UNIVERSITY OF CALCUTTA

Notification No. CSR/ 8 /14

It is notified for the information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 03.03.2014, **approved the Revised syllabus for the M.Sc. Course of study in Genetics** under this University as laid down in the accompanying pamphlet.

The above will take effect from the academic session 2014-2015 and onwards.

12.03.2014

SENATE HOUSE
KOLKATA-700073
The 12th March, 2014

(Prof. Basab Chaudhuri)

Registrar

Syllabus

M.Sc. Genetics

University of Calcutta

2014

Orientation of courses in four semesters for M.Sc in Genetics

1st Semester

Core courses		***Marks***	***Credits***
Gen C11	Principles of Genetics	50	4
Gen C12	Cell and Molecular Biology	50	3
Gen C13	Chromosomes, Genes and Genomes	50	3
Gen C14	Enzymology and Metabolism	25	2
Gen C15	Practicals	75	6
		175 (Theoretical) + 75 (Practicals) = 250	12 (Theoretical) + 6 (Practicals) = 18

2nd semester

Core courses		***Marks***	***Credits***
Gen C21	Microbial Genetics	25	3
Gen C22	Regulation of Gene Expression	50	3
Gen C23	Recombinant DNA Technology	25	2
Gen C24	Immunology	25	1
Gen C25	Biostatistics	25	1
Gen C26	Practicals	100	8
		150 (Theoretical) +100 (Practical) = 250	10 (Theoretical) + 8 (Practical) = 18

3rd Semester

Core courses		***Marks***	***Credits***
Gen C31	Developmental Genetics	50	3
Gen C32	Plant Breeding and Biotechnology	50	3
Gen C33	Animal Genetics and Biotechnology	50	3
Gen C34	Human Genetics and Genomics	50	3
Gen C35	Summer Internship	25	2
Gen C36	Practicals	50	4
		200 (Theoretical) + 75 (Practical) = 275	12 (Theoretical) + 6 (practical) = 18

4th Semester

Core courses		***Marks***	***Credits***
Gen C41	Quantitative and Statistical Genetics	50	4
Gen C42	Ecology, Evolution and Biodiversity	25	2
Gen C43	Proteomics	25	2
Gen C44	Bioinformatics	25	2
Gen C45	Review Paper in Genetics	25	4
Gen C46	Seminar	25	2
Gen C47	Grand Viva	50	2
		125 (Theoretical) + 100 (Practical) = 225	10 (Theoretical) + 8 (Practical) = 18
Total Marks/Credits		**650 (Theoretical) + 350 (Practical) = 1000**	**44 (Theoretical) +28 (Practical) = 72**

Detailed Syllabus for two years M.Sc Course in Genetics, CU - 2014

First Semester

Gen C11: Principles of Genetics~ 50 marks; 4 credits, 50 Lecture hours

Basic Mechanisms of inheritance: Genetics in biology, Model systems in Genetic Analysis -Life cycles of some genetically important organisms such as viruses, bacteria, Neurospora, Drosophila, Maize, Arabidopsis and Homo sapiens.[6]

Mendelian Genetics and Extensions - Mendel's Laws of Inheritance, with specific examples from plants, Drosophila and human. Chromosome theory of inheritance; Mendelian Genetics in Eukaryotic life cycles. Extensions to Mendelism- dominance, co-dominance and incomplete dominance; pleiotropism; lethals and sub-lethals; genotypic interactions-epistasis, mechanism of epistasis; biochemical genetics: Inborn errors of metabolism, one gene –one enzyme hypothesis; multiple alleles-ABO blood groups in humans, pseudoalleles- Rh blood group incompatibility; complex loci; complementation test in genetic analysis; Mitosis and Meiosis in plants, animal and human; Chromosomal theory of heredity [18]

Chromosome segregation and Mapping-meiosis; formation and function of synaptonemal complex, crossing over and chiasmata formation; genes affecting meiosis. Genes and environment; norm of reaction, phenocopies. Linkage and mapping in eukaryotes; Linkage, discovery, cytological basis of crossing over; coupling versus repulsion of syntenic alleles, the chi square test for linkage, recombination frequency and map construction, genetic mapping in a three point test cross, examples of linkage maps, coincidence and interference; haploid mapping-tetrad analysis in fungi; unordered (yeast) and ordered (Neurospora) spores; Specialized eukaryotic chromosome mapping techniques. Analysis of single meiosis [18].

