

SEMESTER IX

Paper I MBCR4901

Part A: Eukaryotic Genetics II (60 marks)

Unit I: Biostatistical Methods: Biostatistical terms, random sampling, statistical errors; χ^2 tests: degrees of freedom, simple, homogeneity and contingency χ^2 , test of association, application of χ^2 test; t-test: unpaired t-test (large sample and small sample), paired t-test; ANOVA: one way and two way, least significant difference; lod score. (20 lectures)

Unit II: Quantitative genetics: Nature and inheritance of continuous traits, polygene hypothesis, quantitative genetic analysis, heritability and its measurements, broad sense and narrow sense heritability. (4 lectures)

Unit III: Population Genetics: Genetic variation in populations, the Hardy-Weinberg law, factors affecting Hardy-Weinberg equilibrium, determination of allelic frequencies and testing a locus for equilibrium, effects of mutation, random genetic drift (bottleneck and founder effects, effects of genetic drift), migration and selection (Hardy Weinberg and natural selection, effects of selection on allele frequencies, heterozygote superiority). (12 lectures)

Unit IV: Screening for genetic diseases: prenatal testing and newborn screening, testing by RFLP analysis, testing using PCR approaches. (3 lectures)

Unit V: Gene therapy: Sickle cell anaemia and DNA molecular testing. Types of gene therapy, gene therapy in animals and humans (somatic gene therapy, gene therapy for SCID, cystic fibrosis). (3 lectures)

Unit VI: Human Genetic Mapping: Genetic mapping in humans: DNA polymorphisms and their analysis, mapping by recombination and pedigree analysis, analysis using DNA markers (RFLPs, SSLPs), fluorescence *in situ* hybridization, determining gene linkage through radiation hybrids. (3 lectures)

Unit VII: Non-Mendelian Inheritance: Mitochondrial genetics (*Poky* mutations in *Neurospora*, *Petite* mutants in yeast) and chloroplast genetics (variegated shoot phenotype of *Mirabilis jalapa*). (2 lectures)

Unit VIII: Gene expression during development: the genetics of cloning, haemoglobin types in humans. (1 lecture)

Teachers involved:

Dr. D. Chakraborti (Units I, II)

Dr. A. Banerji (Units III - VIII)

Recommended texts:

1) **Unit I:** Biostatistical Methods: Introductory Practical Biostatistics – Misra and Misra (Chapters 1, 4, 5 and 6); Biostatistical Analysis – J.H. Zar, Fourth edition (Chapters 1, 2, 8, 9, 10, 11, 22, 23)

2) **Unit II:** Quantitative genetics: iGenetics – A Molecular Approach – P.J. Russell, Third edition (Chapter 22); Concepts of genetics - Klug and Cummings, Seventh edition (Chapter 5)

3) iGenetics – A Molecular Approach. P.J. Russell (2nd ed.). Chapters 16 (Unit VI), 21 (Unit VIII), 23 (Unit VII), 24 (Unit III).

4) An Introduction to Genetic Analysis. A.J.F. Griffiths, S.R. Wessler, R.C. Lewontin, S.B. Carroll (9th ed.). Chapter 20 (Units IV, V).

- 5) Principles of Gene Manipulation & Genomics. S.B. Primrose, R.M. Twyman (7th ed.). Chapter 26 (Unit V)
- 6) Genetic engineering. S. Rastogi, N. Pathak (1st ed.). Chapter 20 (Unit V)
- 7) Genomes 3. T.A. Brown (2nd ed.). Chapter 3 (Unit VI)
- 8) Strickberger's Evolution. B.K. Hall, B. Hallgrimsson (4th ed.). Chapter 22 (Unit III)

Part B: Proteomics and Genomics (40 marks)

Fundamentals of Protein/Peptide Separation Technique: Two-dimensional gel electrophoresis (2D-PAGE); Property of proteins; 2D electrophoresis; Protein detection; 2D DIGE;

