COOCH BEHAR PANCHANAN BARMA UNIVERSITY

PG SYLLABUS FOR ZOOLOGY

NCCF

(National Curriculum and Credit Framework)

Two-Year PG Programme:

Two-Year (1st to 4th Semester) M.Sc.

One-Year PG Programme:

One-Year M.Sc.

(3rd & 4th Semester of this syllabus to be treated as 1st and 2nd Semester)

Effective from Academic Session 2026-2027

Total Credit: 80 (Credit/Semester: 20)

M.Sc. N.C.C.F. Syllabus

Subject-Zoology
Cooch Behar Panchanan Barma University

Sem	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Total Marks
Sem 1	Core-1	Biochemistry & Toxicology +Environmental Physiology	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Core-2	Wild Life & Conservation Biology along with the perspective of Indian Knowledge system + Animal Behavior	50 (Credit = 4)	20 (Field Visit Report)	5	25 (Credit = 1) (Practical+ Field Report+ Viva= (10+10+5)		100
	Core-3	Advances in Developmental Biology – Comparative Anatomy in Vertebrtes	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Discipline Centric Elective	Research Methodology + Bioinstrumentation	50 (Credit = 4)	20	5	25 (Credit = 1)		100

	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Total Marks
Sem 2	Core-4	Parasitology + Immunology and Microbiology & Viral pathology	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Core-5	Animal Biotechnology + Genetics	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Core-6	Cell Biology + Neurobiology	50 (Credit = 4)	20	5		25 (Credit = 1)	100
	General Elective	Biosystematics + Bioinformatics or SWAYAM/ MOOCS course/ courses in accordance with the Department total credit being 5	50 (Credit = 4)	20	5	25 (Credit = 1)		100

SEMESTER 3 & SEMESTER 4 Options

Option-1: Course Work Paper/ Research Paper in both the semesters + Research review/ dissertation in both the semesters

Sem	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Total Marks
Sem 3	Course Work Paper-1	A. Advances in Parasitology/ B. Advances in Ecology	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Course Work Paper-2	A. Molecular Cell Biology/ B. Insect Physiology and Industrial Entomology	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Course Work Paper-3	A. Stem Cell Biology/ B. Molecular Cytology	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Research Paper	Research Based Literature Review					100 (Credit = 5)	100

Sem	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Total Marks
Sem 4	Research Paper-1	A. Epidemiology study with Artificial Intelligence Application / B. Advances in Ethology	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Research Paper-2	A. Advances in Oncology/ B. Advances in Entomology	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Research Paper-3	A. Regenerative Medicine/ B. Cytogenetics	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Final Submission of Research work	Dissertation					100 (Credit = 5)	100

Option-2: Course Work Paper & Research Paper in semester-3+ Research work in semester-4

Sem	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Total Marks
Sem 3	Course Work Paper-1	Elective-A	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Course Work Paper-2	Elective-B	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Course Work Paper-3	Elective-C	50 (Credit = 4)	20	5	25 (Credit = 1)		100
	Research Paper	Research Based Literature Review					100 (Credit = 5)	100

Sem	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Full Marks
Sem 4	Research	Seminar Presentation and submission of Research project/patent	-----					400 (Credit = 20)

Option-3: Research work in semester-3 & 4

Sem	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Full Marks
Sem 3	Research	Seminar Presentation and submission of Research project/patent	------					400 (Credit = 20)

Sem	Paper code	Paper Name	Theo	CE	Attendance	Pract.	Viva/ Seminar	Full Marks
Sem 4	Research	Seminar Presentation and submission of Research project/patent	------					400 (Credit = 20)

SEMESTER 1

Core-1-T

Biochemistry and Toxicology + Environmental Physiology

Theory **Credit:4, Full Marks: 50**

Group-A **Full Marks: 25**
Biochemistry and Toxicology

1. The nature of non-covalent interactions (van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction etc.).
2. Bioenergetics: Internal energy, First Law of Thermodynamics, Enthalpy, Entropy, Second Law of Thermodynamics.
3. Electron-transfer reaction and Oxidative phosphorylation in mitochondria. Major sources of reductive equivalents that drive
   ATP generation.
4. Conformation of proteins - Ramachandran plot, secondary structure, domains, motifs and folds.
5. Conformation of nucleic acids (A, B, Z). Re-association kinetics and genome complexity, C-value paradox.
6. Enzymes: Kinetics, Regulation, Mechanism of catalysis, Isozymes. Stability of protein and nucleic acids.
7. Chemistry of free radicals and antioxidants.
8. Principles of Toxicology: Classification of toxins. Dose-response relationships, LD50, LC50/IC50, ED50; threshold limits, routes of exposure.
9. Toxicokinetics.
10. Toxic effects on different organs. Xenobiotics.

Group-B **Full Marks: 25**
Environmental Physiology

. 1. Stress Physiology: Basic concepts of stress and strain, stress avoidance, stress tolerance, etc.
2. Basic concept and mechanism of Homeostasis.
3. Respiration: Respiratory pigments: Oxygen dissociation curves: Transport of oxygen and carbon dioxide: Bohr effect, Root effect & Haldane effect; Physiology of diving birds and mammals.
4. Energy metabolism: 2nd Law of Thrmodynmics;Fundamentals of animal energetics; Metabolic rate : meaning and measurement; Metabolic scalling; Interplay of aerobic and aenarobic catabolism during exercise; Responses to impaired O2 influx fom the environment.
5. Excretion and Osmoregulation: a) Excretion-Concept of excretory organs in animals: U/P ratio: Food and drinking water; Metabolic water b) Osmoregulation-Control of osmoregulation via ADH: Osmoregulation in aquatic and terrestrial animals c) RAAS in maintaining blood pressure.
6. Thermoregulation: Concepts of terminologies used (Endotherm, Ectotherm, Homeotherm, Poikilotherm, Heterotherm, etc): Concept of Temperature Coefficient (QIO): Acclimatization and acclimation: Adaptations to cold and heat by aquatic & terrestrial animals; Adaptive Hypothermia and Adaptive Hyperthermia; Thermal Neutral Zone: Thermogenesis. Evaporative cooling.

Recommended readings

1. Lehninger PRINCPLES OF BIOCHEMISTRY; David L. Nelson, Michael M. Cox. (2008). V Edition. Macmillan Learning.
2. Biochemsitry; VI Edition. Jeremy Mark Berg, John L. Tymoczko, Lubert Stryer (2007). W.H. Freeman, 2002.
3. Harper's Illustrated Biochemistry; XXVIII Edition. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Lange Medical Books/McGraw-Hill.
4. Biochemistry; Donald Voet, Judith G. Voet. Wiley Blackwell.
5. Animal Physiology. 3rd Edition. Hill, Wyse, Anderson. (2012). Sinauer Associates, Inc. Publishers • Sunderland, Massachusetts.
6. Animal Physiology: From genes to Organisms 2e; Sherwood, Klandorf, Yancey.
7. Environmental Physiology of Animals; Pat Wilmer, Graham Stone, Ian Johnston

Core-2-T

Wild Life & Conservation Biology along with the perspective of Indian Knowledge system (IKS) + Animal Behavior

Theory **Credit: 4, Full Marks: 50**

Group-A **Full Marks: 25**

Wild Life & Conservation Biology along with the perspective of IKS

1. Definition and indices of biodiversity.
2. Levels of biodiversity: genetic, species and ecosystem.
3. Biodiversity act and related international conventions.
4. Threats to biodiversity, sustainable development, natural resource management in changing environment
5. Classification of wildlife according to severity of threats, CITES.
6. Conservation: Rationale for wildlife conservation, models of wildlife management and conservation, *in situ* and *ex-situ* conservation, Socio-economic perspective of wildlife conservation.
7. Wildlife laws and bodies: Wildlife Protection Act, National Biodiversity Authority and National Tiger Conservation Authority (NTCA).
8. Tiger Census: Methods, Trend and Criticism.
9. Joint forest management: Arabari Model.
10. Indigenous Taxonomy and Ethnozoology: How indigenous communities classify animals: folk taxonomy vs. Linnaean system, Ethnozoological practices: knowledge of local fauna by tribes and rural people.
11. Traditional Practices and Animal Use: Traditional animal husbandry and breeding practices (cattle, buffalo, goats, poultry). Ethno-veterinary medicine: herbal treatments, disease management. Traditional pest control, use of natural enemies, biocontrol methods.

12. Conservation, Ethics, and Integration with Modern Zoology: Sacred groves, totem animals, and conservation ethics in traditional societies, Cultural taboos and their role in species protection, Sacred water bodies and aquatic biodiversity conservation, Integrating IKS with modern wildlife management and policy, Challenges: documentation, intellectual property rights, biopiracy, ethical concerns

Group-B **Full Marks: 25**

Animal Behavior

1. Ethology: Definition, Scope, Importance, Basic concepts and models of classical ethology. Questions about.
   animal behaviour, The escaping cockroach, The courtship of the sage grouse, Units of the nervous system, Reflexes and more complex behaviour, Diversity and unity in the study of behavior.
2. The Development of Behaviour : Young animals grow up, Instinct and learning in their biological setting, The characteristics of instinct and learning, Genetics and behaviour, Development and changes to the nervous system, Hormones and early development, Early experience and the diversity of parental behaviour, Play, Imprinting, Bird song development
3. Stimuli and communication: What stimuli are and how they act, Diverse sensory capacities, The problem of pattern recognition, Sign stimuli (key features), 'Supernormal' stimuli, Neuroethological basis of sign stimuli, Other solutions for pattern recognition: generalized feature detection, Communication, What is communication? Animal signals as effective stimuli - aggression, predation, song, complex communication, Honesty and deception in animal signaling, The honeybee dance, The calls of vervet monkeys.
4. Foraging: Optimal foraging theory; learning and foraging; molecular, neurobiological and hormonal aspects of honey bee foraging.
5. Decision-making and motivation: Decision-making on different time scales, Decision-making and 'motivation', Measuring motivation, Is motivation specific or general, Goals as decision points, Homeostasis and negative feedback, Competition between motivations, Inhibition/disinhibition, Decision-making with incomplete information: the role of signals, Conflict and 'abnormal' behavior, The physiology of decision-making, Hormones and sequences of behavior, Conflict and physiological stress, Decision-making, motivation and animal welfare.
6. Learning and memory: Learning as part of adaptation, Sensitization and habituation, Associative learning, Specialized types of learning ability, What do animals actually learn? Are there higher forms of learning in animals?, The comparative study of learning, Social learning and culture, The nature of animal minds, The nature of memory.
7. Evolution: The adaptiveness of behavior, Genes and behavioural evolution, Kin selection and inclusive fitness, Prisoner's dilemma, selfish gene theory and green beard hypothesis, Evolutionarily stable strategies, Sex and sexual selection, Species isolation and species selection, Tinbergen's fourth question: the phylogeny of behaviour.
8. Social organization: The individual in the crowd, Advantages of grouping, Diverse social groups Eusociality: division into castes, Territory in the social

organization of vertebrates, Courtship and Mating systems and social organization, Dominance in social systems, Diverse mammalian social behavior, Nidification in birds, Primate social organization.

9. Wildlife behavior: Aggression, agonistic behavior, competition, territory, dominance, movements and conflict.

Recommended readings

1. Caughley G, Sinclair ARE. 1994. Wildlife Ecology and Management. Blackwell Science
2. Hunter ML, Gibbs JB, Sterling EJ. 2008. Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. BlackwellPublishing
3. Hunter, M. L., J. James & P. Gibbs – Fundamentals of Conservation Biology – John Willey & Sons.
4. Maiti, P. K. and P. Maiti (2017) Biodiversity: Perception, Peril and Preservation in the Indian Perspective. PHI. Leaning Pvt. Ltd. New Delhi. ISBN 978 – 81-203-4380-1, (3nd Eds)
5. Majupuria T. C. – Wildlife of India – Techpress. Bangkok
6. Mukherjee A. K. – Endangered animals of India – Z.S.I
7. New T. R. – Invertebrate Surveys for Conservation – Oxford Univ. Pr
8. Saha G. K. & S. Majumdar – Threatened Mammals of India – Daya Publication House
9. Saha GK, Mazumdar S. 2017. Wildlife Biology: an Indian Perspective, PHI Learning.
10. Saharia VB. 1998. Wildlife in India. Natraj Publishers.
11. Sutherland WJ.1997. Ecological Cencus Techniques, A Handbook. Cambridge University Press.
12. Sutherland WJ.2000. The Conservation Handbook: Research, Management & Policy. Blackwell Sc
13. Van Dyke F. 2008. Conservation Biology: Foundations, Concepts, Application. 2nd Ed. Springer Science Wild life (Protection) Act 1972 – Wild life Society of India (Nataraj Publication)
14. Wilson, E. O. – Biodiversity – National Academic Press Woodroffe R., Thirgood S, Rabinowitz A. 2005. People and Wildlife, Conflict or Co-existence? Cambridge Univ. P 2111
15. Alcock J. 2013. Animal Behaviour, Sinauer Associate Inc., USA.
16. Drickamer LC , Vessey SH . 2001. Animal Behaviour. McGraw-Hill
17. Dugatkin LA. 2014. Principles of Animal Behaviour. 3rd Edn. W.W. Norton and Co.
18. Gadgil, Ramakrishnan, Jain, and Saini focus on India's indigenous environmental and zoological knowledge.
19. Ethno Zoology: Principles and Applications – C.M. Cotton

Core-3-T

Advances in Developmental Biology + Comparative Anatomy in Vertebrates

Theory **Credit: 4, Full Marks: 50**

Group-A **Full Marks: 25**
Developmental Biology

1. Fundamentals of development: Potency, commitment, specification and its types, determination, morphogenetic gradient and French-flag model, fate map, induction and its types, cell-cell communications during development, cell death mechanisms and its importance in development, concept of genomic equivalence.
2. Molecular events associated with the sex determination and dosage compensation in case of *C. elegans*, *Drosophila* and Human.
3. Morphogenesis and organogenesis in animal models: Differentiation and patterning in *Dictyostelium*, Vulva formation in *C. elegans*, Axis patterning and development pattern in *Drosophila*, brain and eye formation in tetrapods, limb formation in tetrapods, axis patterning and organizer concepts in amphibians.
4. Regeneration, metamorphosis and senescence: Examples and events of epimorphic, morphalactic, compensatory regeneration, stem cells and its use in regenerative medicine; metamorphosis in insects, Ascidia, toad, different types of heterochrony in salamanders; aging and senescence, theories and molecular events of senescence.
5. Developmentally important signaling cascades: Wnt, Hh, Notch, SMAD, RTK & NRTK signaling cascades.
6. Stem Cell Science: Stem cell types, sources, stem cell niche concept, regulation of haematopoiesis, different stem cell based therapeutic strategies, concept of IPSC, ethical concerns regarding stem cell research.
7. IVF: Concept of ART and IVF, procedure of IVF and embryo transfer, concept of surrogacy.

