Poisson; Correlation, Linear and non-linear regression.

Tests of significance: Student's t-test, Analysis of variance: One-way and Two-way analysis of L variance (ANOVA), F-test, null hypothesis and chi-square test.

Unit VIII

Experimental design: Basic concepts and principles, completely randomized design (SRD) and randomized complete block design (RCD), Latin square design (LSD) and confounding; Interferential biostatistics: statistical estimation, confidence intervals.

M.Sc. Zoology Semester I

Suggested Books:

1. Text book of Invertebrates: R.L. Hyman.
2. Text book of Invertebrates: R.L. Kotpal.
3. Biology of the Invertebrates: Pechenik, Jan A.
4.
5. Non Chordata: Meglitsch Paul A.
6. Text book of Zoology Vol.- I: Parker T.J. and Haswell, W.A.
7. Moore: An Introduction to the Invertebrates.
8. Invertebrate: Protozoa to Echinodermata: Ashok Verma
9. A Handbook of Zoology: A.K. Verma
10. Invertebrate Zoology: R.D. Barnes.
11. Minor Phyla : R.L. Kotpal.

11.George W. Snedecor, William G. Cochran. Statistical Methods.

12. Frederick Emory Croxton, Dudley J. Cowden. Applied General Statistics

13. Spiegel, M.R.: Theory & Problems of Statistics, Schaum's outline series

14Spiegel, M.R.: Probability and Statistics.

15.Marylees Miller, Irwin MillerFreund, John, E.'sathematical Statistics with Applications.

M.Sc. Zoology Semester I

Core Paper II: Lab on Non-Chordates &Biostatistics

Non-Chordates:

Preparation and study of permanent slides.

Protozoa: Paramecium (whole mount), Conjugation, Binary fission. Demonstration of food vacuoles.

Cnidaria: Bougainvillea, Sertularia.

Arthropoda: Cyclops, Megalopa/Zoea, booklung of scorpion.

Study of larval stages in arthropoda

Mollusca: glochidium larva.

Echinodermata: pedicellaria, tubefeet, Study of Larval stages

Dissections: Arthropoda: reproductive system of Palamnaeu.

Mollusca: nervous system of Mytilus and Aplysia/Sepia.

Study of museum specimens: Porifera. Cnidaria. Arthropoda . Mollusca . Echinodermata

Biostatistics:

Diagramatic representation of hypothetical data. Numerical problems related to variance, SD, Students‘t’ test, Chi square test. Calculation of Calculation of Correlation coefficient.

M.Sc. Zoology Semester I

Core Paper III: Cytogenetics

Unit I

Basic Principles of Heridity, Complementation, Epistasis, Pleiotropy, Penetrance and Expressivity

Various types of Sex determination mechanisms in animals.

Lethal genes, Sex-linked inheritance, Sex-limited and Sex-influenced characteristics,

Sex chromosome, X chromosome inactivation- Lyon hypothesis- Barr body and mosaicism

Multiple alleles and its significance

Unit II

Transposable elements in prokaryotes and eukaryotes, Role of transposable elements in genetic regulation. Cytoplasmic inheritance, Genetic maternal effects, Interaction between genes and environment: Environmental effects on gene expression.

Unit III

Microbial genetics: Bacterial transformation, transduction, conjugation, bacterial chromosome, bacteriophages. Structure and chemical composition of chromosomes - telomeres, centromeres and kinetochores,

Structural Chromosomal aberration, isochromosomes, ring chromosomes, centric fusions and fissions.

Numerical Chromosomal aberrations, Euploidy, Aneuploidy

Unit IV

Chromosome mapping, Molecular cytogenetic techniques (FISH, GISH, chromosome painting), Chromosome Banding (C-Banding, G-banding, Q - banding, R – Banding)), Flow-cytometry. Elements of Eugenics, Imprinting of genes, Human karyotype, Karyotype Analysis of autosomal and sex chromosomal abnormalities, Spectral Karyotyping – SKY

Suggested Books:

1. Molecular Cell Biology. 4th edition Lodish H, Berk A, Zipursky SL, et al.New York
2. Molecular Biology of the Cell: Bruce Alberts and Alexander D. Johnson , Garland Science
3. Cell and Molecular Biology: G. Karp
4. Lewin B Genes VIII, Oxford University Press, Oxford
5. Primrose. Molecular Biotechnology
6. Frederick Hecht: Textbook of Cytogenetics
7. Snusted: Principles of Genetics
8. Klug and Cummings: Concepts of Genetics
9. Genetics: A Conceptual Approach by Benjamin A Pierce (W.H. Freeman & Co. Ltd 2014
10. Genetics. Strickberger M.W., MacMillan Collier Co. Pvt Ltd. 1977.

M.Sc. Zoology Semester I

Core Paper IV :Cytogenetics Laboratory

Study of meiosis in grasshopper testes by squashing method. Temporary squash preparation of polytene chromosomes from salivary glands of Drosophila larvae.

Study of colchicinised metaphase chromosomes in bone marrow of rodent by air dry method

Preparation of human karyotype.

Study of sex chromatin in human female from buccal epithelial and hair bud cells

Study of permanent slides for the following: Dicentric bridge in the anaphase 1 chromosomes of grasshopper . Inversion in polytene chromosomes.

Autoradiography detection of transcription in polytene chromosomes.

Lampbrush chromosomes of Triturus oocyte G-banded and C-banded metaphase chromosomes.

Chromatid exchanges and chromosomal anomalies. Sister chromatid exchanges.

Handling of Drosophila and study of its life cycle.

Examination of wild type (males and females) and mutants of Drosophila, Sex linked inheritance in Drosophila melanogaster,

Linkage and crossing over in Drosophila melanogaster,

Exercise based on human pedigree analysis. Exercise based on Mendalien and Non-mendalien Inheritance.

M.Sc. Zoology Semester I

Core Paper V: Research Methodology

Unit 1:

Introduction to research, Need, Importance and Characteristics of research, Types of research – Analytical vs Descriptive, Quantitative vs Qualitative, Basic vs Applied. Review of literature. Identification, Definition and Statement of Problem, Variables, Role of variables in research, Research Questions and Objectives.

Research design: Features of good design, Important concepts related to good design- Observation and Facts, Prediction and Explanation, Development of Models. Developing a research plan: Problem identification, Experimentation, Determining experimental and sample designs.

Unit II:

Observation and Collection of Data-Methods of data collection- Sampling Methods, Data Processing and Analysis Strategies,

Data Presentation using digital technology, Interpretation of Data; Layout of a Research Paper: Authors, acknowledgements, Numbers, units, abbreviations and nomenclature used in scientific writing; Writing references; Ethical issues related to publishing: reproducibility, plagiarism and self - plagiarism; Selection of Journals in Biological Science; Impact factor of Journals; h Index; citation index.

Unit III:

Statistical Tools: Measures of Central Tendency (Mean, Median, Mode)

Measure of Variability (Range, Variance, Standard Deviation)

Unit IV:

Comparing Means: Independent Sample t-test, Paired Sample t-test, One Way ANOVA, Factorial Design ANOVA, Correlation, Regression and Non-parametric Statistical Techniques.