Fundamentals of Mass Spectrometry: Sample Introduction; Mass Spectrometry Ionization Techniques; Mass analyzers; Peptide fragmentation mechanism; Interpretation of Mass Spectra; Mass-spectrometry data: basics, spectra; Sequence data: databases, tools and resources;

Quantitative Proteomics and Protein Modification Proteomics: post-translational modification proteomics; Interaction Proteomics by Co-immunopurification/Mass-spectrometry; Mass-spectrometry search engines (fundamentals, X! Tandem, Mascot);

Structural Proteomics: Deuterium exchange MS; hydrogen exchange, equilibrium and dynamics, Foot-printing analysis of macromolecules principles of covalent labeling for DNA, RNA, and proteins biophysical analysis (kinetics and thermodynamics) by footprinting, structural analysis of DNA and proteins by mass spectrometry;

Interaction Proteomics Data analysis: Graph-based visualization; Identification of protein clusters and modules; Data analysis challenges: Protein-protein interaction networks; Topology;

Genomics and Relevant Bioinformatics Tools: cDNA & genomic libraries, Sequence formats, storing & retrieval, Genome Mapping, Whole Genome sequencing (Clone-by-clone & Shotgun approaches), Sequence Assembly, Genome Annotation, genome analysis, Gene prediction, Promoter prediction, Evaluation of gene prediction, Functional & Comparative Genomics, Germplasm and maintenance, Human Genome Project overview, applications in forensic, disease prognosis, genetic counseling, Pedigree, etc. - *(Preferably by a guest lecturer)*

Teachers involved:

Dr. J. Dasgupta (Proteomics)
Guest Professor (Genomics)

Recommended texts:

Proteomics by SR Pennington and MJ Dunn

Paper II **MBCR4902**

Immunology II (50 marks)

Unit I: Hypersensitivity Reactions – Gell and Coombs Classification; IgE-mediated (Type I) hypersensitivity; Antibody-mediated Cytotoxic (Type II) hypersensitivity; Immune Complex-mediated (Type III) hypersensitivity; Type IV or Delayed-Type hypersensitivity (DTH).

(4 lectures)

Unit II: Vaccines - active and passive immunization; designing vaccines for active immunization; live, attenuated vaccines; inactivated or “killed” vaccines; subunit vaccines; conjugate vaccines; DNA vaccines; recombinant vector vaccines. **(3 lectures)**

Unit III: Immune Response to Infectious Diseases – viral infections; bacterial infections; parasitic diseases; fungal diseases; emerging infectious diseases. **(4 lectures)**

Unit IV: Major Histocompatibility Complex – general organization, expression and regulation of MHC molecules, self-MHC restriction of T-cells, antigen processing and presentation. **(4 lectures)**

Unit V: Cytokines – properties, receptors, secretion by T_H1 and T_H2 subsets, cytokine-related diseases and -based therapies. **(3 lectures)**

Unit VI: T-cell generation, maturation, activation and differentiation – organization and rearrangement of TCR, TCR complex, alloreactivity. **(5 lectures)**

Unit VII: Tolerance and autoimmunity – central and peripheral tolerance, autoimmune diseases – organ-specific and systemic, animal models for autoimmune diseases. **(4 lectures)**

Unit VIII: Transplantation immunology – immunologic basis of graft rejection, general and specific immune suppressive therapy, immune tolerance to allografts. **(3 lectures)**

Unit IX: Cancer and the Immune System – immune response to tumor antigens, tumor evasion of the immune system, cancer immunotherapy. **(3 lectures)**

Medical Biotechnology

Invited lectures by medical practitioners (unmarked, compulsory component)

Teachers involved:

Immunology II

Prof. S. Roy (Units I-III)

Dr. U. Siddhanta (Units IV-IX)

Medical Biotechnology

Guest Lecturers (medical practitioners)

Recommended Text:

Kuby Immunology – Kindst, Goldsby & Osborne (6th Edition): Ch. 8; 9; 10; 12; 15, 16; 17; 18, 19, 21.