Group-B **Full Marks: 25**
Comparative Anatomy

1. Integumentary System: Structure and derivatives of integument.
2. Digestive System: Alimentary canal and associated glands; Dentition.
3. Circulatory System: General plan of circulation; Evolution of heart and aortic arches.
4. Respiratory System: Skin, gills, lungs, accessory respiratory organs in fishes, air sacs.
5. Skeletal System: Outline of axial and appendicular skeleton; Concept of neurocranium, dermatocranium and splanchnocranium; Structure of a typical vertebra and its classification based on centrum; Jaw suspensorium; General plan of girdles and limbs.
6. Nervous System: Comparative account of brain; Cranial nerves in mammals.

10

7. Sense Organs: Classification of receptors; Structure and function of mammalian eye and ear.
8. Urinogenital System: Succession of kidney; Evolution of urinogenital ducts; Types of uteri in mammals.

Recommended readings

1. Michael J. F. Barresi and Scott F. Gilbert. Developmental Biology, XIII Edition. Oxford University.
2. Kardong, K.V. (2005) Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition.
McGraw-Hill Higher Education.
3. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-
Hill Companies.

Discipline Centric Elective (DCE-T)

Research Methodology + Bioinstrumentation

Theory **Credit: 4, Full Marks: 50**

Group-A **Full Marks: 25**

Research Methodology

1. Foundations of Research: Meaning and Types: Deductive vs. inductive reasoning, exploratory, descriptive, and experimental research. Research Problem: Identifying research gaps, formulating objectives, and writing a research proposal.
2. Literature Review & Referencing Literature Search: Techniques for literature surveys, critical appraisal, and formulating theoretical/conceptual frameworks. Tools: Using reference managers like Zotero, Mendeley, or EndNote, and academic databases (e.g., Google Scholar, Scopus).
3. Research Design & Sampling Design: Experimental, cross-sectional, longitudinal, and case study designs. Variables & Hypotheses: Defining variables (independent, dependent), and formulating null/alternative hypotheses. Sampling: Probability (random, stratified) and non-probability (snowball, purposive) sampling methods.
4. Data Collection & Processing Primary and Secondary Data: Designing questionnaires, conducting interviews, and focus group discussions. Data Cleaning & Preparation: Processing, coding, and formatting raw data for analysis.
5. Data Analysis & Statistics: Concepts of qualitative and quantitative analysis. Concepts of precision and accuracy in experimental measurements, signal to noise ratio. Measures of central tendency and dispersal: probability distributions (Binomial, Poisson and normal). Sampling distribution: Difference between parametric and non-parametric statistics;

Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; X2 test; basic introduction to multivariate statistics, etc.

6. IPR, Biosafety and Bioethics: Intellectual property rights, types of IP, patent databases; biological safety measures, biosafety levels, regulatory guidelines, animal ethics, research ethics, publication ethics, plagiarism, use of AI in research and publication.

Group-B **Full Marks: 25**

Bioinstrumentation

1. Assay: Definition, criteria of reliability.
2. Principles and uses of analytical instruments: Spectrophotometer, Spectrofluorometer, Mass Spectrometry
3. Microscopy: Fluorescence and Confocal Microscopy, Electron Microscopy (SEM and TEM)
4. Chromatography: Principles, Column chromatography, TLC, GLC, HPLC, Ionexchange chromatography, Gel exclusion chromatography, Affinity chromatography
5. Electrophoresis: Basic principles, PAGE, Agarose gel electrophoresis, 2-D gel electrophoresis, Basic concept on Western, Southern and Northern Blotting
6. Centrifugation: Basic principles of Sedimentation, Differential and Density gradient centrifugation.
7. Crystallography and X-ray diffraction, Basic idea of NMR, circular dichroism, ESR
8. Flowcytometry
9. Electrophysiological methods: Single neuron recording, patch-clamp recording, ECG, Brain activity recording, lesion and stimulation of brain, pharmacological testing, PET, MRI, fMRI, CAT.

Recommended readings

1. Research Methodology: Methods and Techniques by C.R. Kothari
2. A Textbook of Research Methodology: Concepts, Tools and Applications" is co-authored by Dr. Sonu Agrawal, Dr. Jaikishan Sahu, and Mr. Ashish Tiwari.
3. Introduction to Biostatistics: P. K. Banerjee
4. Biostatistics: P. N. Arora & P. K. Malhan
5. Wilson and Walker: Principles and techniques of Biochemistry and Molecular Biology
6. Primrose. Molecular Biotechnology
7. Boyer: Modern experimental Biochemistry and Molecular Biology

Core-1-P

Biochemistry & Toxicology + Environmental Physiology

Practical **Credit: 1, Full Marks: 25**

1. Quantitation of DNA by UV-vis spectrophotometer
2. Preparation of Buffers.

2. Protein estimation by Folin Lowry method.
4. Total RBC and WBC counts.
5. DPPH radical scavenging assay.
6. Estimation of carbohydrate/ blood sugar level.

Core-2-P

Wild Life & Conservation Biology along with the perspective of IKS + Animal Behavior

Practical **Credit: 1, Full Marks: 25**

1. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community
2. Submit a report on the biodiversity study undertaken in your campus/locality/forest/river bed/sea shore (Marks: 10) + *Viva Voce* (Marks: 5).
3. Study of primary productivity of a pond using light and dark bottles
4. Physico-chemical analysis of pond water
5. Succession of bacterial population in milk
6. Population studies of Tribolium sp.
7. Learning experiment with white mouse in T-maze.
8. Ethnozoological Survey & Documentation: Field-based collection of indigenous knowledge related to animal use in medicine, agriculture, and ecosystem management.

Core-3-P

Advances in Developmental Biology + Comparative Anatomy in Vertebrates

Practical **Credit: 1, Full Marks: 25**

1. Preparation of chick embryo slides from different incubation hours of egg.
2. Developing organs of chick in histological sections.
3. Study of life cycle of Drosophila melanogaster.
4. Study of different types of feathers of birds.
5. Study of the disarticulated skeleton of pigeon and guineapig (Vertebral Column, Sternum, Girdles, Ribs, Limb bones).
6. Comparative analysis of the skulls of toad, pigeon and guineapig.

DCE-P

Research Methodology + Bioinstrumentation

Practical **Credit: 1, Full Marks: 25**

1. Learning different types of graphical representation of data in Excel (Bar, Line, Pie etc).
2. Learning the calculation of SD value and incorporating the same in Excel graph.
3. Calculation of P (T-Test) - value significance (using online software).
4. Basic understanding of ANOVA for analysis of Variance (using online software).
5. Principle and handling of any one instrument frequently used in biological science research.

SEMESTER 2

Core-4-T

Parasitology + Immunology, Microbiology and Viral pathology

Theory **Credit: 4, Full Marks: 50**

Group-A **Full Marks: 25**

Parasitology

1. Classification, Geographical distribution, Morphology, Life-cycle, Transmission, Pathogenicity, Treatment and Prophylaxis of: a. Protozoan parasites: Entamoeba spp, Trypanosoma spp., Leishmania spp. (any one) b. Intestinal flagellates Giardia spp. c. Cestodes: Taenia spp.
2. Clinical and veterinary parasitology - detection, diagnosis, prophylaxis, treatment, and pharmacology (emergent parasites). 3. Host parasite interaction- immunological nuances in vertebrates and invertebrates and epidemiological surveillance tools. Manipulation of host behaviour, parasitism & altruism, parasites & social behaviour of hosts.
4. Immune evasion strategies of parasitic protozoa and helminthes.
5. Epidemiology of parasitic diseases-general epidemiology, methods of epidemiological study, epidemiology of Malaria, Leishmaniasis, and Amoebiasis.
6. Community medicine.
7. Vector biology with special reference to Malaria and Kala-azar. 8. Genome organization in Plasmodium sp., molecular basis of antigenic variation in Plasmodium sp.

Group-B **Full Marks: 25**

Immunology, Microbiology and Viral pathology

1. Innate Immunity: Overview, Features, Epithelial Barrier, Neutrophil and Macrophage Function, Defense mechanism to Infection (Migration, Inflammation and Phagocytosis), Function of NK cell, Cross-talk with Adaptive Immune system

2. Antigens Capture and Presentation: Concept of APC. Structure and Function of MHC molecule. MHC processing and presentation.
3. Antigen Recognition: B cell and T cell receptor complex. Formation and selection of diversity receptors. VDJ recombination
4. Cell Mediated Immunity: APC- T cell interaction. IL-2 Receptor Role. Clonal Expansion. Th1, Th2 and Th17 response. Cytotoxic T cell function. T cell signaling
5. Humoral Immunity: Neutralization and Opsonization. Functional aspect of B- cell. Class switching. B cell signaling; Thymic hormones and cell immunity
6. Disease immunobiology – role players and systems network, Immunotherapeutics
7. General features of microorganisms; classification of bacteria and virus (Baltimore classifation) & staining techniques. Bacterial cultures, sterilization, media.
8. Environmental and Industrial use of microrganisms, microbial spoilage.
9. Pathogenesis: Sites of viral entry (Respiratory, Alimentary and Urogenital tract), Genetic determinants of Virulence, Cytopathic effect
10. Antiviral drugs: Mode of Action (Amantidine, Nevirapine, Acyclovir, Azidothymidine, Remdesivir, Indinavir), Repurposing of drugs for antiviral treatment (e.g. SARS CoV-2) 3.
11. Bacterial pathogenesis: Virulence & Attenuation, Exotoxins (Cytotoxins, Diphtheria Toxin. Tetanus Toxin, Cholera Toxin), Endotoxins (LPS), Pathogenicity Islands, Quorum Sensing
12. Antibacterial drugs: Targets of antimicrobial agents, Mode of action (Sulfonamides, Quinolones, Penicillins, Cephalosporins, Tetracyclines, Rifampin), Antimicrobial Drug Resistance (Mechanism and Transmission of Resistance)
13. Antimicrobial Drug susceptibility testing: Minimum Inhibitory Concentration (MIC), Antibiotic Sensitivity Testing

Recommended readings

1. 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.
2. Kuby Immunology.
3. Paul's Fundamental Immunology.
4. Basic immunology Functions and Disorders f immune System. Abul K Abbas, Andrew H. Litchman, Shiv Pillai.
4. Pelczar Microbiology.
5. Davies Microbiology.
6. Prescott's Microbiology.

Core-5-T

Genetics + Biotechnology

Theory **Credit: 4, Full Marks: 50**

Group-A **Full Marks: 25**

Genetics

1. Chromosome, allele & Inheritence: Mendelian principles and its extensions, epistasis, penetrance and expressivity and genetic material effect. Lampbrush and polytene chromosome. Pedigree analysis. Extra chromosomal Inheritance.

15

2. Quntitative Genetics. Concept of quantitative traits (Examples – Kernel colour in wheat, Ear length in
Corn); Polygenic inheritance; Heritability – Concept and types (Broad sense heritability and Narrow
sense heritability.
3. Microbial genetics: Transformation, Conjugation, Sexduction, Transduction and mapping of genes.
4. Repair Systems: DNA damage and repair mechanism
5. Recombination: Concept of homologous recombination, Site specific recombination, FLR-FRT system,
Cre-lox system.
6. Gene Regulation: Lac Operon, Trp Operon, Lytic and Lysogeny in Bacteriophage, Methylation and
Eukaryotic gene regulation.

Group-B **Full Marks: 25**

Biotechnology

1. Aims and Scope of Biotechnology.
2. Recombinant DNA technology: Restriction Endonucleases, Vectors, Cloning strategies, selection of
recombinant DNA, DNA sequencing, PCR, Next generation sequencing, Shotgun sequencing of whole
genome, cDNA libraries: construction and screening. Plasmid mapping, Transposons.
3. Expression vectors and expression of fusion proteins
4. Transgenic Animals: production, prospects, advantages and disadvantages
5. Site directed mutagenesis: strategies and prospects
6. Applications of recombinant DNA technology in human gene therapy. vaccine development,
environmental bioremediation and protein engineering

Recommended Readings

1. Griffiths, A.J.F., Doebley, J., Peichel, C. and Wassarman, D.A. (2020). Introduction to Genetic
Analysis. 12th Edition. W.H. Freeman.
2. Russell, P.J. (2009). iGenetics: A Molecular Approach. 3rd Edition. Pearson (Benjamin Cummings)
3. Klug, W.S., Cummins, M.R., Spencer, C. and Palladino, M.A. (2020). Concepts of Genetics. 12th Edition. Pearsons Publication.
4. Pierce, B.A. (2020). Genetics: A Conceptual Approach. 7th Edition. McMillan Learning
5. Tamarin, R.H. (2008). Principles of Genetics. 7th Edition. McGraw-Hill.
6. Strickberger, M.W. (2012). Genetics. 3rd Edition. Pearson Prentice Hall India

7. Snustad, D.P. and Simmons, M.J. (2015). Principles of Genetics. 7th Edition. John Wiley and Sons, Inc
8. Singh, B.D. (2015). Biotechnology: Expanding Horizons. 4th Edition. Kalyani Publishers. New Delhi.
9. Primrose, S.B. and Twyman, R.M. (2007). Principles of Gene Manipulation and Genomics. 8th Edition. Blackwell Publishing
10. Weaver, R.F. (2012). Molecular Biology. 5th Edition. McGraw-Hill, New York
11. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Edition. ASM Press: Washington, DC
12. Brown, T.A. (2010). Gene Cloning and DNA Analysis: An Introduction. 6th Edition. WileyBlackwell, Chichester.