Sex determination; sex linkage and Pedigree analysis: Concept of sex determination and patterns in plants and animals; sex chromosomes; sex determination in flowering plants; dosage compensation; Sex -linked, sex-limited and sex-influenced characters [4]

Extra-nuclear inheritance: determining non-Mendelian Inheritance; maternal effects; cytoplasmic inheritance; mitochondria; chloroplasts; infective particles; prokaryotic plasmids; Imprinting.[4]

Recommended readings:

1. Concepts of Genetics, Klug WS and Cummings MR – Prentice Hall
2. Genetics: a Conceptual Approach, Pierce BA – Freeman
3. Genetics: Analysis of Genes and Genomes, Hartle DL and Jones EW – Jones and Bartlett
4. Principles of Genetics, Snustad DP and Simmons MJ – John Wiley & Sons
5. An introduction to Genetic Analysis, Griffith AF et al., - Freeman
6. Genetics, Strickberger MW – Prentice Hall

Gen C12: Cell and Molecular Biology ~ 50 marks; 3 credits; 45 lecture hours

Origin of life. An overview, endosymbiotic origin of mitochondria and chloroplast Origin of biomolecules, primitive life forms, RNA world, biological evolution .Tree of life**:** rRNA as a chronological marker, Woese's concept of molecular taxonomy. [3]

Cellular organization: Structure of cell organelles - An overview, Cell wall and membrane structure; Membrane constituents- phospholipids, glycolipids, cholesterol, membrane proteins; receptors and phospholipases; Phospholipid bilayer- structure, asymmetry, fluid mosaic model of random diffusion of membrane components, domains in membrane- natural and artificial membranes passive movements of solutes , ion distribution; mediated permeation; ionophores; membrane transport of small molecules and the ionic basis of membrane excitability; principles of membrane transport; carrier proteins and active membrane transport; ion channels and electrical properties of membranes, Cell junctions and cell adhesion molecules; basement membrane; extracellular matrix [10]

Visualization of cells and fine structures: Bright field, fluorescent (confocal and deconvolution) and electron microscopy, Common cell biology techniques: Fractionation, immunoprecipitation, immunolocalization, live cell imaging, flow cytometery; mutant hunts; FRAP, FRET, FLIM, TIRF [5]

Informational molecules: DNA as genetic material, DNA structure and replication. RNA as genetic material, types of RNA, role of RNA in information transfer, concept of central dogma, Genetic code, codon usage, protein structure: primary, secondary and tertiary, processing, sorting and transport; versatility of the proteins in biological processes. [10]

Structural and functional aspect of different PTMs (phosphorylation, glycosylation, ubiquitination, S-nitrosylation, methylation, N-acetylation, lipidation, ubiquitin-like modifiers) [5]

Protein degradation: vacuolar and proteasomal (including ubiquitination) [2]

Cell cycle and its regulation: Cell cycle check points and regulation in *S. cerevisiae* and *S. pombe* [4]

Cell signalling: G-protein coupled receptors, Tyrosine, Serine, Threonine and Histidine Kinases mediated signalling pathways [3]

Mechanisms of DNA damage repair: Proof reading activity of DNA polymerases, Direct reversal of damaged DNA, Post-replication repair, Error-prone repair, Repair of double-strand breaks [3]

Recommended readings

1. Principles of Biochemistry, Lehninger et al., - Freeman
2. Biochemistry, Berg JM, Tymoczko JL and Stryer LT – Freeman
3. Biochemistry, Devlin TM – Wiley-Liss
4. Molecular Biology of the Gene, Watson J et al., - Benjamin Cummings
5. Molecular Cell Biology, Lodish H et al., - Freeman
6. The World of the Cell, Becker WM et al., - Benjamin Cummings

Gen C 13: Chromosomes, Genes, Genomes ~ 50 marks; 3 credits; 45 lecture hours

Chromatin structure: Histones, DNA, nucleosome morphology and higher level organization; Functional states of chromatin and alterations in chromatin organization. [5]

Chromosome organization: Metaphase chromosomes**:** centromere and kinetochore, telomere and its maintenance; Holocentric chromosomes; Heterochromatin and euchromatin, position effect variegation; Chromosomal domains (matrix, loop domains) and their functional significance. [6]

Giant chromosomes: Polytene and lampbrush chromosomes. [1]

Cytogenetic aspects of cell division: Chromosome labeling and cell cycle analysis, Overview of mitosis and meiosis, sister chromatid cohesion remodeling, regulation of exit from metaphase, chromosome movement at anaphase. Genetic control of meiosis with examples from yeast. [3]

Chromosomal anomalies: Changes in Chromosome number and structure: Polyploidy, aneuploidy, chromosomal rearrangements - deletion, duplication, inversion, and translocation. Meiotic consequences in structural heterozygotes, role in speciation and evolution. Numerical and structural alterations induced chromosomal aberrations in somatic cells. [6]

Techniques in the study of chromosomes and their applications: Short term (lymphocyte) and long term (fibroblast) cultures, karyotyping, banding, chromosome labeling, *in situ* hybridization, chromosome painting, comparative genome hybridization (CGH),somatic cell hybrids and gene mapping, premature chromosome condensation. [6]

Concept of gene: Classical and modern views on observable phenotype and identity based on nucleotide sequence. Fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families. [6]