Intellectual property Rights, Commercialization, Copy Right, Royalty, Patent law, Ethics

Suggested Readings:

- Anthony, M, Graziano, A.M. and Raulin, M.L. 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
- Walliman, N. 2011.Research Methods- The Basics. Taylor and Francis, London, New York.
- Kothari, C. R & Garg Gaurav: Research Methodology: Methods and Techniques, New Age International Publishers, New Delhi, 2019. (English & Hindi Print)
- Coley, S.M. and Scheinberg, C.A. 1990, ― Proposal writing‖. Stage Publication.
- Wadhera, B. L.: Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, 2002, Universal Law publishing.
- Sterling, T. and Pollack, S: Introduction to Statistical Data Processing, Prentice Hall, 1968.
- Campbell, W: Forms and style in Thesis Writing, 3rd ed., Boston., Houghton, Mifflim, 1969.
- Boot, Wayne C., Colomb Gregory G, Williams Joseph M: The Craft of Research, University of Chicago Press, Chicago, 2008.
- Creswell John W. and Creswell J. David: Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Sage Publication, New Delhi, 2022
- Flick Uwe: An Introduction to Qualitative Research (5th Edition), Sage Publication, New Delhi, 2023,
- Preston D: Research Methodology and Quantitative Techniques, Kaufman Press, USA, 2022.

M.Sc. Zoology Semester I

Elective Paper I: Toxicology

Unit I

Definition, nature and scope of toxicology, History and sub-divisions of toxicology, Sources of toxic substances in the environment, Classification of toxic agents, natural toxins, animal and plant toxins, food toxins.

Unit II

Genetic poisons and chemical poisons, Dose effect and dose-response relationship, acute toxicity, chronic toxicity-reversible and irreversible effects, Factors affecting toxicity- species and strains, age, sex, nutritional status, hormones, environmental factors. Toxicity tests: Acute toxicity tests for terrestrial and aquatic animals. Chronic toxicity test, Concept of maximum acceptable toxicants concentration (MATC) and safe concentration.

Unit III

Study of different types of insecticides including organophosphates, carbamates, botanical insecticides, Methods of application of insecticides, Hazards of insecticides, Precautions and antidotes, fumigants, Principles and concepts of Integrated Pest Management (IPM), Chemosterilants, Autocides including 3rd and 4th generation pesticides.

Unit IV

Radiation and chemical toxicology, chemical toxicants and their effects on industrial and agricultural wastes. Ecotoxicology; Ecological changes and disease, Principals of biological control- parasites, predators and pathogens affecting insect pests and the efficacy in controlling the insect pests.

Suggested Books:

1. Odum, E.P. Basic Ecology
2. Stiling, P. Ecology: Theories and Applications
3. Begon,M. Harper,J.L. & Townshend, C.R. Ecology
4. Kormondy, E.J. Concepts of Ecology
5. Grant, W.E. and Swannack: Ecological Modelling
6. Derelanko& Auletta: Handbook of Toxicology
7. Casarett & Doull`s: Toxicology: The Science of Poisons
8. P.D.Sharma: Toxicology
9. A.K. DE : Environmental Chemistry.

M.Sc. Zoology Semester I

Elective Paper II: Immunology

Unit I

Overview of immune system-Innate and adaptive immune system, Cells of immune system and their production, introduction to infectious disease, innate immunity to infection, adaptive immunity to infection.

Unit II

Humoral Immunity and cellular immunity, Antigen and haptens, Primary and secondary response, Antibody: types, structure, function, production and diversity.

Unit III

Innate immune system:The effector mechanisms of innate immune system, pattern recognition, complement system, antimicrobial peptides, cytokine production in response to viral, bacterial and parasitic pathogens, antigen processing and presentation.

Unit IV

Vaccines & Immuno-techniques, Vaccination: adjuvants, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization, Monoclonal antibodies, Introduction to different immunodiagnostic techniques like RIA, double diffusion, Mancini radial immunodiffusion, ELISA, Western blot.

Suggested Books:

- Kindit, T.J., Golds by R.A., Osborne, B.A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
- David, M., Jonathan, B., David, R.B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.
- Abbas, K. Abul and Lechtman H. Andrew (2003) Cellular and Molecular immunology. V edition. Saunders Publication.
- Albert *et al*: Molecular Biology of cell (4th Edition) Garland Science, 2002
- F C Hay Olwyn M. R. Westwood, 2002. Practical Immunology. Blackwell Science Ltd

M.Sc. Zoology Semester I
Elective paperIII : Developmental Biology

Unit I

Gametes: structure and formation, fertilization, nature of eggs and their cleavage, Early development of frog and chick up to gastrulation, Organogenesis of vertebrate brain, eye and heart.

Unit II

Metamorphosis: Cellular, Physiological and biochemical events in insects and amphibians, Hormonal Regulation of Metamorphosis,

Causes of fetal deformities, Teratogenesis, Regeneration, Ageing and cellular death, transgenic and knock outs animals.

Unit III

Gradients in developing systems, Determination of polarity and symmetry, pattern regulation in insect imaginable discs, induction and organizer concept, Potency, Commitment, Specification.

Unit IV

Stem cells: Properties of stem cells, embryonic stem cells, adult stem cells, umbilical cord stem cells, Similarities and differences between embryonic and adult stem cells,Pluripotency and Totipotency.

Suggested Readings:

- Gilbert, S. F. (2010). Developmental Biology. LX Edition, Sinauer Associates. Inc. Publishers. Sunderland. Massachusetts, USA.
- Belinsky B.L and Fabian B. C. (1981). An Introduction to Embryology. V Edition. International Thompson Computer Press.
- Kalthoff (2008). Analysis of Biological Development. Il Edition. McGraw-Hill Publishers.
- Lewis Wolpert (2002). Principles of Development. Il Edition, Oxford University Press
- Alfonso Martinez Arias, Alison Stewart: Molecular Principles of AnimalDevelopment
- Adam S Wilkins: Genetic Analysis of Animal Development
- Alfonso M.A.; Molecular Principles of Animal Development
- Michael J. Barry: Molecular Embryology: How Molecules Give Birth to Animals

M.Sc. Zoology Semester I

Elective paper IV: SustainableDevelopment and Waste Management

Unit I

Sustainable Development: Principles, History and emergence of the concept of Sustainable Development, Definitions, Environmental issues and crisis, Natural Resource Management and Sustainability, Resource degradation, greenhouse gases, desertification

Unit II

Sustainable Development: Role of Government; NGOs; Environmental movements; International treaties and conventions; organizations, International efforts (Vienna Convention, Montreal Protocol, UNFCCC, Kyoto Protocol, Copenhagen Summit, etc.; IPCC; Environmental laws and acts; National Environmental Policy; NBAGR, ZSI, WWF, IUCN, Ramsar Convention.

Unit III

Waste-types and their sources of generation, Traditional methods of waste collection, transport and disposal; Factors influencing waste generation and health hazards, Waste composition,

Municipal and Industrial solid waste: Disposal of solid. wastes, Landfill: site selection, site development, site operation, characteristics, generation and control of the movement of gases and leachate in landfill, landfill closure and post closure care.

Unit IV

Hazardous waste and Waste water management, Source, Constituents in waste waterinorganic – Organic and metallic constituents, Industrial water treatment, Bio-medical wastes and their disposal, Chemical and Biological treatment methods.