Core-6-T

Cell Biology + Neurobiology

Theory **Credit:4, Full Marks: 50**

Group-A **Full Marks: 25**

Cell Biology

1. Biomembrane Structure: Lipid composition and structural organization, Membrane proteins, Membrane
Fluidity.
2. Transmembrane Transport: Carrier proteins and active membrane transport (uniport, symport and antiport).
membrane pumps, gated ion channels, Nernst equation.

3. Biomolecule Trafficking: Role of ribosome, endoplasmic reticulum (ER), Golgi bodies, mitochondria and
molecular chaperons in trafficking, co-translational and post-translational protein translocation in ER,
importance of COP-I, COP-II, Clathrin in protein trafficking, mechanism of vesicle formation and fusion.

4. Cell signaling and cell-cell interaction: Cell surface and intracellular receptors, signaling pathways and cross
talk mechanisms, general principles of cell communication, cell adhesion and roles of different adhesion
molecules, gap junctions, extracellular matrix, integrins, cytoskeleton.
5. Cell cycle and its regulation.
7. Cell death mechanisms: Apoptosis, necrosis, anoikis, autophagy.
8. Cancer: Idea about genetic rearrangements in cells due to carcinogenic insult, oncogenes, tumor suppressor genes, cancer associated alteration of cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, basic idea about cancer stem cell, therapeutic interventions of uncontrolled cell growth.
9. Basic idea about cell culture: Types of cell culture, the requirements for cell culture.

17

general precautions to be followed for successful cell culture experiments.

Group-B **Full Marks: 25**

Neurobiology

1. Organization of Nervous System: Origin and Differentiation of Neurons.
2. Electrical potentials Neurilemma and their molecular basis.
3. Propagation of Nerve impulse along Neuritis and their molecular basis.
4. Synapse: Synaptic transmission and Neuromodulation.
5. Integration of synaptic functions: Synaptic plasticity.
6. Neurotransmitters: Classification, synthesis, release and functions, inactivation of Neurotransmitters.
7. Brain motor mechanism: Sensory motor integration.
8. Nature of Somatic motor actions in reference to muscles.
9. Organization and functions of autonomic nervous system: Hypothalamus
10. Neuro-endocrine integration: Components, orders and feedback regulation.
11. Neural basis of learning and memory.

Recommended readings

1. Cooper: Cell- a Molecular Approach
2. Lodish et al: Molecular Cell Biology
3 Alberts et al: Molecular Biology of cell
4. Karp: Cell and Molecular Biology
5. Principles of Neural Science (Kandel, Schwartz, Jessell)
6. Neurobiology (Robinson, D. Editor)
7. Textbook of Neurobiology (Sharma, D., Singh, S. and Singh, R.)

General Elective (GE-T)

Biosystematics + Bioinformatics

Theory **Credit: 4, Full Marks: 50**

Group-A **Full Marks: 25**

Biosystematics

1. Basic concept of Biosystematics: Definition of Biosystematics, Zoological nomenclature, History and theories of biological classification and uses, Different types of taxonomic characters, Taxonomic procedure, collection, preservation, and Identification.

2. Newer trends in biosystematics: Morphological, Embryological, Behavioral, Cytological, Molecular basis of biosystematics, Hierarchy of Categories, Types of taxonomic keys along with their merits and demerits

3. Speciation: Dimension of Speciation, Mechanism of speciation in Panmictic and Apomictic species, Species concept-Sub, eco, ceno, and super species, Different type of

18

species categories-Biological, Evolutionary, Typological, Nomenalistic, and Polytyping.

4. Approaches in classification- Cladistics, Phenetics, DNA Barcoding

5. Trends in Phylogenetic reconstruction - Tools used in building a phylogenetic tree: their advantage and drawbacks, Distance and character based methods in phylogenetic reconstruction

Group-B **Full Marks: 25**
Bioinformatics

1. Introduction and scope of Bioinformatics
2. Major Biological databases and Information retrieval
3. Homology concept and alignment of pairs of sequence, Global and Logical Alignment
4. Basic local alignment search tool (BLAST), Other Blast options, PSI-BLAST
5. Application of BLAST tool
6. Multiple sequence alignment and its application
7. Introduction to Computational Gene Production and Genome annotation
8. Molecular Modelling and Dynamics: 3-D structure visualization and simulation, Basic concepts in molecular modeling, Molecular Mechanics, Force fields etc.
9. Basic concept of the application of Bioinformatics in drug designing.
10. Basic concepts in Computational Phylogenetic Analysis
11. Genomics, Transcriptomics, Proteomics and Metabolomics: Structure and organization of prokaryotic and eukaryotic genomes, Comparative genomics, Global gene expression analysis, Comparative transcriptomics, Differential gene expression; protein interaction analysis and mapping, targeted and untargeted metabolic profiling, DNA finger printing and its applications, DNA bar coding, Single-cell sequencing, single-cell omics.

Recommended readings

1. Biosystematics and Taxonomy, Ramesh Chandra Tripathi, University Book House, 2005
2 Textbook of Biosystematics theory and Practicals by T Pullaiah (Author)3. Barnes & Gray (ed): Bioinformatics for geneticists, Wiley (2003)
4. Lesk: Bioinformatics, Oxford (2003, Indian ed)
5. Campbell A. M. and Heyer, L. J. 2007. Discovering Genomics, Proteomics and Bioinformatics,2nd Edition. Benjamin Cummings.
6. Mount W. 2004. Bioinformatics and sequence genome analysis 2nd Editon CBS Pub

Core-4-P

19

Parasitology + Immunology, Microbiology and microbial pathology

Practical Credit: 1, Full Marks: 25

1. Staining of blood films for parasitic protozoa / microfilaria and gut content of arthropoda / amphibian, with proper illustrations.
2. 2. Whole mount preparation of trematode and arthropod parasites.
3. 3. Staining of scolex and proglottids of cestodes.
4. Collection, preservation, staining, mounting and identification of ectoparasites or endoparasites of wild rat / cattle / dog / chick / human.
5. Collection of Plasma and Serum
6. Preparation of single cell suspension from spleen of mice/rat and cell counting
7. Trypan blue dye exclusion test
8. Gram staining

Core-5-P

Genetics + Biotechnology

Practical **Credit: 1, Full Marks: 25**

1. Study of common mutants in Drosophila spp.
2. Linkage map construction using three-point crosses.
3. Pedigree analysis of common human dominant/recessive traits
4. Detection of ABO blood groups.
5. Bacterial culture: Agar plate, liquid broth
6. Genomic DNA/Plasmid isolation (Demonstration).
7. PCR demonstration.
8. Electrophoretic separation of DNA.

20

Core-6-P

Cell Biology + Neurobiology

Practical (Seminar) **Credit: 1, Full Marks: 25**

1. PPT Presentation 15marks
2. Manuscript submission 10 marks

GE-P

Biosystematics + Bioinformatics

Practical **Credit: 1, Full Marks: 25**

1. Retrieval of nucleotide and protein sequences from the databases.
2. Performing pair-wise alignment of sequences (BLAST) and its interpretation.
3. Multiple sequence Alignment using ClustalW.
4. Construction of phylogenetic tree (using software like MEGA or PHYLIP etc).
5. Prediction of 3D structure of protein using AlphaFold.
6. Visualisation of protein structure using RasMol: Basic analysis.
7. Taxonomic key preparation.
8. Preparation of models showing the status of certain taxa or species in a particular habitat.

Note: For General elective, students can opt for SWAYAM/ MOOCS course/ courses in accordance with the Department total credit being 5

SEMESTER 3 & SEMESTER 4

Option-1: Course Work Paper/ Research Paper in both the semesters + Research review/ dissertation in both the semesters

SEMESTER 3

Course Work Paper-1A-T

Advances in Parasitology

Theory **Credit: 4, Full Marks: 25**

1. Parasites and parasitism: General consideration. Type of parasites. Type of hosts. Symbiosis and

Commensalisms

2. Molecular interaction between host and parasite and evasion of immunity
3. Protozoan parasites, Distribution, habit and habitat, structure, life cycle and diseases caused by

Entamoeba histolytica, Leishmania donovani

4. Epidemiology of diseases of public health importance and disease control
5. Epidemiological aspects of diseases of national importance: Malaria, Filariasis, Leishmaniasis
6. Infectious disease Epidemiology.
7. Biological Sequence Analysis in Parasitology: Analysis of DNA and Protein sequence, Sequence alignment, Fragment assembly, Genome sequence assembly, Neural network concepts and secondary structure prediction, Probabilistic models, Evolutionary analysis.

Recommended Reading:

1. 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.
2. Medical Parasitology. W.B. Saunders, Philadelphia. Prescott M.C, J.P.Hardley and D.A. Clean.2001.
3. Pathophysiological Responses to Parasites. British Society for parasitology, London.
4. Chandrashekhar J Hiware, Babasaheb V Jadhav, Ashok D Mohekar, 2002. Applied Parasitology, A Practical Manual.
5. Panicker, CKJ.1998.Text book of Medical Parasitology, Jaypee, New Delhi.

Course Work Paper-1A-P

Advances in Parasitology

Practical **Credit:1, Full Marks: 25**

1. Smear preparation for protozoa
2. Preparation of whole mounts for helminthes
3. Collection of parasites: Protozoans/ Nematodes/ Helminthes/ Insects.
4. Examination of different living animal hosts (domestic and wild) for collection, preservation, mounting and identification of protozoan parasites and arthropod vectors. Preparation and study of protozoan culture. Study of permanent slides of protozoan parasites and arthropod vectors: Microscopical examination of blood smears for protozoan parasites and isolation and identification of protozoan cysts and eggs of Helminth parasites from feacal samples. Use of Ocular micrometer and Stage micrometer for measurement.
5. Examination of living animal hosts (definitive and intermediate: earthworm, cockroach, bony fish, toad, wall lizard, garden lizard, pigeon, fowl, rat etc.) for collection, preservation, and identification of different helminth parasites. Identification of helminth parasites of man. Studies of different sections

(transverse, longitudinal, sagittal) of parasites by using microtomy method and Histopathological studies of different types of infected tissues of the host. Preparation of Helminth Culture. Extraction and slide preparation of nematodes from different habitats including the isolation of the entomopathogenic nematodes and sampling and estimation of population of nematodes from soil and plant tissues. Microphotography of parasites. Identification of photos of different stages of parasites and diseases.

6. Preservation and Identification of parasites: Protozoans, Nematodes, Helminthes, Insects.

Course Work Paper-1B-T

Advances in Ecology

Theory **Credit: 4, Full Marks: 25**

1. **Concept of habitat and niche:** Distinction between habitat and niche, Fundamental & realized niche,

Hypervolume, Niche metrics (niche width and niche overlap), Niche dynamics (niche shifting, compression, and

expansion), Ecological equivalents, Resource partitioning (African savanna ungulate grazing succession) and

character displacement (Galapagos Darwin's finches).

2. Species Interactions: Intra- and inter-specific interactions; Lotka-Volterra Model of competition and predator-

prey relations; Scramble and contest competition models.

3. Metapopulation: Definition, Characteristics, Levins's model of metapopulation dynamics. Concept of Source-

Sink dynamics and rescue effect.

4. Ecosystem development: Basic Terminology- Nudation, invasion, ecesis, aggregation, competition, reaction.

and stabilization; Types of Succession- Primary vs. Secondary, Autogenic vs. Allogenic, Autotrophic vs.

Heterotrophic; The Climax Concept, Theories of Climax; Hydrosere and Xerosere.

5. Aquatic ecology: Thermal stratification (epilimnion, metalimnion thermocline, hypolimnion), Light penetration

and photic zonation (photic/euphotic zone, aphotic zone, compensation depth), Freshwater lentic and lotic

ecosystems, Marine and estuarine zonation (neritic, oceanic, benthic, intertidal, pelagic), Ecological adaptations

of plankton, nekton, benthos, and neuston.

6. Terrestrial and forest ecology: Vertical forest stratification (emergent, canopy, understory, floor), Vertical niche

partitioning.

Recommended Reading:

1. Ecology Fourth Edition by Robert E. Ricklefs and Gary L. Miller, Textbook This Sacred Earth).
2. Smith, TM and Smith RL 2015. Elements of Ecology, Pearson Education, India.
3. Cain, ML, Bowman, WD and Hacker SD 2011. Ecology, 2nd Edition, Sinauer Associates Inc.
4. Odum, E. P. (2004). Fundamentals of Ecology, Oxford and IBH Publishing Co. Pvt. Ltd.
5. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.
6. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs
7. Alcock J. 2013. Animal Behaviour, Sinauer Associate Inc., USA.
8. Drickamer LC , Vessey SH . 2001. Animal Behaviour. McGraw-Hill
9. Dugatkin LA. 2014. Principles of Animal Behaviour. 3rd Edn. W.W. Norton and Co.
10. The Cambridge Handbook of Evolutionary Perspectives on Human Behavior edited by Lance Workman, Will Reader, and Jerome H. Barkow.
11. Behavioral Genetics by Robert Plomin, John C. DeFries, Valerie S. Knopik, and Jenae M. Neiderhiser.

Course Work Paper-1B-P

Advances in Ecology

Practical **Credit:1, Full Marks: 25**

1. Estimation of pH, Alkalinity & Hardness from water sample.
2. Study of primary productivity of aquatic ecosystem.
3. Collection, Staining, quantification (Sedgwick-Rafter counting cell) and identification of zooplanktons.
4. Calculation of various diversity indices from community study/ supplied data: Shannon-Wiener Diversity Index (H'), Simpson's Dominance Index (D), Simpson index of Diversity (1 -D), Simpson Reciprocal Index (1/D), Pielou's Species Evenness (J'), Sorensen similarity coefficients.
5. Preparation of field report for any community study.