Genome organization in viruses, prokaryotes and eukaryotes: Viral genomes and mobile genetic elements, Transposable elements, Genomes of prokaryotes and eukaryotic organelle, Organization of eukaryotic nuclear genomes, C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs, LINES, SINES, Alu family. [12]

Recommended Readings

1. Essential Cell Biology, Alberts B et al., - Garland
2. Molecular Biology of the Cell, Alberts B et al., - Garland
3. The Eukaryotic Chromosome, Bostock CJ and Summer AT – Elsevier
4. The Chromosome, Hamsew and Flavell Bios
5. Advanced Genetic Analysis, Hawley and Walker – Blackwell
6. Structure and Function of Eukaryotic Chromosomes, Hennig – Springer
7. Genes IX, Lewin B – Pearson
8. Molecular Cell Biology, Lodish H et al., - Freeman
9. Cell and Molecular Biology, De Robertis and De Robertis – Lippincott and Wilkins
10. Genomes, Brown TA - Garland

Gen C14: Enzymology and Metabolism ~~ 25 marks; 2 credits; 25 lecture hours

Enzymes as biocatalysts: Concepts of active site, substrate, coenzyme, cofactors, reaction specificity and classification of enzymes [1]

Enzyme Kinetics and Regulation: Michaelis-Menten model of enzyme kinetics; the steady state approximation; kinetic constants and their significance; enzyme assays and kinetics of enzyme inhibition; deviation from linear kinetics [3]

Allosteric enzymes; regulation of enzyme activity by proteolysis, by reversible covalent modification [2]

Strategies for harvesting and storage of metabolic energy: Carbon cycle, thermodynamics of cellular reactions, metabolic networks - an overview [1]

Glycolysis, Cori cycle, the citric acid cycle, electron transport, oxidative phosphorylation and regulation of ATP production, mitochondria - its structure and role in ATP generation [3]

Synthesis of glucose from non-carbohydrate precursors - gluconeogenesis; the pentose phosphate pathway [2]

Oxidative degradation of fatty acids; Biosynthesis of cholesterol and fatty acids [3]

Biosynthesis and degradation of amino acids; nitrogen fixation mechanisms and control of cycle; urea cycle and porphyrin metabolism [4]

Nucleotide metabolism - biosynthesis and degradation; importance of ribonucleotide reductase and dihydrofolate reductase in DNA and RNA synthesis [3]

Photosynthesis, light and dark reactions; metabolic adaptations in C3 and C4 plants [3].

Recommended readings

1. Biochemical Calculations, Sehgal IH – Wiley
2. Fundamentals of Enzymology TPrice NC and Lewis ST – Oxford
3. Principles of Biochemistry, Lehninger et al., - Freeman
4. Biochemistry, Berg JM, Tymoczko JL and Stryer LT – Freeman
5. Molecular Biology of the Cell, Alberts B et al., - Garland

Gen C15: Practicals (based on theory papers) ~ 75 marks; 6 credits

Second Semester

Gen C21: Microbial Genetics ~ 25 marks; 3 credits; 27 lecture hours

Fundamentals of Bacterial Genetics: Identification and selection of mutants; plasmids - types, detection, replication, partitioning, copy-number control and transfer; properties of some known plasmids; genetic rearrangements and their evolutionary significance; BAC [4]

Methods of gene transfer in Bacteria: Transformation - natural transformation systems, mechanism, gene mapping by transformation; chemical-mediated and electrotransformation [2]

Conjugation-discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F12 heteroduplex analysis, chromosome transfer in other bacteria, molecular pathway of recombination [3]

Transduction- Generalized and specialized transduction; gene mapping by specialized transduction, mechanism of generalized transduction, abortive transduction [2]

Biology and genetics of Bacteriophage - virulent phage (T4) and temperate phage (lambda); Important aspects of life cycles; phage genome and gene mapping; host parasite relationship, immunity and repression; site specific recombination (lambda); transposable phage (Phage Mu), genetic organization, transposition, Mu as a genetic tool, PAC [6]

Yeast genetics- life cyles, nuclear and organellar genomes, making mutants and analyzing genetic interactions in yeast, genetic nomenclature and genome manipulation strategies, random spore analysis, complementation, heterothallism and mating type switches, gene disruption plasmids, YAC [10]

Recommended readings

1. Microbial Genetics, Maloy SR, Cronan JE and Freifelder D – Jones and Bartlett
2. Yeast: Molecular and Cell Biology, Horst – Wiley
3. Modern Microbial Genetics, Streips UN and Yasbin RE – Wiley
4. A Genetic Switch: Phage Lambda Revisited Ptashne M – Kindle edition

Gen C22 Regulation of Gene Expression ~ 50 marks; 3 credits; 50 lecture hours

Regulation of Prokaryotic Transcription and Translation: Lessons from bacteria; *lac*, *trp,* and *ara* operons; control of lysis and lysogeny in lambda phage; gene regulation in yeast - *gal* operon [6]

