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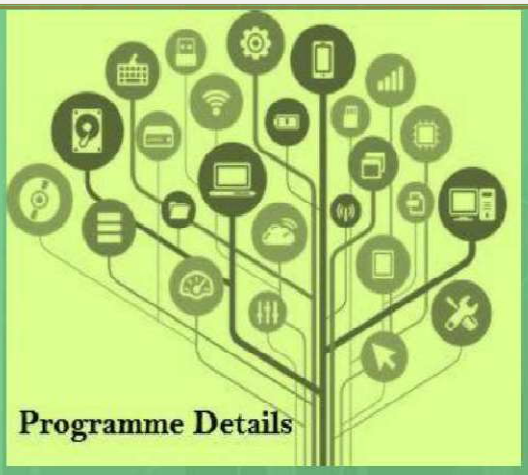
University of Mysore

(Estd.1916)

M.Sc. GENETICS

Flexible Choice Based Credit System (FCBCS) and Continuous Assessment Grading Pattern (CAGP)



UNIVERSITY OF MYSORE

Department of Studies in Genetics

Manasagangotri, Mysuru-570006

Regulations and Syllabus
Master of Science in Genetics
(Two-year semester scheme)

Under

Flexible Choice Based Credit System (FCBCS)
&
Continuous Assessment Grading Pattern (CAGP)

CHAIRMAN
BOS in Genetics

UNIVERSITY OF MYSORE

GUIDELINES AND REGULATIONS LEADING TO MASTER OF SCIENCE IN GENETICS (TWO-YEAR SEMESTER SCHEME) UNDER FLEXIBLE CHOICE BASED CREDIT SYSTEM (FCBCS) AND CONTINUOUS ASSESSMENT GRADING PATTERN (CAGP)

Programme Details

Name of the Department	:	Department of Studies in Genetics
Subject	:	Genetics
Faculty	:	Science and Technology
Name of the Programme	:	Master of Science in Genetics
Duration of the Programme	:	2 years divided into 4 semesters

PROGRAM OBJECTIVES

The knowledge of Genetics has become essential to unravel the mysteries of life processes that are extensively being pursued in today's science. Many research laboratories and Universities in the country and abroad required suitably well trained man power for research/teaching programmes in Genetics. Genetics is a fundamental science which can be studied at all levels. The curriculum designed for the Master degree Genetics programme encompasses different fields of Genetics with an emphasis on both basic and applied aspects. M.Sc., Genetics as an interdisciplinary programme also provides strong basic foundation to any modern research in many fields of life sciences. This programme is being taught under Flexible Choice Based Credit System (FCBCS).

PROGRAMME OUTCOME

1. There is a wide variety of employment opportunities in the field of biomedical, biology and Life Sciences. Applicants who are opting for this career must have a decent knowledge of science.
2. Professionals in this field can seek for job openings in research institutes.
3. They utilize recent scientific tools as well as procedures in laboratory consecutively to comprehend how living systems actually work.
4. Life science also has an extensive variety
5. of job opportunities in numerous areas, for example, biomedical science, material science, chemical science and physical science and engineering.
6. Experts in this field can also opt for teaching jobs in colleges and universities.
7. Biomedical candidates in this field can seek employment offers in healthcare industries such as medical research, pharmaceutical industries, lab technology, genetic engineering and pharmaceutical sales.
8. Biology is one of the career-oriented fields in science stream.

9. Biotechnology and Molecular biology are the topmost parts of employment as an expert are being needed to manage dwindling natural resources.

PROGRAMME SPECIFIC OUTCOME

On successful completion of this programme, each student will be able to

- Build a strong foundation of key concepts of Genetics, Genomics and other branches of life sciences
- Gain good knowledge and skills to choose variety of career options in research and health sector
- Equip the students with skills and knowledge to excel basic genetic research and management of genetic diseases and any other career they opt
- Effectively communicate the importance of knowledge of genetics for the betterment of societal health through teaching and research
- Entrepreneurial skills to pursue career in the field of bioinformatics and Genetics

Semester I						
Paper code	**Title of the Course**	**HC/SC**	**L**	**T**	**P**	**Credit**
1.1	Transmission Genetics	**HC**	3	0	0	**3**
1.2	Chromosome Genetics	**HC**	3	0	0	**3**
1.3	Gene Structure and Function	**HC**	3	0	0	**3**
1.4	Scientific Presentation Skills	**HC**	0	1	0	**1**
1.5	Molecular Cytogenetics	**SC**	3	0	0	**3**
1.6	Cell Biology	**SC**	3	0	0	**3**
1.7	Techniques and Methods in Genetics	**SC**	2	0	0	**2**
1.8	Transmission and Chromosome Genetics	**HC**	0	0	2	**2**
1.9	Cellular and Molecular Genetics	**HC**	0	0	2	**2**
	Total Credits minimum/ maximum					**19/20**

Semester II						
Paper code	**Title of the Course**	**HC/SC /OE**	**L**	**T**	**P**	**Credit**
2.1	Molecular Cell Biology	**HC**	3	0	0	**3**
2.2	Population Genetics and Evolution	**HC**	3	0	0	**3**
2.3	Genes and Development	**HC**	3	0	0	**3**
2.4	Scientific Writing Skills	**HC**	0	1	0	**1**
2.5	Gene Regulation	**SC**	3	0	0	**3**
2.6	Biological Chemistry	**SC**	2	0	0	**3**
2.7	Genetics of Plants and Microbes	**SC**	2	0	0	**2**
2.8	Molecular Cell Biology and Gene Regulation	**HC**	0	0	2	**2**
2.9	Developmental and Population Genetics	**HC**	0	0	2	**2**
2.10	Basic Genetics	**OE**	4	0	0	**4**
	Total Credits minimum/ maximum					**23**

Semester III						
Paper code	**Title of the Course**	**HC/SC /OE**	**L**	**T**	**P**	**Credit**

3.1	Genetic Engineering	**HC**	3	0	0	**3**
3.2	Genome Genetics	**HC**	3	0	0	**3**
3.3	Minor Project	**HC**	0	1	3	**4**
3.4	Biostatistics and Bioinformatics	**SC**	3	0	0	**3**
3.5	Immunology and Cancer Genetics	**SC**	3	0	0	**3**
3.6	Biology of non-coding RNA	**SC**	3	0	0	**3**
3.7	Genetic Engineering and Genomics	**HC**	0	0	2	**2**
3.8	Human Genetics	**OE**	4	0	0	**4**
	Total Credits minimum/ maximum					**18/22**

Semester IV

Paper code	**Title of the Course**	**HC/SC /OE**	**L**	**T**	**P**	**Credit**
4.1	Advanced Human Genetics	**HC**	3	0	0	**3**
4.2	Major Project	**HC**	0	2	5	**7**
4.3	Environmental Impact on Development	**SC**	2	0	0	**2**
4.4	Diagnostic and Therapeutic Genetics	**SC**	3	0	0	**3**
4.5	Macromolecular Interactions	**SC**	2	0	0	**2**
4.6	Advanced Human Genetics	**HC**	0	0	2	**2**
4.7	Nutrition Genetics	**OE**	4	0	0	**4**
	Total Credits minimum/ maximum					**15/16/ 17**
						Total credits = 76

Note: Overall minimum credits to be attained- 76 (HC- 52, SC- 20, OE- 4)

FISRT SEMESTER

HARD CORE

COURSE -I: TRANSMISSION GENETICS

Course Outcome :

On successful completion of this course each student will be able to

- Understand the fundamentals of Mendelian genetics and the extensions of his principles
- Understand the contribution of model system in unravelling the basic principles of genetics
- Comprehend the principles of genetics in the level of genes and molecules
- Understand the pattern of inheritance and their importance in disease manifestation and behaviour

Pedagogy :

Teaching - Using black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

Brief overview of systems commonly used in genetic studies: a) T4 phage, b) *Escherichia coli,* c) *Neurospora crassa*, d) *Saccharomyces cerevisiae,* e) *Caenorhabditis elegans*, f) *Drosophila melanogaster,* g) Mouse, h) Zebra fish, i) Arabidopsis.

UNIT -II

i) Introduction to Genetics: Historical account.

ii) Mendelism: a) Brief overview of Mendels work (Law of segregation, Law of independent assortment) b) Principle of equivalence of reciprocal hybrids, c) Application of laws of probability (Product and Sum rule) d) Chi-square test and its application in analysis of genetic data e) Pattern of inheritance in haploid organisms like *Chlamydomonas* and *Neurospora.*

UNIT -III

Extensions of Mendelian principles:a) Incomplete dominance b) Codominance c) Interaction of genes (Epistasis, Supressors) d) Lethal alleles e) Penetrance and expressivity f) Pleiotropy g) Phenocopy h) Polygenic inheritance.

UNIT -IV

Fine structure of gene: Evolution of gene concept - Definition of factors, alleles, multiple alleles, pseudoalleles, Beadle and Tatum's One gene one enzyme concept, One gene one polypeptide concept, Complementation test, Intragenic complementation, Cistron, Recon and Muton Eg. lz gene in *Drosophila* (Lozenge gene), rII locus in T4 phage.

UNIT -V

i) Sexlinked inheritance: In *Drosophila* and Humans, Inheritance of sex limited and sex influenced traits.

ii) Linkage and crossing over: a) Concept of linkage-Experiments of Bateson and Punnet, Morgans experiment, b) Genetic recombination and construction of linkage maps in *Drosophila*, c) Interference and coincidence, d) Mitotic recombination.