Suggested Readings:

- An Introduction to Sustainable Development, 3rd edition Jennifer A. Elliott HB 0415–3355
- M.S. Bhatt and AsherefIlliyan, Solid Waste Management: An Indian PerspectiveSynergy Books India 2012
- Techobanoglous Thiesen Ellasen; Solid Waste Engineering Principles andManagement McGraw - Hill 1997
- Rajaram Vasudevan , Siddiqui Faisal Zia , Agrawal Sanjeev , Khan Mohammad Emran. Solid and Liquid Waste Management
- Gabriella Marfe, Hazardous Waste Management and Health Risks, Bentham SciencePublishers
- Ram Naresh Bharagava, Pankaj Chowdhary Emerging and Eco-Friendly Approachesfor Waste Management, Springer; 1st ed. 2019 edition
- Manoj Kumar Karnena, Environmental Planning and Sustainable Development,Orange Books Publication; First edition
- Jonathan W. C. Wong; Rao Y. Surampalli; Tian C. Zhang; Rajeshwar D. Tyagi; and Ammaiyappan Selvam, Sustainable Solid Waste Management, ASCE Press.

M.Sc. Zoology Semester II

Core Paper I: Chordata and Comparative Anatomy

Unit I

Origin and characters of chordates, General characters and affinities of protochordates, Distinctive Characters and Classification of Amphibia, Reptilia, Aves and Mammalia, Origin and evolution of Tetrapoda, Retrogressive metamorphosis in Urochordates, Interrelationship of Ostracoderms and Placoderms, General characters and affinities of Cyclostomata.

Unit II

General organisation and affinities of Holocephali, Crossopterygii and Dipnoi, origin and evolution of paired fins in Teleosts, Origin and evolution of lung fishes (Dipnoans), Migration in fishes, Neoteny and paedogenesis in axolotl larva, Parental care in amphibians.

Unit III

Origin and evolution of reptiles, Adaptive radiation in reptiles, Rhynchocephalia, Bird are glorified reptiles, Aerodynamics in birds, Bird migration, Arial adaptations in birds, Flightless birds, General characters and affinities of Prototherians, Aquatic and volant mammals and their adaptations, Adaptive radiations in mammals.

Unit IV

Comparative anatomy of different systems of Vertebrates: integumentary, digestive, respiratory, skeletal, circulatory, excretory, reproductive and nervous systems.

Suggested Books:

1. The Life of Vertebrates: Z J Young
2. The Phylum Chordata: H.H. Newman
3. Textbook of Zoology Vertebrates: Parkar and Haswell
4. An Introduction to The Vertebrates: L. A. Adams
5. Introduction to Chordates: T.C. Majupuria
6. The Vertebrate Life: Harvey et al
7. A Handbook of Zoology: A.K. Verma
8. Evolution of the Vertebrates: E.H . Colbert
9. A Text Book Zoology Vertebrates: R.L. Kotpal
10. The Vertebrate Body: Romer and Parson
11. Anurag Tripathi & M. Rahman (2018). Neuroanatomy of Teleost Fish (Based on Acetylcholinesterase Histochemistry. 1st Ed. Akinik Publication, New Delhi.

M.Sc. Zoology Semester II
Core Paper I: Lab on Chordata and Comparative Anatomy

1. Study of the following specimen to bring out their affinities:
    a. Amphioxus
    b. Balanogossus
    c. Ascidian
    d. Peteromyzon
2. Study of the following specimens with reference to their adaptive features for their respective modes of life
    a. Echeneis
    b. Ichthyophis / Uraeotyphlus
    c. Hyla
    d. Draco
    e. Pigeon
    f. Bat
3. Study of the following skull types with reference to jaw suspensions
    a. Fish
    b. Frog
    c. Calotes
    d. Snake
    e. Rat/Rabbi
4. Dissection and mounting of Webberian ossicles in Cat fish.
5. Dissection of aortic arches in Teleost
6. Dissection of aortic arches in Calotes/rat
7. Dissection and display of IXth and Xth Cranial nerves of cat fish
8. Demonstration of portal system of Rat
9. Demonstration of urinogenital system of Rat.

Core paper III: Animal Physiology &Biochemistry

Unit I

Nutrition - Nutrients - Patterns of digestion, absorption and role of digestive enzymes in animals. Role of gastrointestinal hormones in Digestion.

Excretion: Patterns of nitrogen excretion in different animal groups, Osmoregulation.

Respiration: Respiratory organs in different animals, Gaseous exchange of O_2 and CO_2, Respiratory Pigments and control of respiratory activity, BMR.

Bioluminescence - chemistry and functional significance. Circulation: - physiology of cardiac muscle - heart beat and its regulation, Transport of O_2 and CO_2 in blood and body fluids, - blood coagulation

Unit II

Neuro-muscular co-ordination - types of neurons, transmissions of nerve impulse and reflex action. Chemical composition of muscle fiber and physiology of muscle contraction. Myoneural Junction.

Concept of homeostasis: Thermoregulation in. homeotherms, poikilotherms, hibernation and aestivation, diapause

Unit III

Amino acids - structure, classification and function. Peptide bonds. Essential and non - essential amino acids, isoelectric point, Zwitter ion.

Protein structure- Primary, secondary, tertiary and quaternary; domain and motif, Ramachandran plot.

Structure, function and properties of Oligosaccharides, Polysaccharides, Mucopolysaccharides.

Metabolism: Glycogenesis, Glycogenolysis, Gluconeogenesis, Glycolysis, Kreb's cycle, oxidative phosphorylation,

Unit IV

Lipids: Structure, Classification , properties; Cholesterol
Metabolism: Biosynthesis of lipids; oxidation (beta/omega) of fatty acid and its significance.

Water and Lipid soluble Vitamins - structure, classification, sources and deficiencies in human. Enzymes - general properties, function, classification, nomenclature. Enzyme kinetics - Derivation of Michaelis- Menten equation, Factors affecting enzyme action, Mechanism of enzyme action, Enzyme regulation, Enzyme inhibition.

Suggested Readings:

1. Ganong: Review of Medical Physiology (21st Ed.), Lang Medical Publications, 2003
2. Guyton and Hall: Text Book of Medical Physiology (10th Ed.), W.B. Saunders, 2001
3. Arthur J. Vander, James H. Sherman, Human Physiology: The Mechanisms of Body Function(McGraw-Hill International Editions Series), 7th edition
4. David L. Nelson , Michael Cox, Lehninger Principles of Biochemistry: International Edition,7th Edition
5. Balwan and Verma: Advances in Biochemistry and Biotechnology.
6. Zubay et al: Principles in Biochemistry (2nd Ed.), WCB, 1995
7. Stryer: Biochemistry (5th ed. 2001, Freeman)

8. Voet, D and Voet, J.G. 2004. Biochemistry. John Wiley and Sons, Inc.
9. Jain, J. L. Jain, S. and Jain N. 2005. Fundamental of Biochemistry, S. Chandra & Co. Ltd. New Delhi.
10. Murray, R. K, Granner, D.K. Maynes, P.A and Rodweli, V. W. 1998. Harper's Biochemistry, McGraw Hill, New York

M.Sc. Zoology Semester II

Core Paper IV: Lab on Animal Physiology and Biochemistry

BIOCHEMISTRY

1. Buffer preparation and determination of Ph - Demonstration,
2. Enzyme kinetics - anyone enzyme (Salivary amylase) Maltose standards, influence of enzyme concentration, time course, pH, Temperature, Substrate concentration (Lineweaver Burk Plot) on enzyme activity.
3. Qualitative analysis of urine - protein, glucose, Ketone and acetone bodies.
4. Chromatography: Determination of amino acids.
5. Quantitative estimation of glucose, protein, cholestoerol, urea and creatinine in the serum of goat/Rat.