Eukaryotic Transcription Control: RNA polymerases, DNA sequences, transcription factors, process of initiation, elongation and termination; gel retardation assays, reporter gene assays, EMSA, primer extension, S1 nuclease mapping assays [8]

Long Range Transcriptional control in Eukaryotes: Chromatin loop domains, matrix attachment regions, remodeling of chromatin structure, enhancers, long range and epigenetic control mechanisms, ENCODE project; CHIP assays [6]

Post transcriptional control mechanisms: mRNA capping, poly-adenylation and other processing events, mRNA turnover and stability [6]

Alternative RNA splicing (*cis*- and *trans*-), t-RNA splicing; general idea about snRNPs; RNA editing, nucleocytoplasmic RNA transport and localization [6]

Eukaryotic translation control mechanisms: Ribosome structure; peptidyl transferase as ribozyme; genetic code, codon usage and codon bias; Translation initiation mechanisms, insights from viral systems - internal ribosome entry sites; elongation and termination; post-translational modifications; *in vitro* systems for assay of translation - rabbit reticulocyte and wheat germ lysates [12]

RNA interference: mechanisms and enzymology; RISC complex formation; regulation of gene expression by miRNP pathway; plant-virus interactions and silencing of RNA [6]

Recommended readings

1. Molecular Cell Biology, Lodish H et al., - Freeman
2. The Cell: A Molecular Approach, Cooper GM - Sinauer
3. Molecular Biology of the Cell, Alberts B et al., - Garland
4. Genomes, Brown TA – Garland
5. Human Molecular Genetics, Strachan T and Read AP – Garland Science
6. Modern Genetic Analysis, Griffiths AJF et al., - Freeman
7. Biochemistry Berg JM, Tymoczko JL and Stryer L – Freeman

Gen C23 Recombinant DNA Technology ~ 25 marks; 2 credits; 20 lecture hours

Overview of rDNA technology: applications in genetic engineering, medicine and agriculture; biosafety and ethics [1]

General principles and molecular tools: Restriction modification systems, restriction enzyme types and their classification; modifying enzymes used in molecular cloning; methylases, polymerases, ligases, kinases, phosphatases, nucleases; plasmid and phage vectors, cosmids, yeast & bacterial artificial chromosomes [5]

Restriction mapping, cloning, strategies for construction of genomic and cDNA libraries; PCR and primer design, Rapid amplification of cloned ends (RACE); Positional Cloning (chromosome walking, chromosome jumping) [5]

Strategies for Nucleic acid analysis: Hybridization Probe design and labeling methods; Southern, Northern, Western and South-Western, Dot and Slot blots; Colony hybridization, Subtractive hybridization, Differential display, Serial analysis of gene expression (SAGE) [5]

Sequencing of DNA and RNA by chemical and enzymatic methods [2]

Site-directed mutagenesis and protein engineering [2]

Recommended readings

1. Recombinant DNA, Watson J – Freeman

2. Recombinant DNA: Genes and Genomes, a short course, Watson J, Myers RM, Caudy AA, Witkowski JA - Freeman

Gen C 24: Immunology ~ 25 marks; 1 credit; 30 lecture hours

Innate immunity: Cells (monocytes/macrophages; dendritic cells; NK cells) and organs of the innate immune system; Inflammation; complements [5]

Acquired immunity: B cells maturation, activation and differentiation; Immunoglobulin, subclasses, immunoglobulin genes, generation of antibody diversity, VDJ recombination; Antibody Class switching [8]

T-cell maturation, T_H and T_c activation and differentiation; T-B cooperation; CTL-mediated target cell killing [6]

Immune Mechanisms: Cytokines; Major Histocompatibility Complex; antigen processing and presentation [3]

Clinical Immunology: Inherited and acquired immunodeficiency disorders; Tolerance and autoimmunity; Transplantation and Tumor Immunology [8]

Recommended readings

1. Essential Immunology, Roitt IM - Wiley
2. Kuby Immunology, Goldsby RA, Kindt TJ and Osborne BA - Freeman

Gen C25 Biostatistics ~ 25 marks; 1 credit, 20 lecture hours

Introduction—Biological Data analysis steps [1]

Descriptive statistics [1]

Central tendency, Dispersion, Standard error,

Statistical Inference [12]

Confidence limits, Tests for nominal variables, Exact binomial test, Power analysis,

Chi-square test of goodness-of-fit, Randomization test of goodness-of-fit, Chi-square test of independence, G-test of independence ,Fisher's exact test , Randomization test of independence ,Small numbers in chi-square and G-tests, Repeated G-tests of goodness-of-fit, Cochran-Mantel-Haenszel test,

Tests for one measurement variable, Student's t-test, Introduction to one-way anova, Kruskal-Wallis test,

Paired t-test, Wilcoxon signed-rank test, Sign test, Tests for multiple measurement variables

Regression [4]

Linear regression and correlation, Spearman rank correlation, Polynomial regression, Multiple regression, Logistic regression