Course Work Paper-2A-T

Molecular Cell Biology

Theory **Credit:4, Full Marks: 25**

1. Unit I. Cellular Homeostasis and Stress Responses:

Cellular homeostasis and quality control, Oxidative stress and redox biology, Mitochondrial oxidative stress, Endoplasmic reticulum stress, Unfolded Protein Response (UPR), Proteostasis and ubiquitin-proteasome system, Autophagy, lysosomal degradation, Mitochondrial dynamics (fusion fission), Mitophagy and mitochondrial quality control, Cellular senescence and bioenergetic crisis, Different types of Apoptosis: Pyroptosis, Ferroptosis and cuproptosis, Organelle communication (ER–mitochondria contact sites).

2. Unit II. Cell Signaling and Intercellular Communication
Principles of signal transduction, Calcium signaling, Gasotransmitters (NO, CO, H_2S), Reactive oxygen species as signaling molecules, DAMPs and PAMPs, Mitochondrial DAMPs, Extracellular vesicles and exosomes, Cytokines and chemokines, Cell-cell and cell-matrix communication, Mechanotransduction, Liquid-liquid phase separation in signaling.

3. Unit III. Stem Cell Biology and Regenerative Medicine:
Stem cell potency and hierarchy, Self-renewal and differentiation, Stem cell niche, Dedifferentiation and transdifferentiation, Stem cell isolation and characterization, Organoids and spheroids, Induced pluripotent stem cells (iPSCs), Stem cells in regenerative medicine, Tissue engineering, Clinical applications of stem cells.

4. Unit IV. Molecular Cell Biology Techniques:
Cell culture, Flow cytometry, Mitochondrial membrane potential, Luciferase reporter assay. EMSA, Co-immunoprecipitation, Chromatin Immunoprecipitation (ChIP), Western blotting, RNA interference /CRISPR/Cas genome editing, Single-cell RNA sequencing, Multi-omics approaches.

Recommended Reading:

1. Molecular Cell Biology by Harvey Lodish
2. Existing research papers/review articles published in peer reviewed journals relevant to each topic.
3. The Biology of Cancer by Robert A Weinberg. 2nd Edition. Garland Science (Publisher).
4. Cancer Biology, Carsten Carlberg & Eunike Velleuer. 2nd edition. Springer Cham (Publisher)

Course Work Paper-2A-P

Molecular Cell Biology

Practical **Credit:1, Full Marks: 25**

1. Nucleic acid isolation
2. Western blotting
3. PCR/qPCR demonstration and Primer designing
4. ROS assay.

Course Work Paper-2B-T

Insect Physiology and Industrial Entomology

Theory **Credit:4, Full Marks: 25**

1. Insect hormones: Sources, biosynthesis, transport, mode of action and regulation of their titers
2. Haemolymph, haemocytes and Insect Immunity
3. Intra-specific and inter-specific chemical and mechanical communications in insects
4. Insect flight mechanism and migration
5. Genetics of mulberry silk moth in reference to voltinism, moultinism and economic characters. Breeding strategies in Mulberry silkworms and management of its diseases and enemies.
6. Influence of environment on insect development and life cycle traits: The Degree-

25

Day concept.
7. Mechanisms of change in insecticide susceptibility and resistance management techniques
8. Honey bee: Role in pollination and production of honey, propolis and bee-wax; extraction and
preservation of honey
9. Termites: Eusocial organization, role as builders, reducers and depredators.
10. Insect based drugs, dyes, food and aesthetics.

Recommended Reading:

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

Course Work Paper-2B-P

Insect Physiology and Industrial Entomology

Practical **Credit:1, Full Marks: 25**

1. Studies in internal morphology of *Apis* (digestive and nervous systems), *Musca* (male and female reproductive systems), Grasshopper (nervous and reproductive system)
2. Mounting: wings mouth parts, antennae of insect pests (any three), genitalia of cockroach, bug, house fly mosquito
3. a) Insect collection: Active collection and passive collection
   b) Insect preservation and curation: Dry preservation, fixing and wet preservation
   c) Insect identification: Identification keys
4. Preparation of key
   a) Order level

b) Family levels for major orders
c) Collection and preparation of family level key of pests of major crops of North Bengal i.e. rice , jute, tea, vegetables
d) Identification of stored grain pests

Course Work Paper-3A-T

Stem Cell Biology

Theory **Credit:4, Full Marks: 25**

1. Functional characteristics of stem cells: "Stemness" of stem cells – Definition, self-renewal and differentiation; Potency and clonality of stem cells; Explaining De-differentiation and Trans-differentiation of stem cells; Signaling cascades for the regulation of Stemness.
2. Types of stem cells –
   - Embryonic stem (ES) cells – location, morphology, properties, markers of ES cells; embryoid bodies; clinical potentials of ES cells and utilization in therapy; research on ES cells and controversies; ES like cells in different species.
   - Hematopoietic stem cells (HSCs) – Properties, markers, ontogeny of HSCs; Proliferation and differentiation of HSCs; hematopoiesis supportive growth factors; different hematopoietic colony forming units (CFUs); transplantational use of HSCs.
   - Peripheral blood stem cells and endothelial cells – Types of stem cells in peripheral blood; Therapeutic potential of peripheral blood stem cells and endothelial cells (focusing along with their expression markers)
   - Mesenchymal stem cells (MSCs) – Morphology, location, markers, properties of MSCs; Multiliniage differentiation potentials of MSCs; MSC as trophic mediators; clinical applications of MSC in cell therapy.
   - Neural stem cells (NSCs) – NSCs and neurogenesis.
   - Induced pluripotent stem cells (iPSCs) – Development of iPSCs and re-programming factors; therapeutic importance of iPSCs.
3. Stem cell niche – Stem cell niche hypothesis, components of stem cell niche, role of stem cell niche, germ line stem cell niche, adult stem cell niches in mammals, signaling in stem cell niche, dysregulation of stem cell niches, *Ex-vivo* generation of stem cell niches.
4. Isolation and culture of stem cells – Dye efflux method of stem cell isolation, magnetic and flowcytometric method of isolation of stem cells, density gradient centrifugation in stem cell isolation.

basic idea of cell culture, culture of ESC, MSC, HSC, CFU culture from bone marrow derived cells.

5. Concept of cancer stem cell (CSC) and CSC niche – Defining stemness in cancer, theories of origin of

CSCs, difference between CSCs and normal stem cells, markers of CSCs in different types of

malignancy, functional properties of CSCs, different components of CSC niche, CSC and CSC niche

targeted anti-cancer therapeutic strategies.

Recommended readings

1. Essentials of Stem Cell Biology; Edited by: Robert Lanza and Anthony Atala
2. Cancer Stem Cells and Cancer Therapy (Rasime Kalkan, 2024/2025)
3. Principles of Regenerative Medicine, Edited by: Anthony Atala, Robert Lanza, ... Robert Nerem
4. Regenerative Medicine Using Non-Fetal Sources of Stem Cells, Edited by: Niranjan Bhattacharya, Phillip George Stubblefield.

Course Work Paper-3A-P

Stem Cell Biology

Practical **Credit:1, Full Marks: 25**

1. Isolation of hematopoietic cells from mouse bone marrow, single cell preparation and determination of cellularity
2. Demonstration of marker based isolation of hematopoietic stem cells from flowcytometric data.
3. Determination of hematopoietic cell viability from murine marrow
4. Determination of lysosomal and mitochondrial health of murine bone marrow derived hematopoietic cells.
5. Photographic identification of different hematopoietic progenitor colony from the culture of murine marrow cells.
6. Determination of cellularity of extra-medullary hematopoietic organ (spleen, liver) of mouse.
7. Histological study of murine bone marrow, extra-medullary hematopoietic organs (spleen and liver)
8. Demonstration of immunohistochemistry for the marker based identification of cancer stem cells in oral squamous cell carcinoma

sample.

Course Work Paper-3B-T

Molecular Cytology

Theory **Credit: 4, Full Marks: 25**

1. Cell and Tissue Culture

Culture media: composition, preparation and properties, Primary cell culture, secondary culture and continuous cell lines, Fibroblast and lymphocyte culture, Cell separation techniques (FACS).

2. Mitochondrial Biology

Mitochondrial genome organization, Replication, Mitochondrial dynamics and diseases.

4. Prion Biology

Structure of PrP, Prion replication, Transmissible spongiform encephalopathies (TSE), Molecular mechanism of prion diseases.

5. Stem Cell Biology

Embryonic and adult stem cells, Induced pluripotent stem cells (iPSCs), Stem cell niche, Asymmetric cell division, Applications in regenerative medicine.

6. Biology of Ageing

Hallmarks of ageing, Telomeres and telomerase, Oxidative stress, Cellular senescence, Genetic regulation of ageing.

7. Advanced Patterns of Inheritance

Complex traits, Multiple alleles, Genomic imprinting, Uniparental disomy, Anticipation, Polygenic inheritance, Epigenetic inheritance.

8. Functional Genomics and Genome Editing

Random mutagenesis, Site-directed mutagenesis, Gene knockout and knock-in, RNA interference (RNAi), Ethical concerns of genome editing.

Recommended Reading:

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

29

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.

Course Work Paper-3B-T

Molecular Cytology

Practical **Credit:1, Full Marks: 25**

1. *Drosophila* food preparation, handling of flies and setting up of crosses
2. Study of Drosophila mutant phenotypes.
3. Three-point test cross from gene mapping in *Drosophila*.
4. Construction of Karyotype of Human/Rat.
5. Mammalian cell culture (demonstration).
6. Cell viability assay (Trypan Blue).

Research Paper

Credit:5, Full Marks: 100

Research Based Literature Review

SEMESTER 4

Research Paper-1A-T

Epidemiology study with Artificial Intelligence Application

Theory **Credit:4, Full Marks: 25**

1. Helminth parasites, General characters, organization and larval forms of Platyhelminthes and Nemathelminthes.
2. Distribution. habit and habitat. structure. life cycle and diseases caused by

Plasmodium falciparum
Leishmania donovani
Trypanosoma brucei/cruzi
Fascioloa hepatica
Echinococcus granulosus
Schistosoma haematobium

36

Wuchereria bancrofti

3. Epidemiology of diseases of public health importance and disease control

a) Chronic disease Epidemiology
b) Epidemiological aspects of diseases - Non-Communicable
c) Emerging and Re- Emerging diseases.
d) National Programmes related to Communicable and Non Communicable diseases
e) Dengue, Swine Flu, Chikungunya

4. Artificial Intelligence and Modelling of Biological Systems: Concepts and principles of modelling:

Limitations of models, Models of behaviour, Modelling in Epidemiology and Public Health SIR models,

Introduction to Artificial Intelligence –basics like non monotonic logic Planning Perception Learning

Neural Networks Natural language processing Expert system.

5. Village Placement Programme Cooch Behar is a district of North Bengal where a majority of people lives below the poverty line. The rural mass is economically and educationally backward. Thus the aim of introduction of this village placement programme is to extend out to reach environmental awareness, hygiene and health to the rural people of this region on various aspects related to parasitic diseases. The students in their fourth semester have to visit any one of the village within the jurisdiction of CBPBU University and can arrange various programs to educate the rural mass in the following areas for three days.

f) Environmental awareness.
g) Hygiene and health

6. Bioethics and Medical ethics: Historical perspectives & Introduction to Bioethics. Ethics of clinical trials: Drug trials, vaccine trials.

7. Regulatory framework and guidelines for conduction of human research: Review processes, Institutional ethical committees, composition of committees, review procedures, WHO, UNESCO and ICMR guidelines.

Recommended Reading:

1. 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.
2. Medical Parasitology. W.B. Saunders. Philadelphia. Prescott M.C. J.P.Hardley and D.A. Clean.2001.
3. Pathophysiological Responses to Parasites. British Society for parasitology. London.

4. Chandrashekhar J Hiware, Babasaheb V Jadhav, Ashok D Mohekar, 2002. Applied Parasitology, A Practical Manual.
5. Panicker, CKJ.1998.Text book of Medical Parasitology, Jaypee, New Delhi.

Research Paper-1A-P

Epidemiology study with Artificial Intelligence Application

Practical **Credit: 1, Full Marks: 25**

1. Life cycle studies of parasites: Protozoans, Nematodes, Helminths
2. Fluorescence/ Immunofluorescence microscope studies on parasite tissues
3. Cryosectioning / Preservation/mounting of parasite tissues
4. Estimation of RNA in tissue (Colorimetric method)
5. Feulgen reaction method for DNA localization
6. Localization of RNA by methyl green pyronin –'Y'
7. Polymerase chain reaction (Demonstration)
8. RFLP Analysis (Demonstration)
9. Biological Sequence analysis- Analysis of DNA and protein sequence
10. Modeling in Epidemiology and Public Health SIR models
11. AI applications in epidemiology-Any two
12. Institute/ field visit (Optional)- Marks to be added for CE in case it is carried out.

Research Paper-1B-T

Advanced Ethology

Theory **Credit: 4, Full Marks: 25**

1. **Survival value of Behaviour:** Experimental studies, Darwinian inclusive fitness.
2. **Altruism:** Kin-selection. Inclusive fitness, Hamilton's rule, reciprocal altruism. parental care (in amphibians); Cooperation - Reproductive Cooperation in Rodriques Fruit-Bat, Foraging Cooperation in Harris's Hawk, Byproduct mutualism
3. **Role of environment in development of behaviour:** Interactive theory, early experience and behavioural development, Developmental flexibility – kin discrimination
4. **Mating & Sexual Behaviour:** Monogamy, polyandry without polygyny, polygyny. Sexual dimorphism, mate choice; Intra-sexual selection (male rivalry); Inter- sexual selection (female choice); Courtship behaviour in 3-spine stickleback; Infanticide behaviour.
5. **Biological rhythms:** Periodicity in the environment and in the organisms, Circadian rhythm-Selective advantage, Free-running activity, Zeitgeber, Entrainment. Temperature compensation; Genetic control.
6. **Migratory behavior and animal orientation:** Types of movement: Orientation-Primary and secondary orientation; Kinesis - orthokinesis, klinokinesis; Taxis-tropotaxis and klinotaxis, menotaxis (light compass orientation). Physiological triggers of migration (photoperiod, zugunruhe, hormonal control). Navigational mechanisms (sun, star, geomagnetic, and olfactory compasses). Avian migration routes and

orientation, Fish migration: Anadromous vs. Catadromous, Brief ideas of: Monarch butterfly (*Danaus plexippus*) multi-generational migration, Sea turtle hatchling wave-and-geomagnetic orientation.