PHYSIOLOGY

1. Blood Clotting Time, Bleeding Time, Rouleaux Formation, Preparation of Haemin Crystal.
2. Estimation of Haemoglobin and ESR.
3. Estimation of RQ in Fish with reference to Light and temperature.
4. Salt loss and salt gain in fish
5. Principle and Application of Sphygmomanometer, Kymograph, Electrophoresis, Haemoglobinometer, ESR

M.Sc.II Semester

Core Paper V: Research Project

Objectives:

To promote original thinking, insemination of knowledge, modulation and innovation of thought, as an exercise, in order to transport the young minds to the expanding horizon of their chosen area of knowledge and transform them into knowledge generators.

Evaluation of Research Project: As per the guidelines & spirit of NEP2020 in order to inculcate and foster the research and training, a research project on any area of current bioscience will be assigned to students at the beginning of semester which will be submitted in printed form at the end of semester and it will be kept for record. This project will be evaluated by the external examiner appointed as per University act/UGC guidelines and from the examiners list provided by the Board of studies (Zoology), PRSU, Prayagraj.

M.Sc.II Semester

Elective Paper I: Parasitology

Unit-I

Human clinical and veterinary parasitology- detection, diagnosis, prophylaxis, treatment, and pharmacology (emergent parasites)

Community medicine

Unit II

Host parasite interaction- immunological nuances in vertebrates and invertebrates and epidemiological surveillance tools.

. Vector biology with special reference to Malaria and Kala-azar.

Unit III

Genome organization in Plasmodium

Molecular basis of antigenic variation in Plasmodium
Parasites and Vectors.

Unit IV

Structure, life cycle, pathogenesis, diseases, laboratory diagnosis, treatment and prevention of the following parasites: Protozoan parasites-Entamoeba histolytica, Plasmodium vivax, Lieshmania donovani, Trypanosoma brucei, Trypanosoma cruzi, Trichomonas vaginalis, Giardia lambli. Helminthes :Nematodes-Ascarislumbricoides(Giant round worm), Ancylostomaduodenale (Hook Worm), Enterobiusvermicularis (Pin worm), Wuchereriabancrofti. Helminthes :Cestodes -Taeniasolium A brief study of the following insects, the major diseases they transmit, epidemiology of such diseases, control and preventive measures: Mosquito, Sand fly, House fly, Tse-Tse fly, Fleas, Louse, Bed bug, Ticks, Mites.

Suggested Books:

England P.T. and A.Sher. (eds). 1988. The Biology of Parasitism- A Molecular and Immunological Approach. Alar. R. Liss.New York Ketchum P.A. 1988.

Medical Parasitology. W.B. Saunders, Philadelphia. Prescott M.C, J.P.Hardley and D.A. Clean.2001.

Pathophysiological Responses to Parasites. British Society for parasitology, London.

Chandrashekhar J Hiware, Babasaheb V Jadhav, Ashok D Mohekar, 2002. Applied Parasitology, A Practical Manual

Panicker, CKJ.1998.Text book of Medical Parasitology, Jaypee, New Delhi.

M.Sc.II Semester

Elective Paper II: Environmental Biology

. UNIT-I

Introduction to Ecology & environmental sciences; Principles and Scope of Ecology Structure and Functions of Ecosystems- Abiotic and Biotic components.

Flow of energy and cycling of materials; water, carbon, nitrogen and phosphorus, Trophic pyramids and food webs; Ecosystems Types and Diversity, Alterations of ecosystem function: acid rain, nuclear winter, global warming and ozone hole, an overview of IPCC.

UNIT-II

Populations and communities; Birth, death and population size, age structure;Trends in human population growth; Malthusian growth. Intraspecific interactions and density dependence, Parasitism, Prey-predator relationships, Interspecific interactions; Commensalism, mutualism, competition and predation. Species diversity, community stability and disturbance

UNIT-III

Aquatic and terrestrial communities; rare communities; deep earth, deep sea floor, volcanoes. Primary productivity; basic concepts, Ecological succession inland, water; concepts, Invasive species and control .

UNIT-IV

Practical and Field Experiments using standard methods; Estimation of density and relative abundance of species using quadrats and plotless methods. Estimation of species diversity: introduction to indices. Estimation of primary productivity. Ecological adaptations of the Plant and animal species in the hydrophytes, mesophytes and xerophytes.

Suggested books:

1. Smith, TM and Smith RL 2015. Elements of Ecology, Pearson Education, India.
2. Cain, ML, Bowman, WD and Hacker SD 2011. Ecology, 2nd Edition, Sinauer Associates Inc.
3. Odum, E. P. (2004). Fundamentals of Ecology, Oxford and IBH Publishing Co. Pvt. Ltd.

Reference books:

1. Singh, J.S., S.P & Gupta, S.R. 2006. Ecology, Environment and Resource conservation. Anamaya Publ., New Delhi, 688 pp.
2. Miller. G.T. 2004. Environmental Science. Thomson, California. 538 pgs.
3. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.
4. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs

M.Sc.II Semester

Elective Paper III: Entomology and Economic Zoology

Unit I

External characteristic features of insects, comparative study of antennae, mouth parts, legs and abdominal appendages in different orders of insects. Classification of insects up to sub families in economical important groups, origin and evolution of insects.

Unit II

Pest, Pest status, economic injury level, economic threshold, secondary pest outbreak, pest resurgence.Host-plant interaction by phytophagous insects. Bionomics and damages caused by insect pests of paddy, sugarcane, cotton, oilseeds, fruits, vegetables and stored grains. IPM, Physical, Chemical, Biological and Genetic (SIT), Biorational methods (Pheromones, JH mimics, MH agonists) in pest management.

Unit III

Organization and behaviour in social insects.Beneficial (honey bee, silkworm and lac insects) and medically important insects (fleas, lice, bugs, mosquitoes and flies), their biology and management.Mode of transmission of pathogens by insects.

Unit IV

Basic concepts and principals of economic importance of different groups of animals Apiculture, Sericulture, Lac culture, Pearl culture, Prawn culture, Poultry, Livestocks and Dairy management.

Edible fresh water fishes, Aquaculture and Pisciculture, By products of fishing industry, Economic importance of fishes.

Suggested books:

A general text book of entomology, Imms , A. D., Chapman & Hall, UK

1. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
2. The Insect Societies, Wilson, E. O., Harvard Univ. Press, UK .
3. Agricultural Insects pests of the tropics and their control, Hill, D. S., Cambridge University Press,
4. Medical Entomology for students, Service, M. Cambridge University Press, UK
5. A textbook of insect morphology, physiology and endocrinology, Temphare, D B, New Delhi, S. Chand and Co.
6. Agricultural pest of South Asia and their management by Atwal, A.S., Kalyani publishers.
7. Textbook on Agricultural Entomology. New Delhi, ICAR Publications.
8. Dynamics of insect plant interactions, Ananthkrisnanan, T.N. and Raman, A., Oxford and IBH publishing Co Pvt Ltd, New Delhi

M.Sc.II Semester

Elective Paper IV: Molecular Endocrinology

UNIT-I:

Introduction, objectives and scope of endocrinology - modern concepts and problems in Endocrinology - endocrine glands in crustaceans, insects and vertebrates. Experimental methods of hormone research - general classes of chemical messengers. . Pineal gland structure, biosynthesis of melatonin, diurnal variations of pineal gland functions

Pituitary gland - characteristics, structural organization - hormone secretion and its functions - Hypothalamic control.