Multiple tests [2]

Multiple comparisons, Meta-analysis

Recommended readings

1. Biostatistics, Daniel WW- Wiley
2. Statistical methods in Biology, Bailey NTJ – Cambridge Univ. Press

Gen C26: Practicals (based on theory papers) ~ 100 marks; 8 credits

Third Semester

Gen C 31: Developmental Genetics ~ 50 marks; 3 credits; 45 lecture hours

Basic concepts of development: Gametogenesis, potency, commitment, specification, determination and differentiation, cell fate and cell lineages; mosaic versus regulative development; basic tools to study Developmental Genetics. [5]

Fertilization and early development in animals: Fertilization, cleavage, gastrulation, cell specification; axis and pattern formation with examples from sea urchin, *C. elegans* and *Drosophila*. Induction and competence [5]

Fertilization and early development in plants: Gametophyte development and fertilization, post-fertilization changes, embryogenesis in Arabidopsis, organization of shoot and root apical meristem, leaf development and phyllotaxy; transition to flowering, floral meristems and floral development [5]

Developmental genetics in animals:

Genes for development in Drosophila: Maternal effect genes and zygotic genes; Genetic basis of pattern formation in early development: coordinate genes, gap genes, pair-rule genes, segment polarity genes, homeotic genes, HOX genes

Genetics of dosage compensation in *C. elegans*, Drosophila and mammals

Ocular and neural development in Drosophila

Programming and reprogramming in development.

Morphogen gradients and gene regulatory mechanisms.

Fossils, genes and embryos [15]

Developmental genetics in plants

Approaches to study genes involved in plant development in Arabidopsis and maize

Cell lineages, positional information, Pattern formation and morphogenesis

Genes controlling development: MADS-box genes, KNOX genes; major gene regulatory networks involved

Genetic Control of Phase changes in plant development; juvenile to adult plant; transition to flowering - vegetative to reproductive evocation, floral homeotic mutations in Arabidopsis, Antirrhinum and Petunia, gender expression in monoecious and dioecious plants

Pollination and fertilization; gametophytic and sporophytic incompatibility

Environmental regulation of plant development

The Epigenome and plant development/ epigenetic reprogramming of plant reproductive lineages [15]

Recommended readings

1. Molecular Genetics of Plant Development, Howell SP – Cambridge

2. Developmental Biology of Flowering Plants,V Raghavan – Springer

3. Developmental Genetics and Plant Evolution, Quentin C.B. Cronk, Richard M. Bateman, Julie A. Hawkins - CRC Press
4. Principles of Development, Wolpert L and Tickle C - Oxford
5. Developmental Biology, Gilbert SF, - Sinauer
6. Medical Embryology, TW Sadler – Wolters Kluver Ind Pvt Ltd.

Gen C 32 Plant Breeding and Biotechnology ~ 50 marks; 3 credits; 50 lecture hours

Plant Breeding: History, genetic diversity in plant breeding. [1]

Conventional breeding methods for self, cross-pollinated and vegetatively propagated crop plants. Heterosis breeding .Polyploidy and haploids in plant breeding . Seed production and variety development [4]

Cytogenetic tools in Plant breeding: Cytogenetic architecture of rice, wheat, oat and other crops [3]

Marker assisted breeding: Introduction - molecular markers as new efficient tools in breeding. marker aided selection – foreground and background selection, concept of graphical genotypes, elimination of linkage drags. [10]

Molecular markers for genome mapping: Principles of genetic linkage, concept of genetic distance, development and choice of mapping populations, linkage map construction – relational, integrated and comparative maps. [8]

Plant tissue culture and somatic cell genetics: Plant regeneration pathways - Organogenesis and Somatic embryogenesis; Endosperm culture and triploid production; Anther and pollen culture, and production of haploid and doubled haploid plants; Protoplast culture and fusion, Somatic hybrids; Organelle transfer and cybrids; Micropropagation,artificial seed and bioreactor technology, Virus-free plants by meristem culture; Use of somaclonal and gametoclonal variation for crop improvement; In vitro mutagenesis and mutant selection; Preservation of plant germ plasm *in-vitro*. [6]

Plant transformation vectors and methods: Plant transformation vectors - T-DNA and viral vectors, direct gene transfer vectors; Selectable marker and reporter genes, Plant transformation by Agrobacterium sp., non-Agrobacterium sp., and in planta transformation, Molecular mechanism of T-DNA transfer; Direct gene transfer methods in plants - Gene gun and other methods; Chloroplast transformation; Transgene analysis, silencing and targeting; Marker-free and novel selection strategies; Multigene engineering; Gene tagging; Gene knock-down by ribozymes, antisense RNA and RNA interference. Comparative genomics and cloning, positional cloning [10]