UNIT -VI

i) **Extranuclear inheritance:** a) Organelle heredity: Chloroplast-Variegation in 4'o clock plant; Mitochondria- Petite in Saccharomyces, b) Maternal effect- Shell coiling in Limnaea, c) Cytoplasmic Inheritance - Paramecium (Kappa Particle), d) Infectious heredity - Sigma virus and *Wolbachia* bacterium in *Drosophila.*

ii) Behavioural Genetics: a) Inheritance of behavioral traits b) Nest cleaning behavior in honey bees d) Circadian rhythm in *Drosophila* c) Genetic dissection of behavior using mutations in *Drosophila,* d) Genetic basis of behavior in man: Ex. Genetic and Environmental Influences on Criminal Behavior, Personality Disorders and Traits.

CORSE –II : CHROMOSOME GENETICS

Course Outcome :

On successful completion of this course each student will be able to

- Know the chromosomal basis of inheritance and the chromatin organization
- Understand mechanisms of chromosome rearrangements and their role in genetic diseases
- Comprehend the importance of special chromosomes and their contribution in the understanding of inheritance pattern
- Understand different types of radiations and their role in mutagenesis
- Learning the importance of radiation techniques in research and apply the same in the research they perform

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT
UNIT I & II

i) Chromosomal theory of inheritance: Experimental evidences. Types of chromosomes, Banding Techniques, Karyotyping and its importance.

ii) Chromatin organization: (a) Molecular organization of Eukaryotic chromosome - Nucleosomes, Telomeres, Kinetochore, Centromere, Histone and Non-Histone proteins. Histone & DNA modifications (acetylation, deacetylation, methylation, Histone phosphorylation, 'Histone Code') (b) Chromosome condensation by condensins. (c) Heterochromatin- Constitutive and facultative heterochromatin- Properties and functions, Gene silencing by heterochromatinization (telomeric effect).

UNIT III & IV

i) Structural rearrangements in chromosomes: (a) Cytogenetic implications of Deletions, Duplications, Inversions, Translocations, Centric fusion and Centric fission (b) Permanent structural (Translocation) heterozygosity. Ex. *Oenothera & Rheo* (c) Evolution of new Karyotypes: Ex. *Drosophila* and *Crepis* (d) Practical applications of rearrangements- Balancers, Ring chromosomes, Attached X-chromosome in *Drosophila.*

ii) Numerical variations in chromosomes: (a) Aneuploidy – causes and consequences with examples from *Drosophila*, Datura and Man (b) Euploidy – causes and consequences. Ex. Raphanobrassica, Wheat.

UNIT V

Special chromosomes: (a) Polytene chromosomes: Structural organization and significance. (b) Lampbrush chromsomes: Structural organization and significance. (c) Supernumerary chromsomes: Salient features, Behaviour during cell division and Population dynamics.

UNIT VI

Effects of radiations on chromosomes: (a) Types of radiations, (b) Radiation detection, (c) Dosimetry, (d) Ultraviolet radiations and their importance, (e) Ionising radiations and their cytogenetic effects – Target theory and its modified concepts, (f) Radiation-induced chromosome aberrations.

CORSE -III: GENE STRUCTURE AND FUNCTION

Course Outcome:

On successful completion of this course each student will be able to

- Understand the basic essentials of molecular biology and understand how discoveries and inventions have lead to the understanding of gene
- Comprehend fundamental processes such as DNA replication, Transcription and Translation
- Learninge the importance of DNA repair mechanism and molecular mechanism of recombination

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT –I

(a) Nucleic acids store and convey genetic information – Experiments of Griffith, Avery, MacLeod and McCarty, Hershey and Chase, and Fraenkel Conrat. (b) Overview of nucleic acids: Structure, properties of nucleic acid - Tm, Cot curve, Chargaff's rule, nearest neighbor base frequency analysis, Double Helix, Biosynthesis of nucleic acids (c) Forms of DNA, DNA bending, supercoiling, repetitive sequences, palindromic sequences (d) Structure of rRNA and tRNA (clover leaf model, stem loop, cruciform).

UNIT -II

Replication of DNA: i) Patterns of replication: (a) Experiments of Messelson and Stahl, Taylor (b) Enzyme and non enzyme components of replication machinery (c) Replication process: Initiation of replication: Origin of replication in Prokaryotes and Eukaryotes, Regulation of initiation in relation to cell division.

i) Elongation: Coordinated synthesis of Leading and Lagging strands.

ii)Termination: End replication problem-Protein priming in viruses, telomerase in eukaryotes, Fidelity in replication: Selection, proof reading, mismatch repair, inhibitors of replication.

UNIT -III & IV

i) Mutability of DNA and Repair: (a) Factors causing post replicative DNA damages-intrinsic and extrinsic. (b) Repair of DNA damages: (1) Direct reversal of DNA damages: Photoreactivation, Alkyl transferases (2) Excision repair: Nucleotide excision-UVR ABC system, Base excision and AP nuclease pathway (3) Transcription coupled repair (4) SOS repair (5) Translesion synthesis.

ii) Recombination: Homologous recombination: (1) Models of Recombination- Holliday model, Messelson and Radding's Model, Double strand break model (2) Genetic consequence of homologous recombination (3) Protein Machinery of homologous recombination.

UNIT -V

Transcription: (a) cis components-promoter, enhancers, operator, silencers (b) RNA polymerases (c) Transcription mechanism-Initiation, Elongation and Termination in Prokaryotes and Eukaryotes (d) Post transcriptional modifications of transcripts (1)Prokaryotes: mRNA, rRNA, tRNA. (2) Eukaryotes: mRNA (G-cap, Poly-A tail, Splicing – Reliable recognition of splice sites, ESE sequences, SR proteins, RNA editing), rRNA and tRNA splicing, inhibitors of transcription.

UNIT -VI

Translation: (a) Genetic code: genetic and biochemical analysis of genetic code, features of Genetic code, *evolution of genetic code.* (b) Ribosomes: Molecular anatomy and regulation of ribosome biogenesis (c) Enzymes of translation: AminoAcyl tRNA synthetase, Peptidyl transferase (d) Translation process and factors: initiation, elongation (selection against incorrect Amino Acyl tRNA), and termination (e) Translation dependent regulation of mRNA & protein stability (Post translational modification of proteins) (f) inhibitors of translation.

CORSE-IV : SCIENTIFIC PRESENTATION SKILLS

Course Outcome:

On successful completion of this course each student will be able to

- Effectively deliver a scientific talk / seminar
- Able to understand the importance and appropriateness of the presentation technology in effectively communicating science to the audience
- Understand the importance of story telling and time management in science communication

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions- Two short presentation by each students by selecting their own topics in general science and selecting topic in the M.Sc programme and group discussion

COURSE CONTENT

UNIT I & II

i) Presentations Skills:

(a) Presentation Technology - Generation and styles of Presentation. Components of effective Preparation - Story telling principles; Rehearsal Techniques, (b) Establishing connection with the audience: Role of Enthusiasm; Emotion; Humor; Elevator pitch;

Sustain with pace & participation, (c) How to End on a Powerful note: need to summarize; (d) Importance of Questions and Answers session (e) Concept of Continuous improvement through persistence, (f) Ethics in presentation, data plagiarism.

ii) Presentation of any scientific data by each student.

SOFT CORE

COURSE –V: MOLECULAR CYTOGENETICS

Course Outcome:

On successful completion of this course each student will be able to / this course intends to

- Familiarize the students with fundamental processes such as cell division and cell cycle regulation
- Provide the basic knowledge of molecular mechanism of mutations and their role in diseases
- Able to learn the genetic and molecular basis of sex determination and dosage compensation

Pedagogy:

Teaching - Black board and Power Point presentation, interactive sessions Assignments- Take home assignment hard copy submission and online submission in Limited words

COURSE CONTENT

UNIT -I & II

i) Mutations: (a) Mutations: Types of Mutation: Synonymous, Nonsynonymous, Nonsense, Conservative, Readthrough, and Splice-site mutations, frameshift mutations, Transition and Transversion. (c) Reverse mutations: (1) Exact reversion (2) Equivalent reversion (d) Intragenic suppressors: (1) Frameshift of opposite sign and second site within a gene (2) Second site missense mutation (e) Extragenic suppression: (1) Nonsense suppression (2) Missense suppression (3) Frameshift suppression (4) Physiological suppression. (f) Lethal mutation (g) Loss of function mutation (h) Gain of function mutation- Amorphic, hypomorphic and isoallelic mutations.

ii) Chemical mutagens: (a) Base analogues (b) Nitrous acid (c) Hydroxylamine (d) Hydrazine (e) Alkylating agents (f) Detection of mutations – (1) Bacteria: replica plating technique, Ames test (2) *Drosophila*: Sex-linked recessive lethals, autosomal recessive lethals, dominant lethal test (3) Small mammals: Micronucleus test, dominant lethal assay, Host mediated assay.

UNIT -III & IV

Cell division: (a) Overview of chromosomal dynamics during- Mitosis, Meiosis, Amitosis, Endomitosis and cMitosis and their significance, (b) Molecular Mechanisms involved in polytene chromosome formation (c) Molecular Regulation of cleavage. (d) Molecular organization of centrosome and spindle. (e) Dynamic instability of microtubules during metaphase and anaphase. (f) Role of Motor proteins and segregation of chromosome. (g) Spindle without chromosomes (h) Cytokinesis.