MBCR4952

Immunology Practical (25 marks)

Immunodiffusion – Antigen-Antibody patterns; Antibody titration

Enzyme-linked immunosorbent assay – Sandwich ELISA

Immunoprecipitation (demonstration)

Western Blotting
Immunofluorescence (demonstration)

Teachers involved:

Dr. U. Siddhanta
Prof. S. Roy

Field Trip and Workshop (25 marks)

Unit I: Field Trip – Animal Biology: observation of the diversity of the animal kingdom, methods of wildlife study, preparation of observations on fauna and description of wildlife populations.

Unit II: Field Trip – Plant Biology: observation of the diversity of the plant kingdom and identification; documentation of floristics and description; preparation of herbarium sheets (selected specimens).

Unit III: Workshop

Paper III

MBCR4903

Part A: Biogeography and Conservation Biology (30 marks)

Unit I: Phytogeography: Phytogeographical zones with flora of India; vegetations of India; Major biomes (brief outline), Endemism. (6 lectures)

Unit II: Zoogeography: Zoogeographical regions and fauna; theory of island biogeography; biological rules of distribution: Allen's rule, Bergmann's rule, Gloger's Rule. (5 lectures)

Unit III: Conservation biology: (a) Conservation of bio resources: overview, concept of ecologically sensitive area (ESA), conservation strategies (in situ and ex situ) with special reference to India. (5 lectures)

(b) IUCN and the Red Data Book, endangered and threatened species, extinction and its causes, Project Tiger and tiger conservation., conservation of the great Indian bustard and Olive Ridley turtle, Wetlands and biodiversity, the Ramsar convention and wetland management. (7 classes)

Teachers involved:

Dr. A. Banerji (Units II, III b)
Dr. A. Roy Choudhury (Unit I)
Dr. P. De (Unit III a)

Recommended texts:

1) Ecology: Principles and Applications. J.L. Chapman and M.J. Reiss (2nd ed.). Chapters 18 (Unit II), 20 (Unit III a, b)

2) Ecology and Environment. P.D. Sharma (10th ed.). Chapter 14 (Unit I, III a, III b)

3) Environmental Biology – P.S. Verma and V.K. Agarwal Chapters 22, 23 (Unit I)

4) Relevant references in addition will be provided (Unit I)

5) Fundamental of Ecology – M.C. Dash (2nd ed.). Chapter 7 (Unit III a)

6) Ecology. E.P.Odum (2nd ed.). –Chapter 8 (Unit III a)

7) Environmental Biology. P.D. Sharma (2nd ed.). Chapters 10, 11 (Unit III a)

Part B: Evolution & Behaviour (70 marks)

Unit I: Evolutionary History and consequences: (a) Origin of universe and Hubble constant; frozen accident hypothesis; evolution backward hypothesis; Paleontology, palynology and Fossils, processes of fossilization, dating of fossils, index fossil; form genus and reconstruction of fossil genera; The evolutionary time scale; eras, periods and epoch; Three kingdom model of cellular evolution; major events in the evolutionary time scale; evolution of seed habit and origin of angiosperms; Telome Theory (b) Convergence and divergence; co-evolution (including mimicry); adaptive radiation; speciation: biological species concept, allopatric and sympatric species, quantum speciation, mechanisms of speciation, types of isolating mechanisms (11 lectures)

Unit II: Theories and evidences of Evolution: (a) Lamarckism, Darwinism and De Vries' theory – propositions and criticisms; (b) morphological, anatomical and embryological evidences including Haeckel's Biogenetic Law; missing links (5 lectures)

Unit III: Molecular Evolution: Concept of microevolution, classification, phylogenetic systematics, phylogenetic trees, cladistics and cladogram, molecular clocks and neutral theory of molecular evolution, molecular tools in phylogeny, gene duplication and divergence, Neo-Darwinism and the Synthetic Theory. (3 lectures)

Unit IV: The Origin and Evolution of Primates: the first hominids and origin of modern man. (2 lectures)

Unit V: Communication in animals: mechanisms of communication with reference to bees (bee dances, chemical communication) and birds (song and song development); the concept of releasers. (3 lectures)