Applications of plant transgenic technology: Transgenic crops for resistance against biotic and abiotic stresses; Engineering crops for male sterility and modification of flower colour, flowering, fruit ripening and senescence; GM crops for nutritional quality and quantity; RNAi-mediated crop improvement; Molecular pharming; Metabolic engineering and hairy root culture for secondary plant products; Other applications; Global status and biosafety of transgenic plants. [8]

Recommended readings

1. Principles of Plant Breeding, Allard RW – Wiley
2. Plant Breeding Theory and Practice, Stoskopf NC, Tomes DT and Christie BR – Westview Press
3. Genome Mapping in Plants, Paterson AH – Academic Press
4. Molecular markers in Plant Genetics and Biotechnology, Vienne D – INRA
5. Quantitative Genetics, Genomics and Plant Breeding, Kang MS – CABI Publishing
6. Plant Molecular Breeding, Newbury HJ – CRC Press

GenC33: Animal Genetics and Biotechnology ~ 50 marks; 3 credits; 50 lecture hours

Animal Genetics

Drosophila Genetics:

Drosophila karyotype and genome: wild type and mutants, Genetic crosses, creation of isogenic lines, Autosomal linkage.

Immunogenetic aspects of the cellular immune response of Drosophila against parasitoids.

Neurogenetics of courtship and mating in Drosophila.

Natural behavioral variants of Drosophila.

C. elegans Genetics:

Isolation, complementation and mapping of mutants of *C. elegans* with special reference to screening for suppressor/enhancer mutations and synthetic lethal mutations.

Genes affecting nervous system function and behavior.

C. elegans as a model to study innate immunity.

Mammalian genetics (non-human)

Mouse as a model mammalian genome; establishment of inbred strains; mouse genome database.

Revelations of the genome sequencing of whales and horses.

Genes and environment coming together to shape animal behavior ~ chimpanzee as a model.

Parental Behavior and fosB Mutant Mice.

Behavioral Traits in Breeds of Hunting Dogs.

Environment, Genetics and Cognitive Development. [25]

Animal Biotechnology

Cell culture technology and its applications: Introduction to animal cell culture technology; Primary and established cell line cultures; cell culture media; Role of carbon dioxide; Role of serum and supplements. Serum & protein free defined media and their application; Measurement of viability and cytotoxicity; Biology and characterization of the cultured cells; measuring parameters of growth. Basic techniques of mammalian cell culture *in vitro*: disaggregation of tissue and primary culture, maintenance of cell culture; cell separation; scaling-up of animal cell culture; cell synchronization; cell cloning and micromanipulation; cell transformation.

Application of animal cell culture: Stem cell culture, embryonic stem cells and their applications; Cell culture based vaccines; Organ and histotypic cultures; Measurement of cell death: Apoptosis, three dimensional culture.

Genetic engineering of animals: *in vitro* gamete maturation. *In vitro* fertilization (IVF) and embryo transfer (ET), Sex determination or sex specific makers, sexing of sperm and embryos, Assisted reproductive technology (ART).

Somatic cloning of animals; Creation of transgenic animals: microinjection technology; Improvements of animal production and quality using transgenic approach with specific examples. Animals as bioreactors: Genetically engineered animals for research. Knock-out animals. Conditional knock outs using cre-loxP recombination; tissue specific promoters. [25]

Recommended readings

1. Genetics, Strickberger MW - Garland
2. C. elegans II, Riddle DL, Blumenthal T, Meyer BJ, Priess JR – Cold Spring Harbor Press
3. Mouse Genetics and Transgenics: A Practical Approach, Jackson IJ and Abott CM – Oxford
4. Culture of Animal Cells: A manual of basic techniques and specialized applications, Freshney IR – Wiley-Blackwell

Gen C34: Human Genetics and Genomics ~ *50 marks; 3 credits; 45 lecture hours*

History and Development of Human Genetics

Genes, Hereditary traits, Genetic Disease, Mutations and polymorphisms, Human Genome Project. [1]

Organization of Human Genome: [4]

Repetitive DNA in Human Genome, Simple sequence repeat loci; Intron, exon, UTR, regulatory sequence, non-coding RNAs, mitochondrial genome

Identification of disease gene/locus: Methods of Genetic Study in Human [12]

Mendelian pedigree pattern and analysis Expressivity

Chromosomal Basis of Genetic Disorders: Chromosomal Analysis, Karyotypes and identification of chromosome variation; Nucleic Acid Hybridization Assays, cytogenetic mapping

Single gene disorders: Genetic mapping (Microsatellite and other DNA polymorphisms in mapping), LOD score; Physical mapping, sequencing strategies (PCR based Sanger sequencing to Exome sequencing)

Concept of non mendelian inheritance and complex diseases

Genetic Factors in common Diseases and techniques needed to decipher those: [12]

congenital defects, coronary heart disease, diabetes, mental diseases, Defects in membrane Transport (Cystic Fibrosis); Defects in structural proteins (DMD and BMD); collagen disorders (Osteogenesis Imperfecta); Locus Heterogeneity; Inter-allelic and intra-allelic heterogeneity; Genetics of triplet repeat disorders.