UNIT -V & VI

Sex determination and dosage compensation

(a) Chromosomal basis of sex determination: (1) Simple systems: Eg: XX/XY, XX/XO, ZZ/ZW (2) Multiple systems: Ex. *Paratylotropidia, Drosophila*, Heteroptera and Homoptera (b) Parthenogenesis: Ex. Honey bees and wasps. (c) Chromosomal and Molecular basis of sex determination in *C. elegans*, *Drosophila* and Man (d) Molecular basis of dosage compensation in *C. elegans*, *Drosophila* and Man.

CORSE –VI: CELL BIOLOGY

Course Outcome:

On successful completion of this course each student will be able to / this course intends to

- Provides students an overview of cells and their types
- Able to learn the molecular architecture of the cell and its functions
- Understand the function of cell organelles and the effect of their malfunctioning in disease manifestation

Pedagogy:

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I & II

i) Overview of Cells and their functional specialization: Prokaryotic cells- Bacteria, Mycoplasma; Eukaryotic specialized cells – Neurons, Retinal cells, gametes, blood cells, muscle cell.

ii) Molecular architecture and functions of eukaryotic cell: (a) Biomembranes – composition, structure, fluid mosaic model. (b) Basic functions: permeability, osmotic principles, carrier proteins, channel proteins, passive transport, active transport, membrane pumps, multidrug resistance transport protein, pinocytosis, phagocytosis, receptor mediated endocytosis, transcytosis, electrical properties of membranes.

UNIT -III

i) Endoplasmic Reticulum (ER): Protein secretion, targeting proteins into ER, insertion of proteins into ER membrane, export of proteins and lipids from the ER, fate of misfolded proteins.

ii) Golgi complex: Ultra structural organization, protein glycosylation within Golgi, lipid and polysaccharide metabolism in Golgi, protein sorting and export from the Golgi.

UNIT -IV

i) Mitochondria: Ultrastructure, inner membrane, transport proteins, Electron transport chain, electron transporting complexes, P/O ratio, Q cycle, oxidative phosphorylation, uncouplers and inhibitors, mechanism of ATP synthesis, Mitchell's hypothesis, synthesis and targeting mitochondrial proteins, coupled reaction, group transfer, biological energy transducers.

ii) Chloroplast: Ultrastructure, synthesis and targeting of chloroplast proteins.

UNIT -V

i) Lysosomes: Lysosomal acid hydrolases, mechanism of membrane resistance to lysosomal enzymes, pathways and mechanisms of intracellular digestion, lysosomal secretion/defecation, lysosomal storage diseases.

ii) Microbodies and their function: Peroxisomes, Glyoxysomes, Spherosomes.

UNIT -VI

i) Nucleus: Structure of nuclear envelope, Nuclear Pore Complex (NPC), Nuclear export and import of proteins, structure and function of Nucleolus.

ii) Microtubule based organelles: Ultrastructure and dynamics of ciliary and flagellar movement, Cytoskeleton assembly and regulation of cytoskeleton filament.

COURSE –VII : TECHNIQUES AND METHODS IN GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- To provide basic knowledge of principle working of tools and techniques used in genetic research
- To familiarize the students with handling few equipments employed in genetic research
- To prepare students to enter the field of genetic research and development with skill-sets they acquire during the course

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

Microscopy: Overview of different types of Microscopy – Light, Phase contrast, Polarization, Fluorescence, Electron and Confocal microscopy. (Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy).

UNIT -II & III

i) Mass spectrometric techniques: Introduction, Ionisation Mass analysers, Detectors, Structural information by tandem mass spectrometry, Analysing protein complexes, computing and database analysis.

ii) Chromatographic techniques: Principles of chromatography, High-performance liquid chromatography, Adsorption chromatography, Partition chromatography, Ion-exchange **chromatography, Molecular (size) exclusion chromatography, Affinity chromatography, Gas** chromatography,

UNIT -IV

Immunochemical techniques: Introduction, Making antibodies, Formats of Immunoassay, **Lateral flow devices, Epitope mapping, Immunoblotting, Fluorescent activated cell sorting (FACS) Cell and tissue staining techniques, Immunoaffinity chromatography (IAC), Antibody**-based biosensors, Antibody technology.

UNIT -V

Cell culture methods: Introduction, Bacterial cell culture. Cell culture laboratory equipment. Overview of different types of animal cell culture, Stem cell culture and its uses. Safety considerations in cell culture, Aseptic and good cell culture practices.

UNIT -VI

Modern techniques: RNA-Seq, CAGE-Seq, ChIP-chip and ChIP-Seq, Methylation profiling, Genome editing and other recent techniques.

PRACTICALS - TRANSMISSION AND CHROMOSOME GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Hands-on experience of genetic crosses with various phenotypes and mutants using *Drosophila* as model
- Able to learn the various inheritance patterns through hands-on experiments
- Induce mutations and study the process of mutagenesis
- Understand the molecular organization of chromosomes through karyotyping techniques

Pedagogy:

Teaching the concept of the experiments, Demonstration of the experiments, Collection of the Drosophila flies from nature by field trips and categorization. Conducting the experiments by each students, Result presentation by each students, Discussion of the data by interactive sessions

COURSE CONTENT

No.	Practicals	Hours
1	Study of: (a) Morphology in *Drosophila melanogaster.* (b) *S*tudy of wing, sex comb, genital plate and bristles in *D. ananassae* and *D. nasuta.*	2x4
2	Field trip- collection of *Drosophila* flies and categorization.	1x4
3	Study of mutants of *Drosophila melanogaster* – Dominant, Recessive, Autosomal, Sex-linked and Multiple mutations, Balancers.	1x4
4	Genetic crosses and analysis of P_1, P_2, F_1, F_2 & test cross progeny in *Drosophila* (a) Monohybrid (b) Dihybrid (c) Sex-linked inheritance, (d) Linkage (e) Balanced-Lethal (f) Interaction of genes	2x4
5	Induction of mutations by Chemical/Radiation/P-element Mutagenesis.	2x4
6	Study of Polytene and mitotic chromosomes of *Drosophila* melanogaster.	2x4
7	Study of Polytene and mitotic chromosomes of *Drosophila nasuta.*	2x4
8	Study of inversions in *Drosophila ananassae*.	1x4
9	Study of meiotic chromosomes in mouse.	1x4
10	Study of some of the qualitative and quantitative traits in humans.	2x4

PRACTICALS - CELLULAR AND MOLECULAR GENETICS

Course Outcome:

On successful completion of this course each student will be able to / this course intends to

- Familiarise students with various cell types studying under microscope
- Understand the molecular organization of meiotic chromosomes
- Able to understand the chromosomal aberrations through slide preparation methods
- Familiarise students with separation techniques and their application in genetic research

Pedagogy:

Teaching the concept of the experiments, Demonstration of the experiments, Conducting the experiments by each students, Result presentation by each students, Discussion of the data by interactive sessions

COURSE CONTENT

No.	Practicals	Hours
1	Visit to University IOE lab and learning the principles, working methods and applications of modern instruments and Demonstration of instruments & calculations for making of stock and working solutions.	2x4
2	Study of different cell types (WBCs, Buccal, Sperm cells).	1x4
3	Measurement of cells.	1x4
4	Study of meiotic chromosomes in grasshopper.	1x4
5	Study of meiotic anomalies.	1x4
6	Study of translocations (Rheo/Cockroach/Scorpion).	2x4
7	Isolation of genomic DNA from bacteria and agarose gel electrophoresis.	2x4
8	IsolationofplasmidDNAfrombacteriaandquantificationby Spectrophotometry.	2x4
9	Thin layer chromatography: Eye pigments in *Drosophila*.	1x4
10	Paper Chromatography of amino acids.	1x4
11	Study of proteins by SDS-Polyacrylamide gel electrophoresis.	2x4

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1.2: Chromosome Genetics

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1.3: Gene Structure and Function

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1.4. Scientific Presentation Skills

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3) The Common Presentations in Scientific Communities. 2. Scientific Oral .... Available online at http://www.cysticfibrosis.ca/assets/files/pdf/. Mar 21, 2015.

1.5: Molecular Cytogenetics

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1.6: Cell Biology

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1.7: Techniques and Methods in Genetics

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2) Helgason C D and Miller C L. 2013. Basic Cell Culture Protocols. Springer Protocols.
3) John. R. W. 2000. Animal CellCulture. Oxford university press.
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5) Keith Wilson and John Walker. 2012. Principles and Techniques of Biochemistry and Molecular Biology, CambridgeUniversity Press.
6) Rana. S. V. S. 2004. Biotechniques: Theory and Practice. Rastogi Publications Meerut, India.
7) Liquid Chromatography - Mass Spectrometry: an introduction B. Ardrey, John Wiley & Sons, 2003, 296 pp.

SECOND SEMESTER

HARD CORE

COURSE –I : MOLECULAR CELL BIOLOGY

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Provide detailed understanding of eukaryotic cell cycle regulation and the molecular players involved
- Learn the importance of cell death and different mechanisms of cell death
- Understand the molecular organization of cells and apply that knowledge to understand cell-cell communication

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions

Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

i) Eukaryotic cell cycle & its regulation: (a) Phases of cell cycle (b) Regulation: (1) Cell cycle check points (2) cell intrinsic core regulators of checkpoints- Cyclins and Cdks, CAKs, CKIs, MPF, APC. and regulation at check points (3) Cell intrinsic mediators of regulation- Activators (myc, Ras), Inhibitors (Rb, DNA damage P^{53} dependent and independent inhibitors) (4) Extracellular signals – Growth factors (mitogens, contact inhibition, cell anchorage) (c) Specific regulators at Meiosis, regulation of oocyte meiosis.