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UNIT-II:

Structure of pancreas, pancreatic hormones and their functions.

Structural organizations of adrenals, functions of cortical and medullary hormones. Thyroid gland - structural organizations, metabolic effects of thryroid - effects on reproduction - parathyroid its structure and functions. Thymic hormones and cell immunity.

UNIT-III

. Hormones and human health: Stress, metabolic and reproductive disorders (Pituitary, Pancreas, Thyroid, Testis, Ovary) - molecular basis and therapeutics. Pheromones: Classification, chemical nature, structure, functions, relevance in applied fields, clinical applications. GI tract hormones: Source, composition and functions

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UNIT-IV:

Structure of mammalian testis and ovary - male and female sex accessory organs - hormones of testis and ovary - estrous and menstrual cycle - hormones of pregnancy - parturition - hormonal control of lactation. Hormonal control of metamorphosis in an anuran amphibian.

REFERENCE BOOKS

1. Haris, G.W. and B.T. Donovan. 1968. The Pituitory Gland. S. Chand and Co.,

2. Bentley, P.J. 1985. Comparative vertebrate endocrinology, Second Edition, Cambridge University Press. Cambridge.

3. Mac Hadley. 1992. Endocrinology, 3rd Edition. Prentice - Hall Inc. A Simon & Schuster Company, Englewood Cliffs, New Jersey. USA.

4. Ingleton, P.M. and J.T. Bangara. 1986. Fundamentals of comparative vertebrate endocrinology, Kluwer Academic Publishers.

5. Turner, C.D. and J.T. Bangara. 1986. General endocrinology. Saunders International Student edition. Toppan Company Limited. Tokyo.

6. Barrington, E.J.W. 1985. An introduction to general and comparative endocrinology. Claredon press Oxford

M.Sc.II Semester

Elective Paper V: Vermiculture & Vermicomposting

Unit I

Introduction to vermiculture. definition, meaning, history, economic important, their value in maintenance of soil structure, role as fourr's of recycling reduce, reuse, recycle, restore.
His role in bio transformation of the residues generated by human activity and production of organic fertilizers. How does nature works.
The matter and humus cycle (product, qualities). Ground population, transformation process in organic matter. 4. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Complementary activities of auto evaluation.

Unit II:

Earthworm Biology and Rearing
Key to identify the species of earthworms.
Taxonomy Anatomy, physiology and reproduction of Lumbricidae.
Vital cycle of Eisenia fetida: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors).
Biology of Eudriluseugeniae. a) Taxonomy Anatomy, physiology and reproduction of Eudrilidae. b) Vital cycle of Eudriluseugeniae: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Complementary activities of auto evaluation.

Unit III:

Vermicomposting Technology
Small Scale Earthworm farming for home gardens - Earthworm compost for home gardens
Conventional commercial composting - Earthworm composting larger scale
Earthworm Farming (Vermiculture), Extraction (harvest), vermicomposting harvest and processing.
Nutritional Composition of Vermicompost for plants, comparison with other fertilizers
Vermiwash collection, composition &use
Enemies of Earthworms, Sickness and worm's enemies. Frequent problems. How to prevent and fix them. Complementary activities of auto evaluation.

Unit IV:

Product and Marketing ; Effect of vermicompost application on soil and plant growth,
Vermicompost as a organic manure a good substitute of fertilizers.
Influence of pests and microbes on vermiculture, measures to control them.
Marketing of vermicomposting products and financial support by governments and NGOs for vermiculture.

Suggested Books:

1. Bhatt J. V. & S. R. Khambata (1959) “Role of Earthworms in Agriculture” Indian Council of Agricultural Research, New Delhi.
2. Dash, M.C., B.K.Senapati, P.C. Mishra (1980) “ Verms and Vermicomposting” Proceedings of the National Seminar on Organic Waste Utilization and Vermicomposting Dec. 5-8, 1984, (Part B), School of Life Sciences, Sambalpur University, Jyoti Vihar, Orissa.
3. Edwards, C.A. and J.R. Lofty (1977) “Biology of Earthworms” Chapman and Hall Ltd., London.

4. Lee, K.E. (1985) “Earthworms: Their ecology and Relationship with Soils and Land Use” Academic Press, Sydney.
5. Kevin, A and K. E .Lee (1989) “ Earthworm for Gardeners and Fisherman” (CSIRO, Australia, Division of Soils)
6. Rahudakar V. B. (2004). Gandulkhatashivay Naisargeek Paryay, Atul Book Agency, Pune.
7. Satchel, J.E. (1983) “Earthworm Ecology” Chapman Hall, London. 8. Wallwork, J.A. (1983) “Earthworm Biology” Edward Arnold (Publishers) Ltd. London.
8. Christy, M. V. (2008) Vermitechnology, 1st edition, MJP Publishers.
9. Dash, M. C. (2012) Charles Darwin’s Plough Tool for Vermitechnology, I. K. International Publishing House Pvt Ltd. New Delhi, India.
10. Kumar, A. (2005) Verms and Vermitechnology, APH Publishing.
11. Lekshmy, M. S., Santhi R. (2012) Vermitechnology, Sara Publications, New Delhi, India, 4
12. National Institute of Industrial Research, (2010): The Complete Technology Book on Vermiculture and Vermicompost, Published by National Institute of Industrial Research, Delhi-7, India.
13. Sinha, R. K. et.al (2010) Vermitechnology-The Emerging 21st Century Bioengineering technology for sustainable development and protection of human health and environmentReview, Dynamic Soil and Dynamic Plant, Global Science Books.
14. Sharma S. et .al, (2009) Earthworm and Vemitechnology –Review, Dynamic Soil and Dynamic Plant, Global Science Books.
15. Chauhan, A. (2012) Vermitechnology, Vermiculture, Vermicompost and Earthworms: Vermiculture, Vermicomposting, Vermitechnology and Mirobes,Lambert Academic Publishing, Germany. III) Examination Pattern:

M.Sc.II Semester

Elective Paper VI: Vermiculture & Vermicomposting Lab

Study & culture of Useful species of earthworms.

Suvey and taxonomy of Local & Exotic species of earthworms.

Practical on Small Scale Earthworm farming for home gardens and collection of Earthworm compost from home gardens.

Study on Nutritional Composition of Vermicompost for plants,

Comparison of compost with other fertilizers

Vermiwash collection

M.Sc.II Semester

Elective Paper VII: Mushroom Culture

Unit I

Introduction to mushrooms . Mushrooms -Taxonomical rank -History and Scope of mushroom cultivation - Edible and Poisonous Mushrooms-Vegetative characters Common edible mushrooms .

Unit II

Button mushroom (Agaricus bisporus), Milky mushroom (Calocybe indica), Oyster mushroom (Pleurotus sajorcaju) and paddy straw mushroom (Volvariella volvcea). Principles of mushroom cultivation. Structure and construction of mushroom house. Sterilization of substrates. Spawn production - culture media preparation- production of pure culture, mother spawn, and multiplication of spawn.

Unit III

Composting technology, mushroom bed preparation. Spawning, spawn running, harvesting. Cultivation of oyster and paddy straw mushroom.Problems in cultivation - diseases, pests and nematodes, weed moulds and their management strategies. Health benefits of mushrooms.Nutritional and medicinal values of mushrooms. Therapeutic aspects- antitumor effect Module

Unit IV

Post harvest technology: Preservation of mushrooms - freezing, dry freezing, drying, canning, quality assurance and entrepreneurship.Value added products of mushrooms.