Transition from Genetics to Genomics: [2]

Structural, Functional and Comparative Genomics; Need to study whole genome.

Cancer Genetics: [4]

Somatic Mutations and affected pathways, Oncogenes and TSGs, LOH, Control of Cell Cycle, Epithelial mesenchymal transition; Control of Genome stability, methods to study alterations of gene expression in cancer (through Microarray),

Pharmacogenetics and Pharmacogenomics: [2]

Effects of drugs in individual and susceptibility; personalized medicine

Somatic Cell Genetics [2]

Studying Human Gene structure, Expression and function using cell culture.

Gene Therapy: Lentiviral and adenoviral vectors for correction of single gene disorders; trials in animal models of human disease; safety concerns in clinical applications [1]

Stem Cell Research: Induced pleuripotent stem cells in human genetics research; stem cells as agents for propagation of vectors used in gene therapy [1]

Genetic Counseling and Ethics Genetic screening and pre-implantation genetic diagnosis; Clinical, psychosocial and ethical aspects of human genetics research; case studies [1]

Epigenetics Overview of epigenetic inheritance with regard to DNA and histone modifications, techniques to study epigenetic mechanisms such as restriction landmark genome scanning, sodium bisulphite based DNA sequencing, chromatin immunoprecipitation coupled microarrays; epigenetic phenomena in human disease [3]

Recommended readings

1. Human Molecular Genetics, Strachan T and Read AP – Garland Science
2. Genomes, Brown TA – Wiley Liss
3. Human Genetics and Genomics, Korf BR - Wiley
4. The Book of Genes and Genomes, Willard and Haga, - Springer
5. Modern Genetic Analysis, Griffiths AJF, Gelbart WM, Miller JH et al., - Freeman
6. An Introduction to Genetic Analysis, Griffiths AJF, Miller JH, Suzuki DT et al., - Freeman

Gen C 35: Summer Internship~ 25 marks; 2 credits

A project performance report based on the summer research training in a reputed laboratory of excellence will have to be submitted. A presentation of the accomplishments will be required, before a panel of experts. Evaluation will be based on the project report and the presentation.

Gen C36: Practicals (based on theory papers) ~ 50 marks; 4 credits

Fourth Semester

Gen C41: Quantitative and Statistical Genetics ~50 marks; 4 credits; 48 lecture hours

Population Genetics and Association Mapping

Population structure and effective population size; Hardy-Weinberg Equilibrium: Allele and genotype frequency measurements, Random and non-random mating, inbreeding depression and inbreeding co-efficients; causes of changes in allele frequency through natural selection/artificial selection; migration and random genetic drift

Linkage and Linkage Disequillibrium, Haplotype frequency estimation with unphased genotypes; genetic association and multiple testing corrections; Genome Wide Association analysis (GWAS and EWAS);

Coalescent theory ~Derivation and properties, extensions to include recombination, geographic structure and natural selection; usage in disease gene map analysis, recombination rate estimation and adaptive evolution, large scale surveys of genetic variation [12]

Quantitative Genetics and QTL mapping

QTL mapping strategies; Statistical methods for mapping QTL in experimental cross populations (experimental design, linkage map construction, single-marker analysis, interval mapping and multiple interval mapping)

Estimation of breeding values and genetic variances in general pedigrees, association mapping, genomic selection, direct and associative models of general group and kin selection, genotype by environment interaction models [12]

Molecular Phylogenetics

Genetic diversity, genetic distance and measures of relatedness; Methods for analysis of interspecific DNA and protein sequence data ~ parsimony, maximum likelihood, distance based and Bayesian methods for phylogenetic estimation [12]

Statistical Analysis of Gene Expression Profiing

Theory and application of transcriptomics, Microarray and RNA-seq technologies; statistical basis of hypothesis testing, central role of normalization strategies, examples using the SNM module in R, concept of false positives and false negatives. [10]

Usage of public domain softwares [2]

Recommended readings

1. Statistical Genetics: Linkage, Mapping and QTL analysis, Ben Hui Liu – CRC Press
2. Statistical Genetics: Gene Mapping Through Linkage and Association, ed. By B Neale, M Ferreira, S Medland, D Posthuma – Taylor Francis
3. The Fundamentals of Modern Statistical Genetics NM Lairdand, C Lange - Springer
4. Computational Molecular Evolution, Z Yang, 2006, Oxford University Press.