UNIT -II

Cell death:

i) Programmed: (a) Programmed Apoptosis v/s necrosis (b) Discovery of cell death genes in *C.elegans* & homologous pathway in mammals (c) Caspases – action, inhibition by Survival signals (Trophic factors, neurotrophins) and activation by death signals (TNF, Perforin/granzyme pathway, Mitochondrial permeability).

ii) Alternative Cell Death Mechanisms (Autophagic, Necroptosis, Shedding, Cornification, Entosis) and significance

UNIT -III

Cellular interactions:

i) Cell junctions: (a) Occluding (tight, septate), Anchoring (Adherens, focal adhesion, desmosomes) Communicating (gap, plasmodesmata), (b) Cell adhesion- CAMs, Cadherins (Ca + dependent) NCAMs (Ca+ independent) cell adhesion. (c) Molecular interaction and regulation of male and female reproductive cells (d) Molecular basis of cell migration and Cell affinity.

ii) Cell-Cell signaling: (a) Concept of quorum sensing, endocrine, synaptic, autocrine, cellular response to signaling molecules (specificity, concentration, memory), Nitric Oxide signaling (b) Cell Surface receptors: (1) G-protein linked-structure, mechanism, Cyclic AMP mediated (2) Enzyme-linked -Receptor tyrosine kinases (3) signaling through regulated proteolysis - Wnt-β catenin pathway, calcium signaling (4) Synaptic signaling - Signaling at neuromuscular junction (transmitter gated ion channels, spatial and temporal summation).

COURSE –II : POPULATION GENETICS AND EVOLUTION

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Provide historic overview of evolutionary thought and how a fully formed evolutionary theory was put-forth
- Learn the forces that drive evolution and their mode of action in the level of population
- Familiarise the students with human evolution and the various factors drove it
- Know the various isolation mechanisms and their role in speciation
- Familiarise the students with mode of action of evolution in molecular level

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I & II

i) Theories of Evolution: (a) Overview of History and evolutionary thought (b) Lamarckism and its limitations (c) Darwinism and its limitations (d) Mendelian and Biometrician Controversy (e) Population genetics and Neo-Darwinism: (1) Mendelian Population (2) Gene pool (3) Allele and Genotype frequencies (4) Hardy-Weinberg genetic equilibrium and its applications.

ii) Forces of Evolution that affect the allelic frequencies: (a) Mutation (b) Migration (c) Selection (Stabilizing selection, Directional selection, Disruptive selection, Balancing selection, Frequency dependent selection, Density dependent selection, Group and kin selection), (d) Selection coefficient, Selective value, (e) Genetic drift (f) Nonrandom mating.

UNIT -III

i) Inbreeding and Heterosis: (a) Measurement of inbreeding -inbreeding coefficient, Panmictic index (b) Inbreeding pedigree (c) Assortative and Disruptive mating (d) Heterosis-examples and mechanism.

ii) Human evolution: Hominid evolution: Anatomical, Geographical, Cultural. Molecular phylogenetics of *Homo sapiens*, Peopling of continents (Europe, Africa, Asia).

UNIT -IV

Solating mechanisms: (a) Classification- Geographic, Reproductive isolation (1) Premating isolation- Climatic, Seasonal, Habitat, temporal, Ethological (2) Post mating isolation- gametic mortality, zygotic mortality, Hybrid inviability, Hybrid sterility, Hybrid breakdown (b) Origin of reproduction isolation- Muller's view, Dobzhansky view.

UNIT -V

Speciation: (a) Species types and Species categories (b) Concepts of species (c) Models of speciation (d) Based on distribution- sympatric, allopatric, stasipatric (e) Based on genetic drift – Genetic revolution, Genetic transilience, Founder-flush theory (f) Hybridization, introgression and speciation (g) Phyletic gradualism and punctuated equilibrium (h) Molecular aspect of speciation - speciation genes.

UNIT -VI

Molecular Evolution: (a) Patterns of change in nucleotide and amino acid sequences (b) Molecular clock (c) Neutral theory of molecular evolution (d) Conversion of genetic distance into divergence time (e) Emergence of Non-Darwinism (f) Kinds of molecular data used in

phylogenetic analysis (g) Phylogenetic considerations based on nucleotide and amino acid data (h) Construction of phylogenetic tree.

CORSE –III : GENES AND DEVELOPMENT

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Build a strong understanding of concepts of developmental biology
- Learn the mechanism and molecular players involved in pattern formation
- Understand the stages in the process of development of different organisms and the pathways involved in the same
- Familiarise with the process of metamorphosis and regeneration
- Learn the process of development in an evolutionary perspective

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I & II

i) Introduction: (a) Issues in developmental biology (b) Mechanisms regulating developmental process (1) morphogenetic determinants (2) Cell-Cell Interaction.

ii) Pattern Formation: (a) Cell aggregation and differentiation in Dictyostelium (b) Laying down the primary body axis- (1) *Drosophila* (Anterior/posterior, terminal group genes, Dorso/ventral axis) (2) Amphibians (Dorso/ventral) (3) Left-right axis in mammals. (c) Segmentation genes: Gap genes, Pair-rule genes, Segment polarity genes in *Drosophila*. (d) Homeotic Selector genes in flies, mammals (Hox code).

UNIT -III & IV

i) Gastrulation: (a) Morphogenetic movements and selective affinities of cells in frog and Drosophila (b) Molecular regulators of mesodermal migration (fibronectin) (c) Differential gene regulation by Polycomb and Trithorax proteins.

ii) Neurogenesis: (a) Notch signaling- a skin/nerve regulatory switch in flies. (b) Axonal path finding: Attractants and repulsive signals – (long range and short range), Target selection and forming the synapse. Retinal axon pathfinding

iii) Mesoderm patterning: vertebrate heart development

UNIT -V & VI

i) Limb development: (a) limb bud formation & specification (FGF, Hox, Tbx, genes, retinoic acid) (b) Digit formation- A/P axis specification and ZPA, Cell death in digit formation.

ii) Metamorphosis and Regeneration: (a) Molecular mechanism of ecdysone action-cellular choice between apoptosis and differentiation (b) Molecular responses to thyroid hormone during metamorphosis (Amphibians) (c) Blastema formation and differentiation during regeneration.

iii) Developmental mechanisms of evolutionary changes: (a) Genetic mechanisms- Heterotopy, Heterochrony, Heterometry, Heterotypy (b) Homologous genetic pathways of development.

COURSE –IV : SCIENTIFIC WRITING SKILLS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Understand the clear picture of basics of scientific writing and the components of scientific write up
- Learn the importance of effective communication in scientific write up / scientific research article

Pedagogy :

Teaching the concept using Black board and Power Point presentation, Interactive sessions on writing skills of each students of primary literature summary and critique of the given topics and chosen topics by each students

COURSE CONTENT

i) **Scientific Report writing**:

Historical account, Different types of science writing, The parts of a research paper- Title, Keywords, Classification Numbers, Authors, Affiliations, Abstract, Table of Contents, Introduction, Methodology, Results, Discussion, Conclusions, Data illustrations (Tables, Figures, Photographs, Schemes etc), Acknowledgements, Appendices; References, Footnotes and Endnotes, Bibliography, How and when to write the first draft, revision and when to finish, Structures of other types of science writing. : Impact factor and citations of research papers, H index and i-index.

ii) Presentation of any scientific data by each student.

SOFT CORE

COURSE –V : GENE REGULATION

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- To build strong understanding of the process of gene regulation in prokaryotes and eukaryotes
- Learn the importance of different levels of regulation of a gene and their importance in genetic manipulation in research
- Introduce the students to emerging fields such as epigenetics and the epigenetic regulation of gene expression

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

i) Introduction: Inducible and repressible systems, House-keeping genes, Levels of control of gene activity.

ii) Transcriptional control in Prokaryotes: The Operons - Lactose operon (Allosteric control), Arabinose operon - Positive and negative control, Galactose operon - Alternate start points.

UNIT -II

i) Regulation: beyond transcription initiation, premature termination of transcription - Tryptophan operon (*trp* attenuator) and Histidine operon (*His* attenuator).

ii) Cis-acting elements and Transacting factors: A) Structural and functional motifs, Helix-turn-Helix, Helix-loop-Helix. B) Regulation in Lambda Phage - Lytic and lysogenic cycle induction (Logic of lambda), Autoregulation. C) i) Ribosomal proteins as translational repressors (ii) rRNA-nucleotide sensing system (iii) Riboswitches.

UNIT -III & IV

i) Gene regulation in eukaryotes: Basic considerations, Britten and Davidsons model, Transcription factors, Response elements, Structural domains and motifs - Leucine Zipper and Zinc finger motifs, HLH and HTH motifs.

ii) Transcriptional activators: Recruitment of different transcription machinery proteins by activators, Activators recruit nucleosome modifiers and insulators, Activators work in combinatorial way (eg. Human B interferon, Yeast Mating type switching).

iii) Transcriptional repression: Mechanism - Competition, inhibition, direct repression, indirect repression

UNIT -V

i) Regulation after transcription initiation: (a) Alternative mRNA splicing- Mechanism and its significance eg *sxl* gene, (b) Translational control as in (1) rRNA/GcN4 (2) Ferritin and transferrin mRNA (c)RNA interference miRNA and siRNA (d) mRNA localization & translational regulation during development.