Recommended Reading:

1. Alcock J. 2013. Animal Behaviour, Sinauer Associate Inc., USA.
2. Drickamer LC , Vessey SH . 2001. Animal Behaviour. McGraw-Hill
3. Dugatkin LA. 2014. Principles of Animal Behaviour. 3rd Edn. W.W. Norton and Co.
4. The Cambridge Handbook of Evolutionary Perspectives on Human Behavior edited by Lance Workman, Will Reader, and Jerome H. Barkow.
5. Behavioral Genetics by Robert Plomin, John C. DeFries, Valerie S. Knopik, and Jenae M. Neiderhiser.

Research Paper-1B-P

Advances in Ethology

Practical **Credit:1, Full Marks: 25**

1. Study of nesting behaviour in birds. Identification of different types of nests from field visit/photographs.
2. To study different types of animal behaviour such as habituation, imprinting, courtship behaviour in insects/birds, and parental care from short videos.
3. To study the phototaxis behaviour in insect larvae
4. Construction of an ethogram using suitable data to study animal behaviour.
5. T-Maze study on rat/mice (using live specimen/videograph)
6. Field visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park (or similar places) to study and record the behavioral activities of animals and prepare a short report.

Research Paper-2A-T

Advances in Oncology

Theory **Credit:5, Full Marks: 25**

1. Unit I. Cancer Biology and Tumor Evolution

Hallmarks of cancer, Multistep carcinogenesis. Oncogenes and tumor suppressor genes. Driver vs passenger mutations. Somatic vs germline mutations. Clonal evolution. Cancer stem cells. Tumor heterogeneity. Primary vs metastatic tumors. Precision oncology. Cancer genome atlas. Molecular classification of cancers.

2. Unit II. Oncogenic Signaling and Tumor Metabolism

PI3K/AKT/mTOR signaling, MAPK pathway, Wnt/β-catenin pathway, TGF-β signaling, Hippo pathway, Notch signaling, p53 pathway, Cell cycle checkpoints, DNA damage response, Tumor metabolism,Warburg effect, Oxidative phosphorylation, Metabolic plasticity, Hypoxia and HIF signaling, EMT and EndoMT, Metabolomics, Oncometabolites, Mitochondrial signaling in cancer.

3. Unit III. Tumor Microenvironment and Cancer Immunology

Tumor microenvironment, Cancer-associated fibroblasts (CAFs), Tumor-associated macrophages (TAMs), Immune evasion, Immune checkpoints, Angiogenesis, Lymphangiogenesis, Metastatic niche, Immunometabolism, Extracellular vesicles in cancer, Microbiome and cancer.

4. **Unit IV. Cancer Therapeutics and Precision Medicine**

Chemotherapy, Radiotherapy, Hormonal therapy Targeted therapy, Tyrosine kinase inhibitors, Monoclonal antibodies, Anti-angiogenic therapy, Immunotherapy, Immune checkpoint blockade, CAR-T cell therapy, Cancer vaccines, Oncolytic viruses, Drug resistance, Mechanisms of resistance, Chemosensitization, Synthetic lethality, Precision oncology, Biomarkers, Companion diagnostics, Liquid biopsy, Circulating tumor DNA, Personalized medicine ***Representative drugs:*** Cisplatin, Doxorubicin, Etoposide, 5-Fluorouracil, Paclitaxel, Vincristine, Vinblastine, Tamoxifen, Targeted therapeutics and antibody-drug conjugates.

Recommended Reading:

5. Molecular Cell Biology by Harvey Lodish.
6. Existing research papers/review articles published in peer reviewed journals relevant to each topic.
7. The Biology of Cancer by Robert A Weinberg, 2nd Edition, Garland Science (Publisher).
8. Cancer Biology, Carsten Carlberg & Eunike Velleuer, 2nd edition, Springer Cham (Publisher).

Research Paper-2A-P

Advanced Oncology

Practical **Credit: 1, Full Marks: 25**

1. Mammalian cell/cancer cell culture
2. Trypan Blue assay
3. MTT assay
4. Scratch assay
5. Institute/ field visit (Optional)- Marks to be added for CE in case it is carried out.

Research Paper-2B-T

Advances in Entomology

Theory **Credit:4, Full Marks: 25**

1. Introduction to the pests of paddy, jute, mango, tea, timber and stored grains.

Symptoms of their
attack and crop damage.

2. Medical and forensic Entomology:
   a) Vector biology: mode of transmission of pathogens by vectors & Controls strategies
   b) Insects associated with cadavers with their medico-legal importance.
   c) Poisonous insects
   d) Role of insects as decomposers

3. Concepts of economic entomology:
   e) Pest surveillance, sampling methods of forecasting
   f) Economic threshold and injury level
   g) Determination of EIL & calculation of economic decision level

4. Concept of biological control of pests, application of molecular tools and techniques in control.

5. Host plant resistance, Transgenic resistance to pests

6. Molecular basis of insects biotypes, barcoding technique

7. Quarantine and legislative measures for preventing spread of pests

8. Forest insect pests: Types (Forest nursery insect pests, piercing/sucking insect pests, borers of standing trees,
wood and timber), Profile of sal cockchafer (*Lachnosterna sp.*), teak defoliator (*Hapalia machaeralis*), babul
wood borer (*Coelosterna scabrata*) and bamboo borer (*Dinoderus sp.*)

Recommended Reading:

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

Research Paper-2B-P

Advances in Entomology

Practical **Credit:1, Full Marks: 25**

1. a) Host plant/seed preference study
   b) Quantitative assay of damage of host leaf/seed caused by pest
2. a) Study of insects population density (anyone species)
   b) Comparison of variance of populations of a pest species from different location and different time
   c) Determination of LD50/ LC50 values of pesticides using a pest species
   d) Studies in species RTU/family level diversity of insect community from crop/forest/grassland/ soil habitat
3. a) Study of life cycle of pest (Paddy stem borer: *Scirpophaga (= Tryporyza) incertulas*, jute stem weevil: *Apion corchori*, rice weevil: *Sitophilus oryzae*)/vector (Mosquitoes: *Anopheles sp., Culex sp., Aedes sp.*, house fly: *Musca sp.*)
   b) Submission of stages of life cycle of insect pests and mite pests of crops of North Bengal
   c) Study and calculation based on economics of IPM
4. Visit to institution/experimental plot/ field for acquiring advanced knowledge in entomology. Marks to be added in practical examination in case it is carried out.
5. Institute/ field visit (Optional)- Marks to be added for CE in case it is carried out.

Research Paper-3A-T

Regenerative Medicine

Theory **Credit:4, Full Marks: 25**

1. Pillars of regenerative medicine – Cord blood- cellular composition, HSCs, MSCs and other cord blood derived stem cells, Ex-vivo expansion and differentiation of cord blood derived cells, clinical overview of cord blood transplantation and transfusion, importance of cord blood plasma and cord blood plasma factors (CBPF), use of Cord blood as true blood substitute, cord blood banking (CB collection, testing, processing and storage) and its importance; pregnancy specific biological substance (PSBS)- stem cells in placenta, amniotic membrane, amniotic fluid, therapeutic potentials of PSBS; therapeutic potential of fetal and non-fetal stem cells (menstrual blood derived stem cells, endometrial stem cells, adipose derived stem cells, dental stem cells, breast milk stem cells)
2. Biomaterials in regenerative medicine – Selection of biomaterials for tissue engineering. Bio-scaffold and their design principles. Synthetic Biomaterials. Naturally occurring bio-scaffolds (collagen, chitosan, decellularized amniotic membrane)
3. Tissue engineering and its clinical application – Fundamentals of tissue engineering and regenerative medicine. Cell-biomaterial interaction. Biomimetic scaffolds. Use of nanoparticles in tissue engineering. ECM based hydrogels for tissue engineering. Liposomes

and exosomes as tools of tissue engineering, 3D printing of organs, Concept of bio-ink in tissue engineering, Thermal inkjet printing in tissue engineering, Biomaterials regeneration of bone, cartilage, cardiovascular system, pancreas, liver, corneal tissue, urinary bladder, trachea, Regeneration of skin and scar less wound healing using stem cell and tissue engineering.

4.Clinical applications of stem cell and regenerative medicine –

- Applications of stem cell in immunotherapy – MSCs as immune-modulators, application of stem cells for auto immune disorders, cancer immunotherapy
- Application of stem cell in neurological diseases – Stem cell mediated therapies for Parkinson's disease, cerebral stroke, multiple sclerosis, ALS, spinal cord injuries.
- Applications of stem cell in hematological disorders – Potentialities of umbilical cord blood stem cells in treating different hematological disorders, comparison between HSCs derived from bone marrow and umbilical cord blood in treating hematological disorders, superiority of cord blood stem cells in treating malignancies of blood
- Application of stem cells in scar less healing – Application of freshly collected amniotic membrane in treatment of non-healing foot ulcers (both diabetic and non-diabetic types), use of freshly collected amniotic membrane in treatment of burn, mechanism of scar less healing using stem cells and allied factors with emphasis on difference between repair and regeneration process.
- Applications of stem cells and allied factors of cord blood and psbs in controlling inflammatory conditions – Role of cord blood in controlling cytokine storm in SARS-COV2 cases, role of cord blood in controlling cases of GVHD, potentiality of regenerative medicine in treating Inflammatory Bowel disease (IBD)

5. Ethical concerns about stem cell research.

Recommended readings

1. Essentials of Stem Cell Biology: Edited by: Robert Lanza and Anthony Atala

2. Cancer Stem Cells and Cancer Therapy (Rasime Kalkan, 2024/2025)

3. Principles of Regenerative Medicine, Edited by: Anthony Atala, Robert Lanza, ... Robert Nerem

4. Regenerative Medicine Using Non-Fetal Sources of Stem Cells, Edited by: Niranjan Bhattacharya, Phillip George Stubblefield

Research Paper-3A-P

Regenerative Medicine

Practical **Credit:1, Full Marks: 25**

1. Histological study of Umbilical cord and placenta
2. Determination of RBC count, WBC count, platelet count, reticulocyte count, hemoglobin estimation, differential blood cell count of peripheral blood / cord blood sample.

37

3. Mallory's trichrome staining to identify the endosteal layer of bone marrow and sub-epithelial matrix of oral mucosa.
4. Preparation of single cell and viability determination from amniotic membrane.
5. Photographic identifications of different artificial scaffolds.
6. Visit to institution/ experimental plot/ field for acquiring advanced knowledge in regenerative medicine (Optional). Marks to be added for CE in case it is carried out.

Research Paper-3B-T

Cytogenetics

Credit:4, Full Marks: 25

Theory

1. Genomics and Systems Biology

Genome organization, Systems biology, Transcriptomics, Proteomics, Microarray, RNA-Seq, SAGE, Mass spectrometry, Yeast two-hybrid system

2. Cancer Genetics

Cell cycle regulation, Tumour suppressor genes, Oncogenes, DNA repair pathways, Hallmarks of cancer, Precision oncology

3. Recombinant DNA Technology

Cloning vectors, DNA sequencing, Shotgun sequencing, Next-generation sequencing (NGS), Western, Southern, Southwestern and Northern blotting, Real-time PCR (qPCR)

4. Genome Mapping

Linkage mapping in *Drosophila*, Human linkage mapping, DNA markers (RFLP, SSR, SNP), Positional cloning

5. Molecular Pathology

Molecular diagnosis, Pathogenic mutations, Gain- and loss-of-function mutations, Chromosomal abnormalities, Disease-to-gene approach, Gene-to-disease approach, Molecular biomarkers

6. Molecular Genetics of Human Diseases

Fragile X syndrome, Alzheimer's disease, Parkinson's disease, Schizophrenia

7. Pharmacogenetics and Precision Medicine

Drug metabolism genes, Pharmacogenomics, Personalized medicine, Companion diagnostics

8. Gene Therapy and Translational Genomics

Gene therapy strategies, Viral and non-viral vectors, CRISPR-based therapeutics, Ethical and regulatory issues

Recommended Reading:

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.

Course Work Paper-3B-T

Cytogenetics

Practical **Credit:1, Full Marks: 25**

1. Genomic DNA isolation from blood (human), tissue (mice) and quantification
2. Restriction digestion of Plasmid/Genomic DNA and, Plasmidmapping
3. PCR amplification of known DNA
4. Agarose gel electrophoresis, documentation and image analysis
5. Primer designing for PCR
6. Bioinformatics analysis of CRISPR target sites (computer based)
7. Institute/ field visit (Optional)- Marks to be added for CE in case it is carried out.

Final Submission of Research work

Credit:5, Full Marks: 100

Dissertation

SEMESTER 3 & SEMESTER 4

Option-2: Course Work Paper & Research Paper in semester-3+ Research work in semester-4

SEMESTER 3

Elective-A: 1/2/3/4/5/6

39

Elective A1-T

Fundamentals of Parasitology

Theory **Credit: 4, Full Marks: 25**

1. Parasites and parasitism : General consideration, Type of parasites, Type of hosts, Symbiosis and Commensalisms .
2. Molecular interaction between host and parasite and evasion of immunity
3. Protozoan parasites, Distribution, habit and habitat, structure, life cycle and diseases caused by *Entamoeba histolytica*, *Leishmania donovani*,*Plasmodium falciparum*,*Trypanosoma brucei/cruzi*
4. Helminth parasites, General characters, organization and larval forms of Platyhelminthes and Nemathelminthes; Distribution, habit and habitat, structure, life cycle and diseases caused by *Fascioloa hepatica*, *Echinococcus granulosus*, *Schistosoma haematobium*, *Wuchereria bancrofti*.

Recommended Reading:

1. 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.