Gen C 42: Ecology, Evolution and Biodiversity ~25 marks; 2 credits; 26 lecture hours

Biodiversity: Concept: species diversity, genetic diversity, ecosystem diversity; alpha, beta, gamma diversity; Values- economic, ecological , aesthetic, evolutionary; Biodiversity hot spots; Megadiversity Centres of the world; Centre of origin of crop plants; Concerns: Extinction and threats ; IUCN Categories of threatened species ;conservation: principles, in situ and ex situ –seed, gene and DNA Banks; NBPGR and IBPGR; Biodiversity act; protection of plant varieties and farmers right act; biopiracy and bioprospecting [10]

Ecology: Concept of community and continuum; habitat ; ecological niche; resource partitioning; character displacement; edges and ecotones; succession; characteristics of populations ; population growth curve; life history strategy(r and k selection) ;concept of meta population; ecosystem structure and function ; Theory of Island biogeography; Biogeographic zones of India [8]

Evolution: Adaptive radiation and modifications; Isolating mechanisms; Speciation-allopatric and sympatric, convergent evolution; sexual selection and gene flow, co-evolution, Evolutionary Game Theory, Zahavis hypothesis, Prisoners' Dilemma; origin and evolution of gene.; Molecular Evolution-amino acids and nucleotide substitutions, synonymous codon; Molecular divergence and molecular clock; Molecular tools in phylogeny, classification and identification; Origin of new genes and proteins; gene duplication and divergence [8]

Recommended readings

1. Biodiversity, Wilson EO – The National Academies Press
2. The Diversity of Life, Wilson EO – Penguin Press Science
3. Textbook of Biodiversity, Krishnamurthy KV – Science Publishers
4. Ecology: Principles and Applicatiions, Chapman JL and Reiss MJ – Cambridge Univ. Press
5. Ecology, Ricklefs RE and Miller G - Freeman
6. The Darwinian Tourist: Viewing the World Through Evolutionary Eyes, Wills C – Oxford Univ. press

Gen C43- Proteomics ~ 25 marks; 2 credits; 25 lecture hours

The dynamic proteome: Protein modifications and their importance in cell functions; proteomes and an overview of their importance in studying cellular pathophysiology and biomarker discovery and applications [5]

Overview of proteome analysis: Basic principles of protein purification, separation and characterization; 2D Gel-electrophoresis, tryptic fingerprinting followed by microsequencing, Protein-protein interactions*:* Yeast two hybrid and mammalian cell hybrids*,* and techniques for enrichment of modified proteins; DIGE, *SELDI-TOF, iTRAQ,SILAC, PF-2D, ESI ~ Sample* preparation and data analysis.

Principles of Mass spectroscopy, MALDI-TOF ~ *sample* preparation, types of matrices, fragmentation patterns and data analysis, structural proteomics [20].

Recommended readings

1. Introduction to Proteomics, Liebler DC – Humana Press
2. Introduction to Proteomics: Principles and Applications, Mishra NC - Wiley
3. Proteomics: Human Diseases and Protein Functions, Man TK and Flores RJ
4. Genomics, Proteomics and Bioinformatics, Yu J - Elsevier
5. Molecular Biology, Friefelder D

Gen C44 - Bioinformatics ~ 25 marks; 2 credits; 25 lecture hours

Biological Databases: Overview, Applications, Prospects; Modes of database search, data storage (flat file, db-tables); Gene and protein sequence databases; GenBank, EMBL, DDBJ, PDB; access to sequence databases via internet [3]

Sequence alignment and sequence analysis: Concept of local and global sequence alignment, Pairwise sequence alignment, scoring an alignment, substitutional matrices, Pattern recognition, BLAST; Multiple sequence alignment, homology, analogy (ClustalW, T-Coffee, GeneDoc) [6]

Generation and analysis of high through-put sequence data: Assembly pipeline for clustering of HTGS data, format of '.ace' file, quality assessment of genomic assemblies, International norms for sequence data quality, Clustering of EST sequences, concept of Unigene; Sequence assembly, Staden package; assembly strategies for next generation sequencing [6]

Automated sequence analysis and annotation pipelines (MAGPIE, Blujay); Annotation procedures for high through-put sequence data: Identification of various genomic elements (Protein coding genes, repeat elements, Strategies for annotation of whole genome, functional annotation of EST cluster, gene ontology (GO) consortium. [6]

Higher order structure prediction: Secondary structure prediction, Homology Model, Molecular simulation and dynamics [4]

Recommended readings

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Baxevanis AD and Ouellette – Wiley
2. Bioinformatics Sequence and Genome Analysis, Mount DW – CSHL
3. Introduction to Bioinformatics, Tramontano A – Chapman and Hall
4. Understanding Bioinformatics, Zvelebil M and Baum JO – Taylor and Francis

Gen C44: Review Paper in Genetics ~25 marks; 4 credits

Students will be required to select a seminal topic in Genetics, gather information on the same from library or web based resources, prepare and submit a Review Paper. A panel of examiners should evaluate the Review Paper.

Gen C45: Seminar ~25 marks; 2 credits

The students will be required to give a seminar based on a published paper. A panel of examiners shall evaluate the work performed and the presentation.

Gen C46: Grand Viva ~50 marks; 2 credits

Students will be evaluated on all topics discussed in two years program by a panel of experts.