UNIT -VI

Epigenetics: (a) Introduction to concept and definition of Epigenetics and Epigenetic Memory, Epigenetic Landscape (b) Imprinting of Genes, Chromosomes and Genomes: (1) Pronuclear transplantation experiments in mouse (2) Genomic conflict in Scale Insects,

(c) Molecular basis of epigenetics - DNA methylation, Histone modifications, Non-coding RNAs (d) Epigenetics and diseases (Syndromes, infections, cancer), (e) Epigenetic reprogramming (mammals) Epigenome.

CORSE –VI : BIOLOGICAL CHEMISTRY

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- To build strong understanding of principles of biochemistry
- Learn different classes of biomolecules and their importance in physiology and manifestation of diseases
- Understand the nomenclature and classification of enzymes and their biological and industrial role

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

Principles of Biochemistry: (a) Structure of atoms, molecules and chemical bonds (b) Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction)

(c) Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).

UNIT -II & III

i) Carbohydrates: (a) Overview of Classification, Stereochemistry – D and L, anomer, epimer, chair and boat conformations (b) Digestion of carbohydrates – role of amylases, gluconeogenesis (c) Degradation of monosaccharides.

ii) Proteins : (a) Overview of Classification of amino acids, structure and properties of peptide bond (b) Overview of structure and classification of proteins (1) primary structure-Determination of protein sequence, Types of bonding, determination of S.S. bond position, Anfinsen's experiment (2) Secondary structure – **α helix, β sheet and β bend, P**rediction of secondary structure of proteins, Chou and Fasman algorithm, Helix forming amino acids, Helix breakers, Ramachandran plot. (3) Tertiary and quaternary structures – Myoglobin and hemoglobin (c) Protein misfolding ex. Prion and other neurodegenerative diseases (d) Pathways of degradation of protein:, Proteases, general catabolic reactions of amino acids – decarboxylation, deamination, transamination, Ubiquitination.

iii) Lipids: Structure of Fatty acids – essential fatty acids, Triacyl glycerols, phospholipids, Liposomes. Pathways of lipid degradation – **lipases and phospholipases, β-** oxidation pathway.

UNIT -IV

i) Enzymes: (a) IUB - nomenclature, classification, Localization, isolation, purification and characterization (b) Enzyme kinetics- (In brief) enzyme assay, kinetic assay, coupled assay, end-point assay, Michaelis - Menten equation (Derivation not necessary) Vmax and Km and their determination by Lineweaver- Burk plot. Nature of active site of enzymes, factors affecting catalyses Ex - Aspartyl transcarbamylase as an allosteric enzyme (c) Isoenzymes Ex. LDH (d) Regulation of enzyme activity – feedback regulation.

ii) Hormones: classification, mechanism of action of group I and II hormones, Hypothalamic and pituitary hormones, thyroid hormones, Adrenal gland hormones and hormones of gonads

COURSE –VII : GENETICS OF PLANTS AND MICROBES

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Build strong foundation to the plant and microbial model organisms used in genetic research
- Learn the importance of application of plant genetics in current industrial requirements
- Understand the importance of understanding of microbial genetics in industrial usage of microbes

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

Gene regulation in plants: Overview of plants as genetic model systems, Genes involved in regulation of flower development, Homeotic genes, Development of dorsal and ventral asymmetry in leaves, Role of KNOX genes in evolution of compound leaf, Types of abiotic stresses and gene regulation during water deficit and heat stress, Plant nodule genes, Mechanism of self-incompatibility in plants.

UNIT -II

Applied genetics of plants: Genetic basis of disease resistance and susceptibility in plants, Molecular basis of host pathogen interaction, Molecular and genetic basis of Crown Gall disease development, Agrobacterium- Genetics of Ti plasmid, Plant wound genes and control of 'vir' gene expression, Mechanism of T-DNA transfer and their utility in production of transgenic plants.

UNIT -III

Microbial Genetics: Over view of Microbes as genetic tools for basic and applied studies, Overview of generalized life cycles of microbes, Non- sexual variation, Significance of haploidy, Heterokaryosis and parasexuality, Tetrad analysis and linkage detection in *Neurospora,* Mitotic recombination in *Neurospora crassa and Aspergillus nidulans,* gene conversion in fungi, Biosensors, Multi- Drug Resistance in Bacteria. Molecular mechanisms for origin of new pathogens, Metagenomics.

UNIT -IV

Recombination in bacteria: (a) Conjugation: Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F′, heteroduplex analysis, mechanism of chromosome transfer, molecular pathway of recombinations and gene mapping, (b) Transformation: Natural transformation systems, transformation and gene mapping, (c) Transduction: Discovery, generalized and specialized transduction, phage P1 and P22 mediated transduction, mechanism of generalized transduction, abortive transduction, mechanism of specialized transduction, sexduction.

PRACTICALS - MOLECULAR CELL BIOLOGY AND GENE REGULATION

Course Outcome :

On successful completion of this course each student will be able to /this course intends to

- Familiarize students with quantitative estimation of different components of blood and serum
- Understand induction of recombinant proteins
- Introduce students to the estimation of stress markers

Pedagogy :

Teaching the concept of the experiments, Demonstration of theexperiments, Conducting the experiments by each students, Result presentation by each students, Discussion of the data by interactive sessions

COURSE CONTENT

No	Practicals	Hours
1	Determination of blood glucose in clinical samples	1x4
2	Determination of serum cholesterol in clinical samples	1x4
3	Studies on sperm viability and abnormality in Rat by using Eosin stain.	1x4
4	Studies on apoptosis by using DNA ladder assay	2x4
5	Induction of recombinant protein in bacterial cells and analysis by PAGE	2x4
6	Estimation of SOD/catalase in *D. melanogaster*	2x4
7	Purification of protein from animal tissue.	2x4
8	Enzyme assay of purified protein	1x4
9	Estimation of total antioxidant capacity in human/rat blood	2x4

10	Estimation of LDL/HDL from the clinical sample	1x4
11	Bisulphate sequencing	1x4

PRACTICALS – DEVELOPMENTAL AND POPULATION GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Hands-on experimentation of genetic crosses of *Drosophila* population to understand the effect of evolutionary forces
- Hands-on experiments of embryogenesis
- Understanding the gene expression pattern using different models

Pedagogy :

Teaching the concept of the experiments, Demonstration of the experiments, Conducting the experiments by each students, Result presentation by each students, Discussion of the data by interactive sessions

COURSE CONTENT

No	Practicals	Hours
1	Study of few examples of analogous and homologous organs.	1x4
2	Experiments on (a) genetic drift - Population size, sampling error, (b) natural selection.	1x4
3	Study of Quantitative characters: Sternoplurals - mean, standard deviation.	1x4
4	Study of population genetics problems.	2x4
5	Species identification through genital plate and sex comb for (a) *D. melanogaster*, (b) D. *nasuta* (c) *D. rajasekarii*	1x4
6	Construction of dendrograms using different species data set.	1x4
7	Live observation of *Drosophila* embryogenesis.	1x4
8	Dissection and mounting of Imaginal discs of *Drosophila.*	1x4
9	Reporter gene lac-Z expression in Embryos.	2x4
10	Reporter gene Lac-Z expression in imaginal discs.	1x4
11	Targeting gene expression to different tissues using Gal4-UAS system.	1x4
12	Study of homeotic and maternal effect mutations.	1x4
13	Observation of GFP tagged reporter expression in embryos, imaginal disc and others.	1x4
14	Study of morphology and mutant phenotypes in *C. elegans*.	1x4

OPEN ELECTIVE

COURSE –X : BASIC GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Introduce the students to fundamental of inheritance and pattern of inheritance
- Learn the fundamental processes of molecular biology and genome organization
- Know the basic concepts of animal development using different model systems

- Understand the mechanism of mutagenesis and different kinds of mutations

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

Rules of Inheritance: (a) Milestones in genetics (b) levels of genetics (classical, molecular and population) (c) Mendelian genetics (d) Mendelian laws of inheritance- Monohybrid and dihybrid cross, Examples in pea plants, *Drosophila* and human, Test cross and backcross (e) Patterns of inheritance (f) Probability of inheritance – Punnet's Square (g) concept of gene- past and present.

UNIT -II

Chromosomes: Structure and types of chromosomes, Chromosome theory of inheritance, Mitosis, Meiosis, polytene chromosome, endoreduplication and puffing, Lambrush chromosomes.

UNIT -III

DNA as the genetic material -Experimental evidences, Structure and types of DNA, DNA replication- semiconservative replication, origin and units of replication, proof reading; gene expression: transcription, genetic code, translation: mechanism, post–translation modifications; DNA recombination: concept and models.

UNIT -IV

Genome organization: (a) Prokaryotes- Bacteriophages, Bacteria, Viruses (b) Eukaryotic nuclear genomes: General features, C-value paradox, types of coding and noncoding sequences and Split Genes (c) Eukaryotic organelle genomes- Chloroplast and Mitochondria (d) Jumping genes: Mobile genetic elements in Prokaryotes (bacteria) and Eukaryotes (*Drosophila,* maize and humans)

UNIT -V

Animal development: (a) Basic concepts of development, Embryogenesis and Genes involved in early development in *Drosophila* (b) Genetics of imagnal discs (c) Basic body axis formation -*Drosophila* (Anterior/posterior, terminal group genes, Dorso/ventral axis) (d) Evolution of body plan - Levels of organization, Body symmetry, Differentiation of germ layers, Formation of body cavities, Segmentation, Cephalization, Limb formation.