Unit VI: The Evolution of Social Behaviour: (a) Territoriality: territorial defense and contests, costs and benefits of territoriality (b) Altruism: Prisoner's dilemma, group and kin selection, reciprocal altruism, inclusive fitness (c) Aggressive behaviour: Fight or flight reactions, game theory models of aggression (the hawk-dove model, the sequential assessment model), winner, loser, bystander and audience effects (d) Social insects and social systems: concept of eusociality, characteristics of an insect society with reference to ants and termites. (9 lectures)

Unit VII: The Evolution of Mating Systems and Parental Care: (a) Sexual Selection: mating systems, intra and intersexual selection, role in determination of mate quality, runaway sexual selection. (b) Parental care in animals: various strategies of parental care with reference to fish and amphibians. (6 lectures)

Unit VIII: Biological clocks: types of biological clocks with examples, physiological basis, the circadian clock in *Drosophila* and mammals (with special reference to human), significance of biological clocks. (3 lectures)

Unit IX: Plant Behaviour: Characteristic features of plant behavior: Mimicry; Circadian rhythm; Optimization theory and optimal foraging; territoriality; niche requirement; parental care; analogy of plant-animal nervous system; intelligent behavior of plants (examples); plant memory and learning: forms and examples; case studies of intelligence and memory taking several examples (7 lectures)

Teachers involved:

Dr. A. Banerji (Units IV, V, VI a – c, VII a)

Dr. A. Roy Choudhury (Units I, II, IX)

Dr. P. De (Units III, VI d, VII b, VIII)

Recommended texts:

1) Animal Behaviour. J. Alcock (9th ed.). Chapters 2, (Unit V), 5 (Unit VIII), 7 (Unit V), 8 (Unit VI a), 10 (Unit VII a), 12 (Unit VII b) 13, (Unit VI b, d)

- 2) Principles of Animal Behaviour. L.A. Dugatkin (2nd ed.) Chapters 6 (Unit VII a), 14 (Unit VI c)
- 3) Strickberger's Evolution. B.K. Hall, B. Hallgrimsson (4th ed.). Chapters 2, 11 (Unit III), 20 (Unit IV)
- 4) The Princeton Guide to Evolution. David A. Baum, Douglas J. Futuyma. Chapters 2, 5 (Unit III), 7 (Unit VII b)
- 5) Evolution. D.J. Futuyma (2nd ed.). Chapters 1, 4, 5, 17, 18 (Units I, II)
- 6) Evolutionary Biology. Mohan P. Arora (3rd ed.) Chapters 32, 33, 34, 35, 36, 39, 40 (Units I, II)
- 7) Ecology. J.L. Chapman and Reiss (2nd ed.) Chapters 7 (Unit IX), 8 (Unit VI d), 19 (Units I, II)
- 8) Fundamental of Ecology. M.C. Dash (2nd ed.). Chapter 4 (Unit VIII)
- 9) Relevant research papers will be provided (Unit IX)

Paper IV **MBCR4904**

Part A: Bioethics (50 marks)

Unit I: Intellectual Property Rights (IPR): General idea about intellectual property (IP) and IPR. Different forms of IPR. Patents – basic concept, important features, protection and use. Criteria of patentability. Legal, technical, scientific and commercial aspects. [8 lectures]

Unit II: Biosafety: General idea about risks of dealing with recombinant DNA technology and genetically modified organisms (GMO) in research and large-scale use. Biosafety rules – to avoid biohazards and protect environment; Regulations for biotechnology-based products and processes. Public perception. [4 lectures – ARC + 4 lectures – ACB]