Suggested Books:

1 Marimuthu, T. et al. (1991). Oster Mushroom. Department of Plant Pathology. Tamil Nadu Agricultural University, Coimbatore.

2. Nita Bhal. (2000). Handbook on Mushrooms. 2nd ed. Vol. I and II. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi

3. Pandey R.K, S. K Ghosh, 1996. A Hand Book on Mushroom Cultivation. Emkey Publications.

4. Pathak, V. N. and Yadav, N. (1998). Mushroom Production and Processing Technology. Agrobios, Jodhpur.

5.Tewari Pankaj Kapoor, S. C. (1988). Mushroom Cultivation. Mittal Publication, New Delhi.

6. Tripathi, D.P. (2005) Mushroom Cultivation, Oxford & IBH Publishing Co. PVT.LTD, New Delhi.

7. V.N. Pathak, Nagendra Yadav and Maneesha Gaur, Mushroom Production and Processing Technology/ Vedams Ebooks Pvt Ltd., New Delhi (2000) CERTIFICATE COURSE –MUSHROOM CULTIVATION

M.Sc.II Semester

Elective Paper VII: Mushroom Culture

Training/ Workshop/ Field visit on Mushroom culture and preparation of report.

Sterilization and sanitation of mushroom house.

Study of instruments and substrates

Preparation of mother culture, media preparation, inoculation, incubation and spawn production Cultivation of oyster mushroom using paddy straw/agricultural wastes .

M.Sc.III Semester

Core Paper I: Cell Biology

Unit I

The nucleus: The nuclear envelope, internal organization of the nucleus, the nucleolus, Plasma membrane: structure and chemical composition, movement of substances across the membrane. Cell signaling: general principles of cell signaling, Classes of cell surface receptors protein, Signaling of steroid and thyroid hormones through intracellular receptors, Signaling via G- protein linked cell surface receptors, interferon.

Unit II

Protein sorting and transport: endoplasmic reticulum (the endoplasmic reticulum and protein secretion, export of protein and lipids from the ER), Golgi apparatus (organization of the Golgi complex, protein glycosylation, lipid and polysaccharide metabolism, protein sorting and export), Lysosomes (Ultrastructure,lysosomal acid hydrolases, endocytosis and lysosome formation, phagocytosis and autophagy).

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Unit III

Bioenergetics and metabolism (mitochondria-organization and function, mechanism of oxidative phosphorylation), Peroxisomes and its functions, ultrastructure and functions of ribosomes.

The cell division cycle: regulation of the cell cycle by cell growth and extracellular signals, cell cycle checkpoints, regulation of cell cycle progression.

Unit IV

Cancer: cancer as a micro-evolutionary process, Causes and types of cancer, Properties of cancer cells, Molecular diagnosis, Prevention and treatment, Molecular genetics of cancer,

Chromosome morphodynamics and achromatic apparatus in cell division, Physiology of a dividing cell, Apoptosis and natural cell death.

Suggested Books:

1. Cooper : Cell- a Molecular Approach
2. Lodish et al: Molecular Cell Biology
3. Watson et al: Molecular Biology of the gene
4. Alberts et al: Molecular Biology of cell
5. Karp: Cell and Molecular Biology
6. Lewin B Genes VIII
7. Primrose. Molecular Biotechnology
8. Sambrook et al: Molecular Cloning

M.Sc.III Semester

Core Paper I: Cell Biology Lab

Microscopy: Bright field, phase contrast & Fluorescence Microscopy.

Microtomy: Section cutting and preparation of permanent slides

Preparation of temporary slides.

Slides of barr body and Mitochondria from buccal epithelium

Demonstration of perfusion

Histochemical demonstration of slides on cryocut sections for protein, lipid carbohydrate on fish

Immunocytochemistry of pituitary , pineal and thyroid hormones of teleost and photomicrography.

Instrumental methods for Cell Biology.

Sub cellular fractionation and marker enzymes.

Study of different stages of Mitosis & Meiosis.

Preparation of slides for stages of Mitosis & Meiosis

M.Sc.III Semester

Core Paper III: Biotechnology & Molecular Biology

Unit I

Recombinant DNA technology: introduction, restriction endonucleases, other useful enzymes for molecular cloning, steps in gene cloning, identification and isolation of desired gene, cloning vectors, screening and selection of recombinant DNA clones, Gene probes as diagnostic tools, Genomic DNA libraries, Biosynthesis of insulin, somatostatin and growth hormone, health care biotechnology, gene therapy.

Unit II

Tissue culture, hybridoma technology and monoclonal antibodies, embryonic stem cell transfer, targeted gene transfer, in vitro fertilization in humans, applications of embryo transfer technology, animal cloning.

Environmental biotechnology: bioconversion, pollution control, microbial enhancement of oil recovery, microbial mining and metal recovery, sewage treatment.

Unit III

An introductory knowledge of biosensors, biochips, immobilized enzymes, bioenergy.

Molecular analysis of Eukaryotic DNA-overall composition, reassociation kinetic, kinetic analysis of Eukaryotic DNA, Organisation of eukaryotic gene-globin gene, IgG, rDNA, histone gene.

DNA replication, nucleotide polymerases, repair and mispair mechanism, the basic transcription apparatus, promoters, enhancers, termination and antitermination.

Unit IV

Protein synthesis, Genetic code, mRNA processing and organisation of interrupted genes, ribonucleoprotein, organelle genome, structure and life cycles of bacteriophase T2 or T4, virulent and temperate phages.

RNA phages, tumor viruses and their life cycles, retroviruses, topoisomerases, gyrases, methylases, nucleases, molecular biology of cancer, oncogenes, chemical carcinogenesis, genetic and metabolic disorders, principles and methods of gene targeting, gene silencing.

Suggested Books:

1. Lodish el al: Molecular Cell Biology
2. Freifelder: Essentials of Molecular Biology
3. Brown: Gene Cloning
4. Sambrook and Russel: Molecular cloning
5. Lewin: Gene
6. Primrose: Principles of Gene Manipulation

M.Sc.III Semester

Core Paper IV: Lab on Biotechnology & Molecular Biology

Isolation of genomic DNA.

Southern blotting. RFLP analysis .Isolation of RNA. Isolation of polyA + RNA.

Northern blotting Preparation of probes. In vitro Transcription In vitro translation. Metabolic labeling of proteins and immuno precipitation.

Bacterial culture and antibiotic selection medias.

Prepration of competent cells.

Isolation of plasmid DNA. Isolation of lambda phage DNA .

Quantitation of nucleic acids.

Agarose gel electrophoresis and restriction mapping of DNA.

Construction of restriction map of plasmid DNA.

Preparation, of helper phage and its titration.

Preparation of single stranded DNA template.

Suggested Books:

1. Lodish et al., Molecular cell Biology, 4thEdition, W.H. Freeman & Company, 2000.

2. Smith & Wood, Cell Biology, 2ndEdition, Chapman & Hall, London, 1996.

3. Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA, 2003.

4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley- Blackwell, 2002.

5. Benjamin Lewin, Gene IX, 9thEdition, Jones and Barlett Publishers, 2007.

6. Benjamin Lewin, Gene IX, 9thEdition, Jones and Barlett Publishers, 2007.

7. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6thEdition, Benjamin Cummings Publishing Company Inc, 2007.

8. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002

M.Sc.III Semester

Elective Paper I: Biological tools &Techniques

Unit I

Principles and uses of Spectrophotometer, spectroflurophotometer, atomic adsorption spectrophotometry.

Elementary principle of fluorescence and electron microscopy (transmission electron, scanning electron and atomic force microscope).

Unit II

Chromatography: paper and thin layer chromatography, Gas liquid chromatography, column chromatography, gel exclusion chromatography, high performance liquid chromatography, affinity chromatography.

Unit III

Separation of biomolecules by electrophoresis (purification and fractionation of nucleic acids), Principles of differential and density centrifugation.

Unit IV

Nucleic acid hybridization, PCR, DNA finger printing, Methods of determining genetic diversities- isozymes, RFLP, RAPD, gene sequencing, generating molecular data bases.

Suggested Books:

1. Wilson and Walker: Principles and techniques of Biochemistry and Molecular Biology
2. Primrose. Molecular Biotechnology
3. Boyer: Modern experimental Biochemistry and Molecular Biology
4. David Freifelder: Physical Biochemistry
5. Wilson and Walker: Practical Biochemistry
6. Ruthman: Methods in Cell Research

M.Sc.III Sem.

Elective Paper II: Fish and Fisheries

Unit-I

Classification: Systematic and classification of Elasmobranches, Holocephalians, Dipnoans and Actinopterygians including the ancestral groups of Acanthodians, Placoderms and Crossopterygians.

Origin and evolution of major groups of fishes. General features, origin and evolution of the skin, scales and fins of teleosts.

Unit II

Adaptation: Major adaptations developed in teleosts with special reference to hill stream and deep sea fishes.

Specialized organs: Important specialized organs developed in fishes; Electric organs, Bioluminescence, Air bladder and Weberian apparatus, Lateral line organs and poison glands.

Endocrine glands: Major endocrine glands found in fishes with special reference to reproduction and migration.

Unit III

Anatomy and Physiology: General features, anatomy and physiology of internal organs of teleosts; Alimentary canal and digestion, Excretion and osmoregulation, Reproductive organs and reproduction, Respiratory organs and mechanism of respiration, Blood circulation and aortric arches, Sensory organs and nervous system, Central and peripheral skeletal system.

Unit IV

Embryonic development: Fertilization, Zygote formation, Stages of embryonic development, Organogenesis, Hatching and larval development; Viviparity in fishes.

Fish Behavior: Migratory behavior of Salmon and Eel and their hormonal regulation; Courtship behavior, Parental care and nest building, Air-gulping behavior in air-breathing fishes.

Suggested Books:

1. Datta Munshi, J.S. and M.P. Srivastava, Natural History of Fishes and Systematic of Fresh Water Fishes of India.
2. Jayaram KC, Fundamentals of Fish Taxonomy.
3. Hoar WS, Randall DJ and Donaldson EM, Fish Physiology
4. Gupta S.K. and Gupta P.C., General Applied Ichthyology.

5. Srivastava, C.B.L. A Text book of Fishery Science and Indian Fisheries.
6. Lagler, Ichthylogy.
7. Norman, J.R., History of Fishes.
8. Kyle, H.M.A., Biology of Fishes.
9. Khanna, S.S., An Introduction to Fishes.
10. C B L Srivastava : Soft anatomy
11. Anurag Tripathi & M. Rahman (2018). Neuroanatomy of Teleost Fish (Based on Acetylcholinesterase Histochemistry. 1st Ed. Akinik Publication, New Delhi.

M.Sc. Sem III

Elective Paper III : Evolutionary Biology & Animal behaviour

UNIT-I:

Evidences: The need of evidences for the fact of evolution - evidences from comparative anatomy, embryology, physiology and biochemistry - visual pigments, hemoglobin, protein sequences in phylogeny. Biogeography, Platetectonics and continental drift - Evidences from systematic, evolutionary taxonomy - Evidences from paleontology - evolutionary trends in fossils, types of fossils. Process of fossilization - Evolution of homeotherms - Evidences from genetics - gene and chromosome homology, hybridization, universality of the genetic code.

Mutationism - Views of De Vries and of R.B. Golschmidt; hopeful monsters. Inadequacies of mutationism.

Lamarckism - Life of Lamarck - Lamarckian postulates - inadequacies of Lamarckism.

Natural selection - In nature and laboratory - Creative aspects of natural selection - modern understanding of selection, stabilizing and diversifying and directional selection.

Adaptation - Nature and types of adaptation - Adaptive trends - Quantifying adaptation - Batesian and Mullerian mimicry and evolution.

Polymorphism - Transient and stable - Maintenance of polymorphism.

UNIT-II:

Mutations and their role in evolution - the neutralist hypothesis - population size and evolution - the role of genetic drift - hybridization and evolution - The role of polyploidy, isolating mechanisms - premating, post mating - problems of the origin of isolating mechanism.

Structure of species - Clones, peripheral population isolates,

Genetics and Ecology of speciations. Mayer's founder principle and genetic evolution in the peripheral isolates - Ecological opportunities for speciation.

Sociobiology Definition and scope - selfish gene, altruism and kin selection bioethics.

Unit III

Concepts of animal behaviour: Definition and general concepts of ethology and animal behaviour, Fundamental mechanisms of animal behaviour, Major contribution of scientists in classical ethology and modern behavioural biology.Methods used in the study of animal behaviour in their natural habitat, Role of various types of Taxes, Reflexes and Orientation in animal behaviour, Development of innate behaviours,Fixed action patterns (FAPs), Innate releasing mechanisms, Biological rhythms.

Unit IV

Social behaviour: Characteristics of true society, Social organization and social hierarchies; Territorial behaviour: Demarcation and protection of territories, Expression of aggressive behaviour and hormonal control of aggression; Courtship Behaviour: Mating patterns in animals, mechanisms of courtship behaviour; Migratory behaviour: Migratory pattern of fishes and birds and their hormonal control mechanisms, Patterns of

communication in animals, Classification or forms of learning and memory, Neural mechanisms of learning and memory, Evolution of behaviour.

Suggested Books

1. Alfonso Martinez Arias, Alison Stewart: Molecular Principles of Animal Development
2. Gilbert SF.: Developmental Biology.
3. Adam S Wilkins: Genetic Analysis of Animal Development
1. Alfonso Martinez Arias, Alison Stewart: Molecular Principles of Animal Development
2. Gilbert SF.: Developmental Biology.
3. Adam S Wilkins: Genetic Analysis of Animal DevelopmentAlfonso M.A.; Molecular Principles of Animal Development
4. Michael J. Barry: Molecular Embryology: How Molecules Give Birth to Animals
5. Janice Moore and Michael D Breed: Animal Behaviour
6. Marian Dawkins: Observing Animal Behaviour
7. Manning, A.: An Introduction to Animal Behaviour
8. P. J. B. Slater: Essentials of Animal Behaviour
9. Russell, E.S.: The Behaviour of Animals
10. David McFarland: Animal Behaviour
11. Alcock, J. Animal Behaviour: An evolutionary approach
12. Dugatkin, Lee: Principles of Animal Behaviour
13. Silverman, P.: Animals Behaviour in the laboratory.
14. Nikolaas Tinbergen: The Study of Instinct
15. Chris Barnard: Animal Behaviour: Mechanism, Development, Function and Evolution

M.Sc. Sem III
Elective IV: Ecology & Wild Life conservation

UNIT-I

Introduction to Ecology & environmental sciences; Principles and Scope of Ecology Structure and Functions of Ecosystems- Abiotic and Biotic components, Flow of energy and cycling of materials; water, carbon, nitrogen and phosphorus, Trophic pyramids and food webs; Ecosystems Types and Diversity, Alterations of ecosystem function: acid rain, nuclear winter, global warming and ozone hole, an overview of IPCC.