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

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

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

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

Elective A1-P

Fundamentals of Parasitology

Practical **Credit: 1, Full Marks: 25**

1. Smear preparation for protozoa
2. Preparation of whole mounts for helminthes
3. Collection of parasites: Protozoans/ Nematodes/ Helminthes/ Insects.
4. Examination of different living animal hosts (domestic and wild) for collection, preservation, mounting and identification of protozoan parasites and arthropod vectors. Preparation and study of protozoan culture. Study of permanent slides of protozoan parasites and arthropod vectors; Microscopical examination of blood smears for protozoan parasites and isolation and identification of protozoan cysts and eggs of Helminth parasites from feacal samples. Use of Ocular micrometer and Stage micrometer for measurement.
5. Examination of living animal hosts (definitive and intermediate: earthworm, cockroach, bony fish, toad, wall lizard, garden lizard, pigeon, fowl, rat etc.) for collection, preservation, and identification of different helminth parasites. Identification of helminth parasites of man. Studies of different sections (transverse, longitudinal, sagittal) of parasites by using microtomy method and Histopathological studies of different types of infected tissues of the host. Preparation of Helminth Culture. Extraction and slide preparation of nematodes from different habitats including the isolation of the entomopathogenic nematodes and sampling and estimation ofpopulation of nematodes from soil and plant tissues. Microphotography of parasites. Identification of photos of different stages of parasites and diseases.

40

6. Preservation and Identification of parasites: Protozoans, Nematodes, Helminthes, Insects.
7. Life cycle studies of parasites: Protozoans, Nematodes, Helminths

Elective A2-T
Fundamentals of Molecular Cell Biology and Cancer Biology

Theory **Credit: 4, Full Marks: 25**

Unit I. Cellular Homeostasis and Stress Responses:

Cellular homeostasis and quality control, Oxidative stress and redox biology, Mitochondrial oxidative stress, Endoplasmic reticulum stress, Unfolded Protein Response (UPR), Proteostasis and ubiquitin-proteasome system, Autophagy, lysosomal degradation, Mitochondrial dynamics (fusion/fission), Mitophagy and mitochondrial quality control, Cellular senescence and bioenergetic crisis, Different types of Apoptosis: Pyroptosis, Ferroptosis and cuproptosis, Organelle communication (ER–mitochondria contact sites).

2. **Unit II. Cell Signaling and Intercellular Communication:**

Principles of signal transduction, Calcium signaling, Gasotransmitters (NO, CO, H_2S), Reactive oxygen species as signaling molecules, DAMPs and PAMPs, Mitochondrial DAMPs, Extracellular vesicles and exosomes, Cytokines and chemokines, Cell-cell and cell-matrix communication, Mechanotransduction, Liquid-liquid phase separation in signaling.

3. **Unit III. Fundamentals of Cancer Biology**

Hallmarks of cancer, Multistep carcinogenesis, Oncogenes and tumor suppressor genes, Driver vs passenger mutations, Somatic vs germline mutations, Clonal evolution, Cancer stem cells, Tumor heterogeneity, Primary vs metastatic tumors, Precision oncology, Cancer genome atlas, Molecular classification of cancers.

Recommended Reading:

1. Molecular Cell Biology by Harvey Lodish
2. Existing research papers/review articles published in peer reviewed journals relevant to each topic.
3. The Biology of Cancer by Robert A Weinberg, 2nd Edition, Garland Science (Publisher).
4. Cancer Biology, Carsten Carlberg & Eunike Velleuer, 2nd edition, Springer Cham (Publisher)

Elective A2-P
Fundamentals of Molecular Cell Biology and Cancer Biology

Practical **Credit:1, Full Marks: 25**

1. Nucleic acid isolation
2. PCR and primer designing
3. Isolation and estimation of RNA/DNA
4. ROS detection assay

41

Stem Cell Biology (Basic Concept)

Theory **Credit: 4, Full Marks: 25**

1. Functional characteristics of stem cells: "Stemness" of stem cells – Definition, self-renewal and differentiation; Potency and clonality of stem cells; Explaining De-differentiation and Trans-differentiation of stem cells; Signaling cascades for the regulation of Stemness.

2.Types of stem cells –

- Embryonic stem (ES) cells – location, morphology, properties, markers of ES cells; embryoid bodies; clinical potentials of ES cells and utilization in therapy; research on ES cells and controversies; ES like cells in different species.
- Hematopoietic stem cells (HSCs) – Properties, markers, ontogeny of HSCs; Proliferation and differentiation of HSCs; hematopoiesis supportive growth factors; different hematopoietic colony forming units (CFUs); transplantational use of HSCs.
- Peripheral blood stem cells and endothelial cells – Types of stem cells in peripheral blood; Therapeutic potential of peripheral blood stem cells and endothelial cells (focusing along with their expression markers)
- Mesenchymal stem cells (MSCs) – Morphology, location, markers, properties of MSCs; Multiliniage differentiation potentials of MSCs; MSC as trophic mediators; clinical applications of MSC in cell therapy.
- Neural stem cells (NSCs) – NSCs and neurogenesis.
- Induced pluripotent stem cells (iPSCs) – Development of iPSCs and re-programming factors; therapeutic importance of iPSCs

3. Stem cell niche – Stem cell niche hypothesis, components of stem cell niche, role of stem cell niche, germ line stem cell niche, adult stem cell niches in mammals, signaling in stem cell niche, dysregulation of stem cell niches, *Ex-vivo* generation of stem cell niches.

4. Isolation and culture of stem cells – Dye efflux method of stem cell isolation, magnetic and flowcytometric method of isolation of stem cells, density gradient centrifugation in stem cell isolation, basic idea of cell culture, culture of ESC, MSC, HSC, CFU culture from bone marrow derived cells.

5. Concept of cancer stem cell (CSC) and CSC niche – Defining stemness in cancer, theories of origin of CSCs, difference between CSCs and normal stem cells, markers of CSCs in different types of malignancy, functional properties of CSCs, different components of CSC niche, CSC and CSC niche targeted anti-cancer therapeutic

strategies.

Recommended readings

1. Essentials of Stem Cell Biology; Edited by: Robert Lanza and Anthony Atala
2. Cancer Stem Cells and Cancer Therapy (Rasime Kalkan, 2024/2025)
3. Principles of Regenerative Medicine, Edited by: Anthony Atala, Robert Lanza, ... Robert Nerem
4. Regenerative Medicine Using Non-Fetal Sources of Stem Cells, Edited by: Niranjan Bhattacharya, Phillip George Stubblefield

Elective A3-P

Stem Cell Biology (Basic Concept)

Practical **Credit: 1, Full Marks: 25**

1. Isolation of hematopoietic cells from mouse bone marrow, single cell preparation and determination of cellularity
2. Demonstration of marker based isolation of hematopoietic stem cells from flowcytometric data.
3. Determination of hematopoietic cell viability from murine marrow
4. Determination of lysosomal and mitochondrial health of murine bone marrow derived hematopoietic cells.
5. Determination of cellularity of extra-medullary hematopoietic organ (spleen/ liver) of mouse.
6. Histological study of murine bone marrow, extra-medullary hematopoietic organs (spleen and liver)
7. Demonstration of immunohistochemistry for the marker based identification of cancer stem cells in oral squamous cell carcinoma sample.

Elective A4-T

Advances in Molecular and Cell Biology

Theory **Credit: 4, Full Marks: 25**

1. **Unit 1. Cell and Tissue Culture**

Culture media: composition, preparation and properties. Primary cell culture, secondary culture and continuous cell lines. Fibroblast and lymphocyte culture. Cell separation techniques (FACS and MACS)

43

2. **Unit 2. Cell Signalling**
   Cell surface receptors, G-protein coupled receptors (GPCR), Receptor tyrosine kinases (RTKs); Second messengers, Signal amplification, MAPK and PI3K-AKT signalling pathways
3. **Unit 3. Mitochondrial Biology**
   Mitochondrial genome organization, Replication, Maternal inheritance
4. **Unit 4. Stem Cell Biology**
   Embryonic stem cells, Adult stem cells, Induced pluripotent stem cells (iPSCs), Stem cell niche, Asymmetric cell division, Applications in regenerative medicine
5. **Unit 5. Biology of Ageing**
   Hallmarks of ageing, Telomeres and telomerase, Oxidative stress, Cellular senescence, Genetic regulation of ageing

Recommended Reading:

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

Elective A4-P

Advances in Molecular and Cell Biology

Practical **Credit: 1, Full Marks: 25**

1. Mammalian cell culture (demonstration)
2. Laboratory safety and aseptic techniques in cell culture
3. Cell viability assay (Trypan Blue)
4. Construction of Human/Rat karyotype
5. Cell counting using haemocytometer

Elective A5-T

Fundamentals of Entomology

Theory **Credit: 4, Full Marks: 25**

1. **Introduction:** Insect characters, origin and evolution of insects
2. **Integument:** Structure, chemistry, cuticular modifications, moulting, sclerotization
3. **Head:** Segment, skeleton, tentorium, cephalic appendages
4. **Thorax:** Segment, skeleton, endothorax, thoracic appendages
5. **Wings:** Origin, morphological variations, structure, insect flight

Dispatched
Date ..... Time...
.....Date .....Time.....

6. **Digestive system:** Alimentary canal, salivary glands, nutrition, mechanism of digestion
7. **Respiratory system:** Organs (Aerial and aquatic), mechanism of gaseous exchange
8. **Excretory system:** Organs, mechanism of excretion, osmoregulation
9. **Visual and sensory system:** Dorsal ocelli, stemmata, compound eyes, mechanoreceptors, chemoreceptors, thermohygroreceptors
10. **Reproductive system:** Male and female reproductive systems, egg maturation
11. **Insect development:** Egg, early embryonic, embryonic, post embryonic development and metamorphosis
12. **Insect classification:** Modern scheme of insect classification, characters and examples of extant insect orders

Recommended Reading:

1. Chandra, G. (2000). *Mosquito*. Sree Bhumi Publication Co., Kolkata
2. Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th Ed. Cambridge University Press
3. Dorothy, E. G. (2006). *Forensic Entomology*. Wiley
4. Gennard, D. (2012). *Forensic Entomology: An Introduction*. 2nd Ed. Wiley-Blackwell
5. Gullan, P. J. and Cranston, P. S. (2005). *The Insects: An Outline of Entomology*. 3rd Ed. Blackwell Publishing
6. Hati, A. K. (2001). *Medical Entomology*. Allied Book Agency, Kolkata
7. Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata
8. Kettle, D. S. (1995). *Medical and Veterinary Entomology*. 2nd Ed. CAB International
9. Pedigo, L. P. and Rice, E. M. (2009). *Entomology and Pest Management*. Pearson/Prentice Hall
10. Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological Control of Insect Pests*. Lewis Publishers
11. Service, M. (2012). *Medical Entomology for Students*. 5th Ed. Cambridge University Press, New York
12. Tembhare, D. B. (2012). *Modern Entomology*. 2nd Ed. Himalaya Publishing House, Mumbai

Elective A5-P

Fundamentals of Entomology

Practical **Credit: 1, Full Marks: 25**

1. Studies in internal morphology of *Apis* (digestive and nervous systems), *Musca* (male and female reproductive systems), Grasshopper (nervous and reproductive system)
2. Mounting: wings mouth parts, antennae of insect pests (any three), genitalia of cockroach, bug, house fly mosquito
3. a) Insect collection: Active collection and passive collection
   b) Insect preservation and curation: Dry preservation, fixing and wet preservation
   c) Insect identification: Identification keys
4. Preparation of key
   a) Order level

b) Family levels for major orders

Elective A6-T

Basic Ecology

Theory **Credit: 4, Full Marks: 25**

1. **Population Ecology:** Characteristics of population, population size and exponential growth, limits of population growth, population dynamics, life history pattern, life table, fertility rate and age structure, dispersal.
2. **Community:** Community characteristics: Species richness, dominance, diversity, abundance; Ecotone and Edge effect; Ecotype.
3. **Environmental Ecology:** Environmental Stresses and their management, global climatic pattern, global warming, atmospheric ozone depletion, acid rain; El-nino, La-nina, Southern Oscillation and their ecological impact.
4. **Bioaccumulation**: Factors influencing bioaccumulation in food chain and during trophic transfer. Impact of chemical pollutants on biodiversity of animals.
5. **Bioindicator and biomarkers**: Bioindicator and biomarkers of environmental health. Biodegradation and bioremediation of chemicals.
6. **Human ecology:** Ecological background of human origin, Disruptive and directional selection, Brain evolution, Human Population Growth.

Recommended Reading:

1. Ecology Fourth Edition by Robert E. Ricklefs and Gary L. Miller, Textbook (This Sacred Earth)
2. 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.
4. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.
5. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs

46

Basic Ecology

Practical **Credit:1, Full Marks: 25**

1. Estimation of free carbon dioxide & dissolved oxygen (Winkler's Method) from water sample.
2. Study of primary productivity of aquatic ecosystem (Light & Dark Bottle method)
3. Sampling techniques: line transect/ point transect/ quadrat
4. Identification of zooplanktons from permanent slides/photographs
5. Calculation of Shannon-Wiener Diversity Index (H') & Sorensen similarity coefficients from community study/ supplied data.

Elective-B: 1/2/3/4/5/6

Elective B1-T

Applied Parasitology

Theory **Credit:4, Full Marks: 25**

1. Biological Sequence Analysis in Parasitology: Analysis of DNA and Protein sequence, Sequence alignment. Fragment assembly, Genome sequence assembly, Neural network concepts and secondary structure prediction. Probabilistic models. Evolutionary analysis.

2. Artificial Intelligence and Modelling of Biological Systems: Concepts and principles of modelling: Limitations of models, Models of behaviour, Modelling in Epidemiology and Public Health SIR models, Introduction to Artificial Intelligence –basics like non monotonic logic Planning Perception Learning Neural Networks Natural language processing Expert system.

3. Bioethics and Medical ethics: Historical perspectives & Introduction to Bioethics. Ethics of clinical trials: Drug trials, vaccine trials.