Unit III: Biodiversity-status, monitoring and management: Types of biodiversity, alpha, beta and gamma biodiversity, keystone species, Ecads, ecotypes, ecospecies and coenospecies, vulnerability, endangered and rare species, causes of loss of biodiversity, reasons for higher biodiversity in tropics, centre of origin of plants & Vavilov's concepts; center of diversity; hotspots of biodiversity in India, Strategies of biodiversity conservation: Conservation in seed banks, gene banks or germplasm reserves, core collection and minicore collection, Contribution of CGIAR, IBPGR and NBPGR, Indian Biological Diversity Act, National Biodiversity Authority, National Policy of Biodiversity Conservation, Legislation measures of Biodiversity Protection: CBD and its provisions, CITES, TRIPS, Global Plan of action, Bioprospecting, Biopiracy, Environmental Impact Assessment, Sustainable development - objectives, imperatives and management strategies, Remote sensing and its application [10 lectures]

Unit IV: Bioethics: [10 lectures]

Ethical issues with animal and human systems: cloning, organ transplants, stem cell research, gene therapy, Surrogacy and sperm donation, issues concerning reproduction, birth, life and death

Ethical issues with transgenic research: genetic engineering of micro organisms, plants and animals, status of Biotech crops in India and their present status, Socio-economic and ethical considerations for transgenic crops, National Biosafety Regulatory Framework in India, Recombinant DNA safety guidelines and guidelines for transgenic research and movement of transgenic germplasm, ethical issues with toxicity, allergenicity, antibiotic resistance, promoter use, gene flow and ecological aspect associated with GM crops; Cartagena Protocol and applications

Teachers involved:

Dr. A. Roy Choudhury [Units II (part), III and IV]

Dr. A.C. Banerjee [Units I, II (part)]

Textbooks recommended:

- 1) Plant Biotechnology by H.S. Chawla – Ch. 26, 27, 30
- 2) Ecology by P.D. Sharma – Ch. 14, 21
- 3) Bioethics by S. Ignacimuthu – Ch. 2, 3, 4, 5
- 4) Relevant review papers will be provided

Part B: Animal Biotechnology III (25 marks)

Unit I: Culture of economically important insects: Lac culture, Sericulture, Apiculture (Overview of basic biology of the insects, culture methodologies and economic importance).

(5 lectures)

Unit III: Animal Husbandry: Poultry and dairy farming (Overview of animal breeds, farming techniques, economic importance).

(4 lectures)

Unit III: Medical biotechnology: (a) Outline of diagnostic histochemistry and histophysiology.

(b) Disease diagnostic markers. (3 lectures)

Unit IV: Genetic engineering in animals: (a) Strategies and methods for generation of transgenic animals, improvements of animals using transgenic approach.

(b) Animal cloning, nuclear transfer and embryo splitting.

(c) Animals as bioreactors, biopharming. (5 lectures)

Unit V: Therapeutic targets in cancer: Chemotherapy, radiotherapy, gene therapy strategies for cancer, cancer pathway signalling inhibitors, use of natural products in cancer treatment, resistance to therapy. (3 lectures)

Unit VI: Environmental regulation of development: Environmental regulation and disruption of normal development, polyphenisms, endocrine disruptors and teratogenic agents. (3 lectures)

Unit VII: Stress Biology: Basic concepts. (1 lecture)

Teachers involved:

Dr. A. Banerji (Units IV-VII)

Dr. P. De (Units I-III)

Recommended texts:

- 1) Principles of Gene Manipulation & Genomics. S.B. Primrose, R.M. Twyman (7th ed.) Chapter 12 (Unit IV)
- 2) The Biology of Cancer. R.A. Weinberg (1st ed.) Chapter 16 (Unit V)
- 3) Developmental Biology. S.F. Gilbert (8th ed.). Chapter 21 (Unit VI)
- 4) Genetic engineering. S. Rastogi, N. Pathak (1st ed.). Chapter 20 (Unit IV)
- 5) Relevant scientific literature (Units V, VII)
- 6) Text Book of applied zoology. P.V. Jabde. Chapters 3-5 (Unit I)
- 7) Economic zoology biostatistics and animal behavior. S. Mathur. Chapters 6-8 (Unit I), 13,14 (Unit II)
- 8) Relevant scientific literature (Unit III)

Part C: Term Paper (Written component, 25 marks)