UNIT -VI

Genetic basis of heritable change – Mutation and its effects, Forward mutations: at DNA level and) at protein level, Reverse mutations, Loss of function mutation, Gain of function mutation, Classification of chromosomes and Karyotyping, chromosomal variations - types with relevant examples, Chromosomal syndromes with examples, Genetic basis of evolution; NeoDarwinism: concept, Hardy-Weinberg law of genetic equilibrium and destabilizing forces (Natural selection, Mutation, Genetic drift, Migration) micro- and macroevolution, punctuated equilibrium.

References

2.1: Molecular Cell Biology

1) Abbas, A. K., A. H. Lichtman and J. S. Pober. 1994. Cellular and molecular immunology. W. B. Saunders Company.
2) Alberts, B, A Johnson, J. Lewis, M. Roff, K. Roberts and P. Walter 2002. Molecular Biology of the Cell IV Edition. Garland Science, New York.
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8) Malacinski, G. M. 2003. Essentials of Molecular Biology. Jones & Barlett
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2.2: Population Genetics and Evolution

1) Dobzhansky, Th., F. J. Ayala, G. L. Stebbins and J. M. Balentine, 1976. Evolution. Surjeet Publication, Delhi.
2) Freeman, S and J. C. Herron 1998. Evolutionary Analysis. Prentice Hall, New Jersey.
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4) Smith, J. M. 1998. Evolutionary Genetics. Oxford University Press. Oxford.
5) Stearns, S. C. and R. F. Hoekstra 2000. Evolution: An Introduction. Oxford University Press. Oxford.
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7) Strickberger, M. W. Evolution.2014. 5th edition. Jones and Bartlett Publishers. Boston.
8) Futuyma D. J. 2013. Evolution. Macmillan education.

2.3: Genes and Development

1) Gilbert, S. F. 2003. Developmental Biology. John Wiley Publishing.
2) Gilbert, S. F. Developmental Biology.2015. 11th edition. John Wiley Publishing.
3) Rao, V. 1994. Developmental Biology: A Modern Synthesis. Oxford and IBH. New Delhi.
4) Watson, J. D., T. A. Baker S. P. Bell, A Cann, M. Levine and R. Losick, 2004. Molecular Biology of Gene V Edition, Pearson Education RH Ltd. India.
5) Watson, J. D., T. A. Baker S. P. Bell, A Cann, M. Levine and R. Losick, 2014. Molecular Biology of Gene 7th Edition, Pearson Education RH Ltd. India.
6) Alberts, B, A Johnson, J. Lewis, M. Roff, K. Roberts and P. Walter 2002. Molecular Biology of the Cell IV Edition. Garland Science, New York.
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9) Wolpert, L, Beddington R, Jessel T, Lawrence P, Meyerowitz E, Smith J, 2015. Principles of Development, 5th edition. Oxford University Press.

H2.4: Scientific writing skills

1) Michael Alley (1996) The Craft of Scientific writing, springer, New York .
2) "How to Write and Publish a Scientific Paper". Sixth edition. 2006, Day and Gastel. Greenwood Press. www.amazon.in/How-Write-Publish-Scientific-Paper/dp/0313330409
3) "Essentials of Writing Biomedical Research Papers". Second edition.2000. Zeiger. McGRAW-Hill.
4) Reynolds, G. 2011. Presentation Zen: Simple ideas on presentation design and delivery. New Riders.
5) Reynolds, G. 2009. Presentation zen. New Riders.

S2.5: Gene Regulation

1) Griffiths A J F, H. J. Muller, D. T. Suzuki, R. C. Lewontin and W. M. Gelbart 2000.
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S2.7 Genetics of Plants and Microbes

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OE2.8: Basic Genetics

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2) Gardner E. J. M. J. Simmons and D.P. Snustad 1991 Principles of Genetics. John Wiley & Sons. INC. New York.
3) Klug, W. S. and M. R. Cummings 1994 Concepts of Genetics MacMillan Colley Publishing and Company NY.
4) Strickberger M. W. 1996. Genetics. Mac Millan Publishing Co. NewYork 5) Tamarin,. R H. 1999 Principles of Genetics. McGraw-Hill.
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6) Simmons S 2006, Principles of genetics, 4th Edition, John Wiley & Sons (Asia) Pte Ltd. New Jersey.

THIRD SEMESTER

HARD CORE

COURSE –I : GENETIC ENGINEERING

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Build strong foundation for the understanding of principles of genetic engineering
- Learn the components involved in cloning and recombinant gene technology
- Understand the importance of techniques employed in genetic engineering
- Familiarize the students with the application of genetic engineering to meet the current demands

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I & II

Principles of Genetic Engineering: (a) Historical account, Definition and Objectives (b) Components of gene cloning- (1) Nucleic acids (principles of isolation, purification and quantification) (2) DNA modifying enzymes (Restriction and modification enzymes, Other nucleases, Polymerases, Ligase, Kinases and Phosphatases) (3) Cloning vectors (Plasmids, Phages, Cosmids, Artificial chromosomes and Expression vectors) (4) Cloning hosts (*E. coli, Saccharomyces,* Plant and animals cells) (c) Gene transfer (Physical and vector mediated methods) and cloning methods (Directional cloning and TA cloning methods) (d) Gene/ DNA library Screening and isolation - Strategies, DNA libraries (Genomic DNA, cDNA and expression libraries), Probe Selection and labeling, Hybridization (principles of hybridization) gene screening (colony, plaque, dot, Southern & Northern blot screening, Antibody screening)

UNIT -III & IV

i) PCR: Principle, Methodology, Types - RT-PCR, RAPD, AFLP, ISSR, inverse PCR and Real time PCR and their applications.

ii) DNA sequencing: DNA sequencing methods and their applications- (a) Maxam and Gilbert's method (b) Sanger's method (c) Automated DNA sequencing methods (1) Capillary gel electrophoresis (2) NGS methods (Dye based-Illumina, pH based-Ion Torrent/Proton, Nanopore) and their applications.

UNIT -V

DNA Engineering techniques: (a) Gel electrophoresis of nucleic acids (agarose, pulse-field) (b) Blotting of macromolecules and hybridization (c) Oligonucleotide synthesis (d) Promoter characterization (e) DNA fingerprinting (f) Site directed mutagenesis (g) *In vitro* translation (*E.coli*, wheat and reticulocytes) (h) Genome editing techniques- a) TALENS b) CRISPR.

UNIT -VI

Applications of Genetic Engineering: (a) Production of Transgenic organisms (b) Human health (Production of vaccines, biomolecules, diagnostic kits and molecular medicine)(c) Biosafety (d) Intellectual Property Rights (patenting, trade secrets, copy right, trade and their regulations) (e) Risks and ethics of GMO products.

COURSE –II : GENOME GENETICS

Course Outcome :

On successful completion of this course each student will be able to / This course intends to

- Build strong foundation to the understanding of genome organization of prokaryotes, eukaryotes and extra-nuclear genomes
- Introduce to different genome mapping methods and their importance in genomic research
- Understand the various genome projects and techniques involved
- Understand the pattern of genome evolution

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I & II

Organization of genomes: (a) Introduction: Genome, Genomics, Omics and its importance (b) Prokaryotes - Bacteriophages, Bacteria, Viruses (c) Eukaryotic organelle genomes - Chloroplast and Mitochondria (d) Eukaryotic nuclear genomes (General features, C-value paradox, types of coding and noncoding sequences and Split Genes) (e) Mobile genetic elements in Prokaryotes (bacteria) and Eukaryotes (*Drosophila,* maize and humans).

UNIT -III

Mapping of genomes: (a) Genetic mapping- (1) Cross breeding and pedigree analysis (2) DNA markers - RFLPs, SSLPs, SNPs. (b) Physical mapping - Restriction mapping, Fluorescent *in situ* hybridization, Radiation hybrid mapping and Sequence tagged site mapping.

UNIT -IV & V

Genomics:

i) Genome projects: The Human genome project, HapMap Project, The 1000 genome project, and The ENCODE Project.

ii) Structural genomics: (a) Assembly of a contiguous DNA sequence- shotgun method, clone contig method, and whole –genome shotgun sequencing. (b) Understanding a genome sequence: locating the genes in a genome sequence, determining the functions of individual genes

iii) Functional genomics: Study of transcriptome (By sequence analysis, and Microarray analysis) and Proteome (Interacting proteins by phage display and Yeast two hybrid system)

iv) Comparative genomics: of Bacteria (*H. influenzae*), organelles, eukaryotes (Yeast, *Caenorhabditis elegans, Drosophila*, *Arabidopsis*, Human).

UNIT -VI

Pattern of genome evolution: (a) The origin of genomes- Origin of macromolecules, RNA world and DNA world (b) Acquisition of new genes (By gene duplication) and Gene families (Types, Pseudogenes, Origin of gene families (lateral gene transfer, allopolyploidy) (c) Synthetic genomes and their applications.