Unit-II

Diversity of life; origin of life on earth and Speciation; Human Ecology and Human Settlements, Evolution of early life and changes in earth's atmosphere. Trends in human population growth; Malthusian growth. Intraspecific interactions and density dependence, Parasitism, Prey-predator relationships, Interspecific interactions; Commensalism, mutualism, competition and predation. Species diversity, community stability and disturbance

Unit III

Aquatic and terrestrial communities; rare communities; deep earth, deep seafloor, volcanoes. Primary productivity; basic concepts, Ecological succession inland, water; concepts, Invasive species and control

Threats to and loss of biodiversity-Global deforestation rate- extinction crises. Causes for extinction: habitat loss, industrialization, hunting and bio invasions; invasive species: wiser use & management. Extinction through geological time scale: mass extinction. Current extinction trends. The theory of island biogeography; edge effect.

UNIT-IV

Conservation strategies: In-situ and ex-situ conservation, biodiversity hot spots, hottest hot spots, mega diversity countries, centers of plant diversity and endemism. India – Biospheres, National parks and Wildlife sanctuaries, Wild life conservation projects: Crocodile Conservation, GOI-UNDP Sea Turtle project.

Overview of Conservation efforts: global protected area network. Protected areas and functions; UNESCO biosphere reserves; IUCN conservation categories-endangered, threatened, vulnerable, Red Data Books. Regulation of biodiversity: Convention on Biological Diversity, National Biodiversity Authority, WCMC, CITES.

Suggested Books

: 1. Singh, J.S., S.P & Gupta, S.R. 2006. Ecology, Environment and Resource conservation. Anamaya Publ., New Delhi, 688 pp.

2. Miller. G.T. 2004. Environmental Science. Thomson, California. 538 pgs.

3. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.

4. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs

5. Primack, Richard B., and Anna Sher (2016). Introduction To Conservation Biology. Sinauer Associates, Incorporated, Publishers.

6.Berlatsky (2013) Biodiversity – Global Viewpoints. Gale Cengage Publishers. ISBN: 9780737769050.
7. Gary G. Mittelbach (2012) Community Ecology. Sinauer Associates, Inc.; 1 edition. ISBN: 97

Elective Paper V: Computational Biology and Bioinformatics

Unit I

Computer networking, Internet and E-mail, Concept of home pages and web-sites, World Wide Web, Uniform Resource Locators, Introduction and scope of Bioinformatics, Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny.

Unit II

Applications and Limitations of Bioinformatics, Bioinformatics and its relation with molecular biology, Examples of related Tools (FASTA, BLAST, BLAT, RASMOL), Biological databases (GENBANK, Pubmed, PDB) Nucleic acid sequences, Genomes, Protein sequence and structures and software (RASMOL, Ligand Explorer).

Unit III

Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic, Programming, BLAST and FASTA), Local and global alignment, pair wise and multiple sequence alignments, Similarity, identity and homology of sequences.

Unit IV

Trees: Rooted and unrooted trees, Species tree and Gene tree: Homology, Homoplasy, Orthology, Paralogy and Xenology Trees Construction Methods: Maximum Parsimony, Maximum Likelihood, Branch and Bound.

Suggested Books:

1. Barnes & Gray (ed): Bioinformatics for geneticists, Wiley (2003)
2. Lesk: Bioinformatics, Oxford (2003, Indian ed)
3. Dan E. Krane and Michael L. Raymer, Pearson Education inc.
4. Jaspreet Kaur and Jasvinder Kaur, Bioinformatics Practical, Manual :An easy guide to In-silico analysis
5. Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)
6. Campbell A. M. and Heyer, L. J. 2007. Discovering Genomics, Proteomics and Bioinformatics,2nd Edition. Benjamin Cummings.
8. Mount W. 2004. Bioinformatics and sequence genome analysis 2nd Editon CBS Pub

Elective Paper VI: Lab on Computational Biology and Bioinformatics:

Computer thinking and programming

Computer network

Data base Management

Preparation of PPT/ Uploading of contents and vidios.

Various search engines

Practice on formatting of manuscript, figures tables.

Reference writing

Nucleic acid and protein databases.

Retrieval and analysis of DNA or protein sequence from NCBI

Sequence Alignment in excel sheet for data processing.

Elective paper VI : Aquaculture

Unit-I

Major cultivable species for aquaculture; A knowledge of inland water bodies suitable for culture in India. Culture of Indian Major Carps: exotic carps of Fish Hatcheries and their management. Bundh breeding and Induced breeding of carp by hypophysation and use of synthetic hormones. Preparation and Management of Indian major carp culture ponds – nursery, rearing and production ponds.

UNIT – II

Culture of Giant fresh water prawn, Macrobrachium rosenbergii - seed collection formation sources. Hatchery management. Culture of tiger shrimp, Penaeus monodon and Litopenaeus Vannamei.

UNIT – III

Culture of brackish water fish – Chanos and Lates, Osteobrama belangeri. Culture of pearl oysters.

UNIT – IV

Culture of sea weeds: Major commercial importance seaweed species. Methods of Crab culture Culture of ornamental fishes. Culture of air-breathing fishes in India. Culture of Molluscs,

Suggested Books:

1. Bardach, JE et al. 1972. Aquaculture – The farming and husbandry of freshwater and marine organisms. John Wiley & Sons, New York.
2. Chakraborty C & Sadhu AK. 2000. Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Daya Publ. House. FAO. 2007. Manual on Freshwater Prawn Farming.
3. Huet J. 1986. A text Book of Fish Culture. Fishing News Books Ltd.
4. ICAR. 2006. Hand Book of Fisheries and Aquaculture. ICAR.
5. Jhingran V.G. 1991. Fish and Fisheries of India. Hindustan Publ. Corporation, India.
6. Landau M. 1992. Introduction to Aquaculture. John Wiley & Sons.
7. Mcvey JP. 1983. Handbook of Mariculture. CRC Press.
8. MPEDA: Handbooks on culture of carp, shrimp, etc.
9. New MB. 2000. Freshwater Prawn Farming. CRC Publ.
10. Pillay TVR. 1990. Aquaculture- Principles and Practices. Fishing News Books Ltd.,
11. London. Pillay TVR & Kutty MN. 2005. Aquaculture- Principles and Practices.2nd Ed.
12. Blackwell Rath RK. 2000. Freshwater Aquaculture. Scientific Publ.
13. Stickney RR. 1979. Principles of Warmwater Fish Culture. John Wiley & Sons.

Elective Paper: Aquaculture lab:

1. Identification of major cultivable species - fin fish and shell fish, molluscs.
2. Pituitary gland extract preparation.
3. Visit to hatcheries and grow out farms/ Visit to fish processing unit.
4. Analysis of fish for Biochemical constituents.
4. Method of evaluation of freshness of fish.
5. Identification of Fish and Shrimp disease.
6. Examination of normal and diseased fish.
7. External examination on diseased fish diagnostic features and procedure.
8. Atrophy of organ of diseased fish, Host examination – collection of parasites.
9.Histopathology of organs of diseased fish.
10. Slides of fish parasites.
11. Use of probiotics in aquaculture farms.