Recommended Reading:

1. 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.
2. Medical Parasitology. W.B. Saunders. Philadelphia. Prescott M.C. J.P.Hardley and D.A. Clean.2001.
3. Pathophysiological Responses to Parasites. British Society for parasitology. London.
4. Chandrashekhar J Hiware. Babasaheb V Jadhav. Ashok D Mohekar. 2002. Applied Parasitology. A Practical Manual.
5. Paniker, C.K.J.1998.Text book of Medical Parasitology. Jaypee. New Delhi.

47

Elective B1-P

Applied Parasitology

Practical **Credit: 1, Full Marks: 25**

1. Fluorescence/ Immunofluorescence microscope studies on parasite tissues
2. Cryosectioning / Preservation/mounting of parasite tissues
3. Estimation of RNA in tissue (Colorimetric method)
4. Feulgen reaction method for DNA localization
5. Localization of RNA by methyl green pyronin –'Y'
6. Polymerase chain reaction (Demonstration)
7. RFLP Analysis (Demonstration)
8. Biological Sequence analysis- Analysis of DNA and protein sequence

Elective B2-T
Molecular Mechanisms of Cell Function and Cancer Progression

Theory **Credit: 4, Full Marks: 25**

1. **Unit I. Stem Cell Biology and Regenerative Medicine**
   Stem cell potency and hierarchy, Self-renewal and differentiation, Stem cell niche, Dedifferentiation and transdifferentiation, Stem cell isolation and characterization, Organoids and spheroids, Induced pluripotent stem cells (iPSCs), Stem cells in regenerative medicine, Tissue engineering, Clinical applications of stem cells.
2. **Unit II. Oncogenic Signaling and Tumor Metabolism:**
   PI3K/AKT/mTOR signaling, MAPK pathway, Wnt/β-catenin pathway, TGF-β signaling, Hippo pathway, Notch signaling, p53 pathway, Cell cycle checkpoints, DNA damage response, Tumor metabolism,Warburg effect, Oxidative phosphorylation, Metabolic plasticity, Hypoxia and HIF signaling, EMT and EndoMT, Metabolomics, Oncometabolites, Mitochondrial signaling in cancer.
3. **Unit III. Tumor Microenvironment and Cancer Immunology**
   Tumor microenvironment, Cancer-associated fibroblasts (CAFs), Tumor-associated macrophages (TAMs), Immune evasion, Immune checkpoints, Angiogenesis, Lymphangiogenesis, Metastatic niche, Immunometabolism, Extracellular vesicles in cancer, Microbiome and cancer.

Recommended Reading:

1. Molecular Cell Biology by Harvey Lodish
2. Existing research papers/review articles published in peer reviewed journals relevant to each topic.
3. The Biology of Cancer by Robert A Weinberg, 2nd Edition, Garland Science (Publisher).
4. Cancer Biology, Carsten Carlberg & Eunike Velleuer, 2nd edition, Springer Cham (Publisher)

Elective B2-P
Molecular Mechanisms of Cell Function and Cancer Progression

48

Practical Credit: 1, Full Marks: 25

1. Mammalian/cancer cell culture
2. Trypan blue viability assay.
3. MTT cell proliferation assay
4. Scratch (wound healing) assay.

Elective B3-T

Regenerative Medicine & Tissue Engineering

Theory **Credit: 4, Full Marks: 25**

1. Pillars of regenerative medicine – Cord blood- cellular composition, HSCs, MSCs and other cord blood derived stem cells, Ex-vivo expansion and differentiation of cord blood derived cells, clinical overview of cord blood transplantation and transfusion, importance of cord blood plasma and cord blood plasma factors (CBPF), use of Cord blood as true blood substitute, cord blood banking (CB collection, testing, processing and storage) and its importance; pregnancy specific biological substance (PSBS)- stem cells in placenta, amniotic membrane, amniotic fluid, therapeutic potentials of PSBS: therapeutic potential of fetal and non-fetal stem cells (menstrual blood derived stem cells, endometrial stem cells, adipose derived stem cells, dental stem cells, breast milk stem cells).
2. Biomaterials in regenerative medicine – Selection of biomaterials for tissue engineering, Bio-scaffold and their design principles. Synthetic Biomaterials. Naturally occurring bio-scaffolds (collagen, chitosan, decellularized amniotic membrane).
3. Tissue engineering and its clinical application – Fundamentals of tissue engineering and regenerative medicine. Cell-biomaterial interaction. Biomimetic scaffolds. Use of nanoparticles in tissue engineering. ECM based hydrogels for tissue engineering. Liposomes and exosomes as tools of tissue engineering. 3D printing of organs. Concept of bio-ink in tissue engineering. Thermal inkjet printing in tissue engineering. Biomaterials regeneration of bone, cartilage, cardiovascular system, pancreas, liver, corneal tissue, urinary bladder, trachea. Regeneration of skin and scar less wound healing using stem cell and tissue engineering.

Recommended readings

1. Essentials of Stem Cell Biology: Edited by: Robert Lanza and Anthony Atala
2. Cancer Stem Cells and Cancer Therapy (Rasime Kalkan, 2024 2025).
3. Principles of Regenerative Medicine, Edited by: Anthony Atala, Robert Lanza, Robert Nerem

4. Regenerative Medicine Using Non-Fetal Sources of Stem Cells, Edited by: Niranjan Bhattacharya, Phillip George Stubblefield.

Elective B5-P

Regenerative Medicine & Tissue Engineering

Practical **Credit: 1, Full Marks: 25**

1. Histological study of Umbilical cord and placenta
2. Determination of RBC count, WBC count, platelet count, reticulocyte count, hemoglobin estimation, differential blood cell count of peripheral blood/ cord blood sample.
3. Mallory`s trichrome staining to identify the endosteal layer of bone marrow and sub-epithelial matrix of oral mucosa.
4. Preparation of single cell and viability determination from amniotic membrane.
5. Photographic identifications of different artificial scaffolds.

Elective B4-T

Advances in Genetics and Genome Engineering

Theory **Credit: 4, Full Marks: 25**

1. **Unit 1. Advanced Patterns of Inheritance**
   Complex traits, Multiple alleles, Genomic imprinting, Uniparental disomy, Anticipation. Polygenic inheritance, Epigenetic inheritance
2. **Unit 2. Functional Genomics and Gene Expression**
   Random mutagenesis, Site-directed mutagenesis, Gene knockout and knock-in, Gene expression regulation, RNA interference (RNAi)
3. **Unit 3. Genome Editing**
   CRISPR-Cas9 system, Base editing, Prime editing, Epigenome editing, Applications of CRISPR, Ethical issues of genome editing
4. **Unit 4. Genome Mapping**
   Linkage mapping in *Drosophila*, Human linkage mapping, DNA markers (RFLP, SSR and SNP), Positional cloning
5. **Unit 5. Molecular Genetics of Human Diseases**
   Fragile X syndrome, Alzheimer's disease, Parkinson's disease

Recommended Reading:

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

50

5. Primrose. Molecular Biotechnology
6. Frederick Hecht: Textbook of Cytogenetics
7. Snusted: Principles of Genetics

Elective B4-P

Advances in Genetics and Genome Engineering

Practical **Credit: 1, Full Marks: 25**

1. Drosophila food preparation and handling
2. Study of *Drosophila* mutant phenotypes
3. Three-point test cross for gene mapping
4. Bioinformatics-based CRISPR guide RNA design
5. Primer designing for PCR

Elective B5-T

Economic & Industrial Entomology

Theory **Credit: 4, Full Marks: 25**

1. Agricultural entomology: Insect pests, classification of pests
2. Pest control measures: Mechanical, physical, cultural, legislative and quarantine measures
3. Chemical control of pests: Classification of insecticides, insecticidal pharmacodynamics, mode of action of insecticides, drawbacks of chemical control
4. Pest of major crops: Cotton (Spotted bollworm), sugarcane (Stem borer), paddy (Stem borer), wheat (Armyworm), pests of stored grains (Greasy cutworm, mustard sawfly, rice weevil), vegetables (potato tuber moth, brinjal shoot and fruit borer, cabbage caterpillar)
5. Insects of medical importance: Mode of transmission (Mechanical and biological), common vector insects (Life cycle, diseases and control of mosquitoes, house fly and tsetse fly)
6. Veterinary insects: Insect parasitism, major veterinary insects (Life cycle, diseases and control of horse fly, stable fly, buffalo fly, cattle warble fly and screw worms)
7. Forest insect pests: Types (Forest nursery insect pests, piercing/sucking insect pests, borers of standing trees, wood and timber), Profile of sal cockchafer (*Lachnosterna sp.*), teak defoliator (*Hapalia machaeralis*), babul wood borer (*Coelosterna scabrata*) and bamboo borer (*Dinoderus sp.*)
8. Sericulture: Mulberry, tasar, muga and eri silkworm culture, life cycle, diseases with causative agents, symptoms and control
9. Apiculture: Classification of honey bees, diseases and enemies of honey bees, products of apiculture industries and their uses

Recommended Reading:

9. Chandra, G. (2000). *Mosquito*. Sree Bhumi Publication Co., Kolkata

10. Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th Ed. Cambridge University Press
11. Dorothy, E. G. (2006). *Forensic Entomology*. Wiley
12. Gennard, D. (2012). *Forensic Entomology: An Introduction*. 2nd Ed. Wiley-Blackwell
13. Gullan, P. J. and Cranston, P. S. (2005). *The Insects: An Outline of Entomology*. 3rd Ed. Blackwell Publishing
14. Hati, A. K. (2001). *Medical Entomology*. Allied Book Agency, Kolkata
15. Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata
16. Kettle, D. S. (1995). *Medical and Veterinary Entomology*. 2nd Ed. CAB International
9. Pedigo, L. P. and Rice, E. M. (2009). *Entomology and Pest Management*. Pearson/Prentice Hall
10. Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological Control of Insect Pests*. Lewis Publishers
11. Service, M. (2012). *Medical Entomology for Students*. 5th Ed. Cambridge University Press, New York
12. Tembhare, D. B. (2012). *Modern Entomology*. 2nd Ed. Himalaya Publishing House, Mumbai

Elective B5-P

Economic & Industrial Entomology

Practical **Credit: 1, Full Marks: 25**

1. a) Host plant/seed preference study
   b) Quantitative assay of damage of host leaf/seed caused by pest
2. a) Study of insects population density (anyone species)
   b) Comparison of variance of populations of a pest species from different location and different time
   c) Determination of LD50/ LC50 values of pesticides using a pest species
   d) Studies in species RTU/family level diversity of insect community from crop/forest/grassland/ soil habitat
3. Study of life cycle of pest (Paddy stem borer: *Scirpophaga (= Tryporyza) incertulas*, jute stem weevil: *Apion corchori*, rice weevil: *Sitophilus oryzae*)/vector (Mosquitoes: *Anopheles sp., Culex sp., Aedes sp.*, house fly: *Musca sp.*)
4. Collection and preparation of family level key of pests of major crops of North Bengal i.e. rice, jute, tea, vegetables
5. Observation of mouthparts of worker honey bee under microscope
6. Study of variations in body size (Length and wing size) and body shape of a worker, drone and queen

Elective B6-T

Advances in Ecology

Theory **Credit: 4, Full Marks: 25**

1. **Concept of habitat and niche:** Distinction between habitat and niche. Fundamental & realized niche. Hypervolume. Ecological equivalents. Resource partitioning (African

savanna ungulate grazing succession) and character displacement (Galapagos Darwin's finches)

2. **Species Interactions:** Intra- and inter-specific interactions; Lotka-Volterra Model of competition

3. **Metapopulation:** Definition, Characteristics, Levins's model of metapopulation dynamics

4. **Ecosystem development:** Basic Terminology- Nudation, invasion, ecesis, aggregation, competition, reaction, and stabilization; Types of Succession- Primary vs. Secondary, Autogenic vs. Allogenic, Autotrophic vs. Heterotrophic; The Climax Concept, Theories of Climax; Hydrosere

5. **Aquatic ecology:** Thermal stratification (epilimnion, metalimnion/thermocline, hypolimnion), Light penetration and photic zonation (photic/euphotic zone, aphotic zone, compensation depth), Ecological adaptations of plankton, nekton, benthos, and neuston.

6. **Terrestrial and forest ecology:** Vertical forest stratification (emergent, canopy, understory, floor), Vertical niche partitioning.

Recommended Reading:

1. Ecology Fourth Edition by Robert E. Ricklefs and Gary L. Miller, Textbook (This Sacred Earth)
2. 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.
4. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.
5. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition). Benjamin Cummings Publ. 688pgs

Elective B6-P

Advances in Ecology

Credit: 1, Full Marks: 25

Practical

1. Estimation of pH, Alkalinity & Hardness from water sample.
2. Collection, Staining, identification and quantification (Sedgwick-Rafter counting cell) of zooplanktons

3. Calculation of various diversity indices from community study/ supplied data: Simpson's Dominance Index (D), Simpson index of Diversity (1-D), Simpson Reciprocal Index (1/D), Pielou's Species Evenness (J')
4. Identification of soil arthropods from specimens/ photographs
5. Preparation of field report for any community study

Elective-C: 1/2/3/4/5/6

Elective C1-T

Epidemiology with AI application

Theory

Credit:4, Full Marks: 25

1. **Core Epidemiological Principles and Methods**

This foundational component covers the tools and study designs used to investigate disease in populations. Key topics include:

i) Study Designs: Understanding cross-sectional, case-control, and cohort studies, as well as field and clinical trials.

ii) Measures of Disease: Calculating and interpreting key metrics like incidence, prevalence, relative risk, odds ratio, and the basic reproductive ratio (R0) .

iii) Data Analysis: Managing and analyzing epidemiological data using statistical software and methods, including calculating sample sizes .

iv) Predictive Modeling and Genomic Data Analysis: Building models to predict disease outbreaks, patient risk, or treatment outcomes. For example- build a model to classify plant leaves as healthy or diseased or predict crop yield based on environmental factors and learn to evaluate these models using appropriate metrics. Analyzing pathogen sequencing data to

trace transmission chains and understand evolution. This involves using bioinformatics tools and packages in R or Python.