COURSE –III : MINOR PROJECT WORK

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Introduce students to various aspects of research project
- Know the importance of literature review before going ahead with a research project
- Learn the various methods used in research

Pedagogy :

Teaching the basic concept of the research project by individual project guides, Literature survey of the topic selected, Identification of the lacunae in the subjects and formulation of objectives, Selection of appropriate materials and methods for experimentation and conducting the pilot experiments. Discussion in the interactive session.

COURSE CONTENT

SOFT CORE

COURSE –IV : BIOSTATISTICS AND BIOINFORMATICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Build a strong foundation for the understanding of biostatistics and it's usage in genetic research
- Introduce students to various databases and their importance
- Learn the importance of *in silico* analysis using bioinformatics in genetic research and healthcare
- Know the usefulness of drug designing and protein modelling

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT I & II

Biostatistics: (a) Measures of central tendency: Mean, Median, Mode (b) Measures of dispersion: Range, Mean deviation, Variance and Standard deviation (c) Probability distributions (Binomial, Poisson and normal) (d) Sampling distribution (e) Difference between parametric and non-parametric statistics (f) Heritability (g) measurement of variability (h) Hypothesis Testing: Errors level significance, Confidence Interval Tests based on student t, F and Chi-square (x2) (i) Analysis of Variance: one way and two way, Ancova (j)Correlation and regression: Correlation, Correlation coefficient, Univariate and Multivariate analysis, Simple linear regression, Logistic regression (k) Computational statistical analysis (SPSS), (l) Applications of Statistics in Genetics.

UNIT-III & IV

i) Databases: (a) Introduction to Bioinformatics, Databases, Importance of databases (b) Nucleic acid Sequence databases- NCBI, EBI, DDBJ (c) Protein Sequence Databases- UNIPROT, SWISS-PROT, PIR (d) Structure Databases- PDB (e) Bibliography Databases- PUBMED (f) Secondary Databases- CATH, SCOP, PRODOM, PROSITE (g) Introduction to sequence submission softwares- webin, seqin, sakura (h) Genome databases (i) Proteomic databases (j) Metabolomic databases.

ii) Predictive methods using DNA sequences: Introduction to Bioinformatics software's, Gene prediction strategies, Gene prediction programs, BLAST (its variants), Multiple sequence

alignments, ORF Mapping, CpG Plot, Primers, Primer Designing, Restriction Enzyme digestion, Expressed sequence tag,

iii) Predictive methods using Protein sequences: Protein prediction strategies, Secondary structure prediction, Identifying domains, Posttranslational modifications, Protein function prediction, Proteolytic enzyme digestion, helical wheel, and protein expression analysis.

UNIT V & VI

i) Protein structure and Modeling: Protein Structure prediction, Intrinsic Tendency of Amino Acids to Form β Turns. Molecular Visualization, Pdb File Format, RASMOL Display Styles Wire Frame. Ball And Stick, Space Fill, Ribbons, Cartoons. Homology modeling, Three-Dimensional structure prediction, Comparative modeling, Construction of initial model, refining the Model, Manipulating the model.

ii) Structure based drug designing: Introduction to basic concepts, Molecular recognition by receptor and ligand design, Generation of Rational Approaches in Drug design, Introduction to drug designing, Discovering a drug, Target identification and validation, Identifying the lead compound, Optimization of lead compound.

iii) Docking methods: Introduction, three dimensional description of binding site environment and Energy calculation, Automatic Docking Method, Three Dimensional database search Approaches, Automated structure Construction methods, AUTODOCK, Argos Lab.

COURSE –V : IMMUNOLOGY AND CANCER GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Know an overview of immune system and the various components of it
- Understand the biological significance of antigens and immunoglobulins
- Understand how vaccines are produced and how impactful they are in the human health
- Know the genetic basis of cancer, it's manifestation, molecular diagnosis, prevention and management

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT I

Overview & Cells of the Immune system: (a) Historical account, (b) Primary and secondary lymphoid organs, (c) Biology of cells of the immune system: Hematopoiesis, Stem cells, NK cells, Macrophages, T Lymphocytes, B-Lymphocytes, Dendritic cells, (d) Types of immunity - Innate immunity: Anatomic barriers, Physiologic barriers, Phagocytic barriers, Microbial antagonism, Inflammation, PRRs, TLRs and PAMPs. Acquired immunity: Naturally acquired and artificially acquired, (e) Humoral and cell mediated immunity (f) Complement system: components, activation and biological consequences.

UNIT II

Antigens and Immunoglobulins: (a) Factors influencing immunogenicity (b) Haptens (c) Classes of immunoglobulins (d) Structure of IgG (e) Kinetics of immunoglobulin synthesis (f) Genetic basis of immunoglobulin diversity (g) MHC molecules- Types and structure, (h) Clonal selection and immunological memory (i) Antigen recognition- exogenous pathway, endogenous pathway, cross presentation.

UNIT III

Vaccines: Principles of vaccination, primary and secondary responses, antibody engineering, Monoclonal antibodies and their applications, antigen-antibody interactions, congenital and acquired immunodeficiency, Autoimmunity and autoimmune diseases, Hypersensitivity, Detection of antigens/molecules using ELISA, RIA, western blot.

UNIT IV

Biology of Neoplasm: (a) Development and causes of cancer: types of cancer, development of cancer, causes of cancer, properties of cancer cells, transformation of cells in culture (b) Tumor viruses: Hepatitis B Viruses, SV40, Papilloma viruses, Adenoviruses, Herpes viruses, and Retroviruses.

UNIT V

Genetics of cancer: Genetic rearrangements in progenitor cells, (a) Oncogenes: Retroviral oncogenes, proto-oncogenes, oncogenes in human cancer, functions of oncogene products (b) Tumor suppressor genes: Functions of tumor suppressor gene products, roles of oncogenes and tumor suppressor genes in tumor development, (c) Cancer as a multistep process, (d) Cancer therapy: early detection and prevention, molecular diagnosis, treatment, Virus-induced cancer, Metastasis, cancer cell lines, interaction of cancer cells with normal cells.

UNIT VI

Cancer Treatment: Present and Future. Cancer therapy: Radiation therapy, Chemotherapy, Current Therapies. Therapies based on understanding the Loss of Cell cycle control and Genetic instability of cancer cells. New Therapies, immunotherapy, Stem cells therapy, Rational tailored medical treatments, Cancer drugs.

COURSE –VI : BIOLOGY OF NON-CODING RNA

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Familiarise students with different classes of RNAs
- Understand the biological significance of non-coding RNAs
- Know the mechanism and application of RNA inference

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT I & II

i) Discovery of RNA interference (RNAi): Introduction to non-coding RNA, discovery of RNA interference, Endogenous miRNA, miRNA biogenesis pathway, Categories of small non-coding RNAs: dsRNAs, siRNAs, shRNAs, piRNAs and miRNAs, Detection of small RNAs.

ii) Mechanism of RNAi: Different components of RNAi pathway and their evolutionary conservation and role in gene silencing, RNAi-like pathway in bacteria, Molecular basis of RNAi /siRNA /miRNA mediated gene silencing, RNAi in defense and the regulation of chromatin structure and gene expression, RNAi suppressors.

UNIT III & IV

i) miRNAs and siRNAs: Pathways, expression and functions of microRNAs, High-throughput analysis of miRNA gene expression; siRNA vectors, siRNA delivery in vitro and in vivo; RNA informatics - Computational tools for miRNA discovery, siRNA and miRNA design. miRNAs in development, miRNAs in cancer: tumor suppressors and oncogenes.

ii) Other classes of small noncoding RNAs: piRNAs, Long noncoding RNAs: XIST, and lincRNAs.

UNIT V & VI

i) Large-scale genetic analysis using RNAi: Genome-wide RNAi screens in C. elegans, and *Drosophila* systems, High-throughput small RNA profiling, RNAi microarrays.

ii) Applications: RNAi vectors and generation of transgenic animals and plants, Analysis of expression of dsRNA and gene silencing; The use of RNAi in the prevention of diseases in animal models and crop improvement; RNAi therapy; Future prospects of RNAi in biology, medicine and agriculture.

PRACTICALS - GENETIC ENGINEERING AND GENOMICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Know the hands-on experience of different recombinant DNA techniques
- Familiarise the students with advanced bioinformatics analysis
- Learn the complete analysis of gene in wet - lab and dry lab

Pedagogy :

Teaching the concept of the experiments, Demonstration of the experiments, Conducting the experiments by each students, Result presentation by each students, Discussion of the data by interactive sessions

COURSE CONTENT

No	Practicals	Hours
1	Isolation of DNA from Blood (Human) and Tissue by phenol-chloroform extraction method.	2x4
2	*In vitro* DNA synthesis by PCR method and cloning by TA cloning method (Ligation, competent cell preparation and Transformation)	2x4
3	Isolation of recombinant DNA, Restriction digestion, and electrophoresis.	2x4
4	Isolation of Blood mRNA, quantification, cDNA conversion and quantification of *GAPDH* gene.	2x4
5	Genetic mapping by RFLP analysis.	1x4
6	Physical mapping of bacteriophage genome / recombinant DNA clone by restriction mapping	1x4
7	Homology sequence analysis using Blast (Blast n, Blast p, Blast x), and FASTA.	1x4
8	Identifying gene features through DNA sequence analysis and primer designing (gDNA, cDNA and miRNA).	1x4
9	Multiple sequence alignment and phylogenetic tree construction.	1x4
10	Whole genome/exome sequence analysis.	1x4
11	Protein 3D structure visualization.	1x4
12	Performing protein 3D structure modeling and docking.	1x4

OPEN ELECTIVE

COURSE –VIII : HUMAN GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Know the basic understanding of human genetic and how it has come about
- Familiarize students with various mapping techniques of complex traits
- Learn the genetic basis of various syndromes and disorders
- Understand the importance of diagnosis, genetic counselling and therapy

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I

Human Genetics: (a) History, Construction and analysis of Pedigrees, Pattern of inheritance. (b) Identifying recombinants and non-recombinants in pedigrees (c) Somatic cell fusion, and Radiation hybrids, (d) Genetic and physical map distances, (e) Two-point mapping - LOD score analysis.