2. Epidemiology of Infectious and Zoonotic Diseases

A significant portion of the syllabus is dedicated to diseases that can transmit between animals and humans, with a focus on their ecological and evolutionary dynamics.

i. **Zoonoses:** In-depth study of bacterial, viral, parasitic, and fungal zoonotic diseases (e.g., Anthrax, Rabies, Influenza, Plague, Leishmaniasis), covering their etiology, transmission patterns, and public health significance .

ii. **Parasitology:** Focus on the life cycles, transmission, and control of economically important parasites and vector-borne diseases .

iii. **Disease Dynamics:** Topics may include the role of ecology in disease maintenance, epidemic curves, transboundary diseases, and the impact of climate and environmental factors on disease spread .

3. Village Placement Programme Cooch Behar is a district of North Bengal where a majority of people lives below the poverty line. The rural mass is economically and educationally backward. Thus the aim of introduction of this village placement programme is to extend out to reach environmental awareness. hygiene and health to the rural people of this region on various aspects related to parasitic diseases. The students in their fourth semester have to visit any one of the village within the jurisdiction of CBPBU University and can arrange various programs to educate the rural mass in the following areas for three days. a) Environmental awareness, b) Hygiene and health.

4. Regulatory framework and guidelines for conduction of human research: Review processes. Institutional ethical committees, composition of committees, review procedures, WHO, UNESCO and ICMR guidelines.

Recommended Reading:

1. 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.

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

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

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

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

Elective C1-P

Epidemiology with AI application

Practical **Credit: 1, Full Marks: 25**

1. Advanced and Applied Techniques

Modern epidemiological training includes sophisticated methods for surveillance, analysis, and control.

2. Molecular Epidemiology: Using genetic data (phylodynamics) to trace pathogen evolution, transmission routes, and demographic history with software like BEAST.

3. Surveillance and Control: Principles of designing and evaluating health surveillance systems, risk assessment, disease monitoring, and outbreak investigation.

4. Spatial Analysis: Using Geographic Information Systems (GIS) and remote sensing to map disease distribution, identify hotspots, and analyze spatial risk factors

5. Data Wrangling and Cleaning: Working with "dirty" data is a crucial first step. Practicals will involve handling missing values, correcting data formats, and merging different datasets (e.g., combining health data with climate or social data) .

6. Predictive Modeling and Genomic Data Analysis: Building models to predict disease outbreaks, patient risk, or treatment outcomes. For example- build a model to classify plant leaves as healthy or diseased or predict crop yield based on environmental factors and learn to evaluate these models using appropriate metrics. Analyzing pathogen sequencing data to trace transmission chains and understand evolution. This involves using bioinformatics tools and packages in R or Python.

7. Computational Epidemiology: Simulating disease spread. Build an SIR model to understand how an infectious disease moves through a population, or an agent-based model to study the impact of interventions.

8. **Institutional visit (Optional)-** Marks to be added for CE in case it is carried out.

Elective C2-T
Molecular Technologies and Precision Oncology

Theory **Credit: 4, Full Marks: 25**

1. Unit I. Molecular Cell Biology Techniques:

Cell culture, Flow cytometry, Mitochondrial membrane potential, Luciferase reporter assay, EMSA, Co-immunoprecipitation, Chromatin Immunoprecipitation (ChIP), Western blotting, RNA interference CRISPR/Cas genome editing, Single-cell RNA sequencing, Multi-omics approaches.

2. Unit II. Cancer Therapeutics and Precision Medicine:

Chemotherapy, Radiotherapy, Hormonal therapy Targeted therapy, Tyrosine kinase inhibitors,

Monoclonal antibodies, Anti-angiogenic therapy, Immunotherapy, Immune checkpoint blockade, CAR-T cell therapy, Cancer vaccines, Oncolytic viruses, Drug resistance, Mechanisms of resistance, Chemosensitization, Synthetic lethality, Precision oncology, Biomarkers, Companion diagnostics, Liquid biopsy, Circulating tumor DNA, Personalized medicine ***Representative drugs:*** Cisplatin, Doxorubicin, Etoposide, 5-Fluorouracil, Paclitaxel, Vincristine, Vinblastine, Tamoxifen, Targeted therapeutics and antibody-drug conjugates.

Recommended Reading:

1. Molecular Cell Biology by Harvey Lodish
2. Existing research papers/review articles published in peer reviewed journals relevant to each topic.
3. The Biology of Cancer by Robert A Weinberg, 2nd Edition, Garland Science (Publisher).
4. Cancer Biology, Carsten Carlberg & Eunike Velleuer, 2nd edition, Springer Cham (Publisher)

Elective C2-P
Molecular Technologies and Precision Oncology

Practical **Credit: 1, Full Marks: 25**

Molecular Cell Biology and Oncology Laboratory III

1. Buffers preparation
2. Western blotting
3. PCR/qPCR demonstration and PCR program set up.
4. Immunocytochemistry/Immunohistochemistry demonstration

Elective C3-T

Applications of stem cell and regenerative medicine & ethical concerns

Theory **Credit: 4, Full Marks: 25**

1. Applications of stem cell in immunotherapy – MSCs as immune-modulators, application of stem cells for auto immune disorders, cancer immunothera
2. Application of stem cell in neurological diseases – Stem cell mediated therapies for Parkinson's disease, cerebral stroke, multiple sclerosis, ALS, spinal cord injuries.
3. Applications of stem cell in hematological disorders – Potentialities of umbilical cord blood stem cells in treating different hematological disorders, comparison between HSCs derived from bone marrow and umbilical cord blood in treating hematological disorders, superiority of cord blood stem cells in treating malignancies of blood
4. Application of stem cells in scar less healing – Application of freshly collected amniotic membrane in treatment of non-healing foot ulcers (both diabetic and non-diabetic types), use of freshly collected amniotic membrane in treatment of burn, mechanism of scar less healing using stem cells and allied factors with emphasis on difference between repair and regeneration process.
5. Applications of stem cells and allied factors of cord blood and psbs in controlling inflammatory

conditions – Role of cord blood in controlling cytokine storm in SARS-COV2 cases, role of cord blood in controlling cases of GVHD, potentiality of regenerative medicine in treating Inflammatory Bowel disease (IBD).

6. Clinical strategies for the regeneration of mammalian bone and nervous system.

7. Ethical concerns about stem cell research.

Recommended readings

1. Essentials of Stem Cell Biology; Edited by: Robert Lanza and Anthony Atala
2. Cancer Stem Cells and Cancer Therapy (Rasime Kalkan, 2024/2025)
3. Principles of Regenerative Medicine, Edited by: Anthony Atala, Robert Lanza, ... Robert Nerem
4. Regenerative Medicine Using Non-Fetal Sources of Stem Cells, Edited by: Niranjan Bhattacharya, Phillip George Stubblefield
5. Michael J. F. Barresi and Scott F. Gilbert. Developmental Biology, XIII Edition. Oxford University.

Elective C3-P

Applications of stem cell and regenerative medicine & ethical concerns

Practical **Credit:1, Full Marks: 25**

1. Basic cell culture setup: Sterilization, media preparation, aseptic techniques, and mammalian cell viability/cytotoxicity assays.

2. Marker based analysis of flowcytometric data regarding mesenchymal stem cells.

3. Photographic identification of different hematopoietic progenitor colony from the culture of marrow cells/ cord blood cells.

4. Cytochemical staining for the identification of bone cells, fat cells, cartilage cells.

Elective C4-T

Genomics, Recombinant DNA Technology and Molecular Medicine

Theory **Credit:4, Full Marks: 25**

1. **Unit 1. Genomics and Systems Biology**
   Genome organization, Systems biology, Transcriptomics, Proteomics, DNA microarray, RNA-Seq, SAGE, Mass spectrometry, Yeast two-hybrid system
2. **Unit 2. Recombinant DNA Technology**
   DNA sequencing, Shotgun sequencing, Next-generation sequencing (NGS), Southern, Northern, Western and Southwestern blotting, Real-time PCR (qPCR)

3. **Unit 3. Cancer Biology and Molecular Pathology**
   Cell cycle regulation, Tumour suppressor genes, Oncogenes, DNA repair pathways, Hallmarks of cancer, Molecular diagnosis, Gain- and loss-of-function mutations, Molecular biomarkers
4. **Unit 4. Gene Therapy and Precision Medicine**
   Gene therapy strategies, Viral and non-viral vectors, Ethical and regulatory issues
5. **Unit 5. Prion Biology**
   Structure of PrP, Prion replication, Transmissible Spongiform Encephalopathies (TSE), Molecular mechanism of prion diseases

Recommended Reading:

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

Elective C4-P

Genomics, Recombinant DNA Technology and Molecular Medicine

Practical **Credit: 1, Full Marks: 25**

1. Genomic DNA isolation and quantification
2. Restriction digestion and agarose gel electrophoresis
3. Agarose gel documentation and image analysis
4. Plasmid mapping
5. PCR amplification of DNA

Elective C5-T

Advances in Entomology

Theory **Credit: 4, Full Marks: 25**

1. **Learning and behavior of insects:** Neural basis of learning, bee language and bee dance, colour change mechanism and adaptive behavior, motor control of *Drosophila* courtship song
2. **Immunity in insects:** Antibacterial immunity, antiviral immunity, bacterial resistance to insect immunity and biological significance of insect immunity
3. **Insect viruses and pest control:** Insect viruses as biological control agents of insect pests
4. **Forensic entomology:** Principle and scope, forensic insects and factors, forensic entomological investigation methodology.

Elective C5-P

Advances in Entomology

Practical **Credit:1, Full Marks: 25**

1. Study of bee language and bee dance (From field, photos, and videos)
2. Study of motor control of *Drosophila* courtship song (From laboratory, photos, and videos)
3. Study of flashing patters of fire worms (From field, photos, and videos)
4. Identification with reasons of forensic insects (Blow fly: *Calliphora sp.*, flesh fly: *Chrysomya sp.*, cheese skipper fly: *Piophila sp.*, rove beetle: *Creophilus sp.*, carcass beetle: *Saprinus sp.*, skin beetle: *Dermestes sp.*, scarab beetle: *Onitis sp.*)

Recommended Reading:

17. Chandra, G. (2000). *Mosquito*. Sree Bhumi Publication Co., Kolkata
18. Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th Ed. Cambridge University Press
19. Dorothy, E. G. (2006). *Forensic Entomology*. Wiley
20. Gennard, D. (2012). *Forensic Entomology: An Introduction*. 2nd Ed. Wiley-Blackwell
21. Gullan, P. J. and Cranston, P. S. (2005). *The Insects: An Outline of Entomology*. 3rd Ed. Blackwell Publishing
22. Hati, A. K. (2001). *Medical Entomology*. Allied Book Agency, Kolkata
23. Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata
24. Kettle, D. S. (1995). *Medical and Veterinary Entomology*. 2nd Ed. CAB International
9. Pedigo, L. P. and Rice, E. M. (2009). *Entomology and Pest Management*. Pearson/Prentice Hall
10. Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological Control of Insect Pests*. Lewis Publishers
11. Service, M. (2012). *Medical Entomology for Students*. 5th Ed. Cambridge University Press, New York
12. Tembhare, D. B. (2012). *Modern Entomology*. 2nd Ed. Himalaya Publishing House, Mumbai

Elective C6-T

Advances in Ethology

Theory **Credit:4, Full Marks: 25**

1. **Survival value of Behaviour:** Experimental studies, Darwinian inclusive fitness.

2. **Altruism:** Kin-selection, Inclusive fitness, Hamilton's rule, reciprocal altruism, parental care (in amphibians); Cooperation - Reproductive Cooperation in Rodriques Fruit-Bat, Foraging Cooperation in Harris's Hawk, Byproduct mutualism

60

3. **Role of environment in development of behaviour:** Interactive theory, early experience and behavioural development
4. **Sexual Behaviour:** Sexual dimorphism, mate choice; Intra-sexual selection (male rivalry); Inter-sexual selection (female choice); Courtship behavior in 3-spine stickleback; Infanticide behaviour.
5. **Biological rhythms:** Periodicity in the environment and in the organisms, Circadian rhythm- Selective advantage, Free-running activity, Zeitgeber, Entrainment, Temperature compensation; Genetic control
6. **Migratory behavior and animal orientation:** Orientation- Primary and secondary orientation; Kinesis - orthokinesis, klinokinesis; Taxis- tropotaxis and klinotaxis, Physiological triggers of bird migration (photoperiod, zugunruhe, hormonal control), Avian migration - orientation, Fish migration: Anadromous vs. Catadromous

Recommended Reading:

1. Alcock J. 2013. Animal Behaviour, Sinauer Associate Inc., USA.
2. Drickamer LC , Vessey SH . 2001. Animal Behaviour. McGraw-Hill
3. Dugatkin LA. 2014. Principles of Animal Behaviour. 3rd Edn. W.W. Norton and Co.
4. The Cambridge Handbook of Evolutionary Perspectives on Human Behavior edited by Lance Workman. Will Reader, and Jerome H. Barkow.
5. Behavioral Genetics by Robert Plomin, John C. DeFries, Valerie S. Knopik, and Jenae M. Neiderhiser.

Elective C6-P

Advances in Ethology

Practical **Credit: 1, Full Marks: 25**

1. Study of nesting behaviour in birds. Identification of different types of nests from field visit/photographs.
2. To study different types of animal behaviour such as habituation, imprinting, courtship behaviour in insects/birds, and parental care from short videos.
3. To study the phototaxis behaviour in insect larvae
4. Study of aggressive behaviour in *Betta* fish
5. T-Maze study on rat mice (using live specimen videograph)
6. Visit to Forest Wild life Sanctuary Biodiversity Park Zoological Park (or similar places) to study and record the behavioural activities of animals and prepare a short report.

SEMESTER 4

Seminar Presentation and submission of Research project/patent (Credit:20, Full Marks:400)

SEMESTER 3 & SEMESTER 4

Option-3: Research work in semester-3 & 4

SEMESTER 3

Seminar Presentation and submission of Research project/patent (Credit:20, Full Marks:400)

SEMESTER 4

Seminar Presentation and submission of Research project/patent (Credit:20, Full Marks:400)