UNIT -II

Genetic mapping of complex traits:(a) Difficulties in mapping complex traits (b) Allele sharing methods- Affected sib pair analysis (c) Allelic association mapping (d) Linkage disequilibrium mapping e) Transmission disequilibrium test (f) Whole genome scan and mapping (g) Integration of Cytogenetic, genetic and physical maps.

UNIT -III &IV

Genetic basis of syndromes and disorders: (a) Monogenic diseases (Cystic fibrosis and Marfan syndrome) (b) Inborn errors of metabolism (Phenylketonuria) (c) Neurogenetic disorders (Parkinson disease) (d) Genetic disorders of Haemopoietic systems (Sickle cell anemia) (e) Genetic disorders of eye (Retinitis pigmentosa) (f) Muscle genetic disorders (Duchenne and Becker Muscular Dystrophy) (g) Genome imprinting syndromes (Prader-Willi & Angelman syndromes) (h) Congenital heart diseases (i) Learning disorders (j) Genetics of Infertility (k) Cognitive disabilities, Schizophrenia and Anxiety disorders

UNIT -V &VI

Diagnosis, Counseling, Therapy and Ethics: (a) Prenatal diagnosis: (1)Noninvasive methods- X- radiation, Ultrasonography and Fetal echocardiography (2) Invasive methods- Maternal serum screening, Amniocentesis, Chorionic villus sampling and Fetoscopy (b)Technology in reproductive assistance (c) Genetic counseling: (d) Risk assessment and counseling in Mendelian and multifactorial syndromes (e) Gene therapy (f) Genome editing (g) Management of genetic disorders (h) Eugenics, human genetics and legal, social and ethical considerations.

REFERENCES

H3.1 : *Genetic Engineering*

1) Brown, T. A. 1995. Gene Cloning: An introduction. Chapman and Hall, London
2) Brown, T. A. 2015. Gene Cloning: An introduction. 7th edition. Chapman and Hall, London
3) Glick, B. R. and Pasternak, J. J. 1994. Molecular Biotechnology: Principles and applications of recombinant DNA. ASM Press, Washington D.C.
4) Kreuzer, H. and A. Massey. 2001. Recombinant DNA and Biotechnology. ASM Press, Washington D.C.

H3.2: Genome Genetics

1) Brown T. A. 2007, Genomes 3. Garland Science Publishing, New York.
2) Dunham, I., 2003. Genome Mapping and sequencing. Horizon Scientific
3) Graur, D and W H Li, 2000. Fundamentals of molecular evolution. Sinauer Associates.
4) Hartwell, L. H., L. Hood, M. L. Goldberg, A. E. Reynolds, L. M. Silver and R. G. Veres. 2004. Genetics from Genes to Genomes. McGraw Hill.
5) Lewin B. 2003. Genes VIII. Oxford University Press. Oxford.
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7) The Human Genome 2001, Nature Vol. 409.
8) The *Drosophila* Genome. 2000, Science Vol. 267.
9) The *Caenorhabditiselegans* genome 1998. Science Vol. 282.
10) The Arabidopsis Genome 2000 Nature vol. 408.
11) Primrose, S. B., and R. M. Twyman . 2006. Principles of gene manipulation and
12) Genomics, Blackwell Publishing MA. USA.

S3.4: *Biostatistics and Bioinformatics*

1) Bioinformatics : a practical guide to the analysis of genes and proteins, baxevanis & bff oluellette, 2001 – ad – wiley interscince – new york
2) Bioinformatics : methods and protocol, stephen misener & stephan a. krawetz, :– 2000 : humana press, new jersey.
3) Bioinformatics :sequence, structure and databanks, des higgins & willie tylore:– 2000: oxford university press.
4) Bioinformatics sequence & genome analysis, david. w. mount, cold serving harbor laboratory
5) Proteomics from protein sequence to function ,by ennington sr 0 / dunn mj
6) Proteomics from protein sequence to function , by pennington sr
7) Purifying proteins for proteomics a laboratory manual ,by richard j simpson
8) Discovering genomics proteomics & bioinformatics ,by malcolm campbell / laurie j heyer
9) Guidebook on molecular drug design ,by claude cohen n
10) Molecular modelling & drug design,by anand solomon k Drug design ,by morris sylvin
11) Introduction to drug design ,by Pandeya sn / dimmock jr

S3.5: Immunology and Cancer Genetics

1) Abbas, A. K., A. H. Lichtman and J. S. Pober. 1994. Cellular and molecular immunology. W. B. Saunders Company.
2) Alberts, B., A. Jhonson, J. Lewis, M. Raff, K. Roberts and P. Walter 2008. Molecular Biology of the cell. V Ed. Garland Science, New York.

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S3.6: Biology of non-coding RNA

1) RNA Worlds: From Life's Origins to Diversity in Gene Regulation. Edited by John F. Atkins, *University of Utah, University College Cork, and Trinity College Dublin;* Raymond F. *Utah;* Thomas R. Cech, *Howard Hughes Medical Institute, University of Colorado.* 2011. 366 pp

2) RNA Interference Technology: From Basic Science to Drug Development. Eds. Fire et. al. Cambridge, University Press, Cambridge University Press; 725th edition (January 17, 2005)

3) RNAi: A Guide to Gene Silencing. Ed. Gregory J. Hannon, CSHL Press, Cold Spring Harbor Laboratory Press,U.S.; 1st edition (1 August 2003)

4) RNA Silencing: Methods and Protocols Ed. Gordon G. Carmichael, CSHL Press 4th Edition

5) RNA Interference in Practice: Principles, Basics, and Methods for Gene Silencing in C. elegans, Drosophila, and Mammals. Wiley Publications. 336 pages, November 2004

6) Genes IX. Lewin B. Jones and Barlett Publishers, Jones and Bartlett Publishers, Inc; 9th Revised Edition (6 March 2007).

S3.7: Human Genetics

1) Cummings, M. R. 1994. Human Heredity: Principles and Issues. West Publishing Company.

2) Cummings, M. R. 2014. Human Heredity: Principles and Issues. West Publishing Company.

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7) Strachan, T. and A. P. Reads, 2004. Human Molecular Genetics 3. Garland Science, London.

FOURTH SEMISTER

HARD CORE

COURSE –I : ADVANCED HUMAN GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Build a strong understanding of human genetics
- Familiarise students with various mapping techniques of Mendelian traits and complex traits
- Know the genetic basis of syndromes and disorders
- Understand the importance of diagnosis, genetic counselling and therapy

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT I

Genetic mapping of Mendelian traits: (a) History of human genetics, Pedigree analysis, Pattern of inheritance. (b) Identifying recombinants and non-recombinants in pedigrees (c) Somatic cell fusion, cell hybrids and Radiation hybrids, (d) Genetic and physical map distances (e) Two-point mapping - LOD score analysis (f) Multipoint mapping (g) Homozygosity mapping.

UNIT II

Genetic mapping of complex traits:(a) Difficulties in mapping complex traits (b) Allele sharing methods- Affected sib pair analysis (c) Allelic association mapping (d) Linkage disequilibrium mapping (e) Transmission disequilibrium test (f) Whole genome scan and mapping (g) Integration of Cytogenetic, genetic and physical maps.

UNIT III &IV

Genetic basis of syndromes and disorders: (a) Monogenic diseases (Cystic fibrosis and Marfan syndrome) (b) Inborn errors of metabolism (Phenylketonuria and Mucopolysaccharidosis) (c) Neurogenetic disorders (Charcot-Marie-Tooth syndrome and Parkinson disease) (d) Genetic disorders of Haemopoetic systems (Sickle cell anemia and Thalassemias) (e) Genetic disorders of eye (Retinitis pigmentosa, Glaucoma and Cataracts) (f) Muscle genetic disorders (Duchenne and Becker Muscular Dystrophy) (g) Genome imprinting syndromes (Prader-Willi & Angelman syndromes, Beckwith-Wiedeman syndrome (h) Genetic disorders in skeleton and skin (i) Congenital heart diseases (j) Learning disorders (k) Genetics of Infertility (l) Cognitive disabilities, Schizophrenia and Anxiety disorders (m) Complex syndromes (Atherosclerosis, Diabetes mellitus, Rheumatoid Arthritis) (n) Mitochondrial syndromes.

UNIT V &VI

Diagnosis, Counseling, Therapy and Ethics: (a) Prenatal diagnosis: (1) Noninvasive methods - radiation, Ultrasonography and Fetal echocardiography (2) Invasive methods- Maternal serum screening, Amniocentesis, Chorionic villus sampling and Fetoscopy (b) Pre-implantation diagnosis (c) Technology in reproductive assistance (d) Genetic counseling: Definition, Components, Psychotherapeutic counseling, Decision making, risk assessment and counseling in Mendelian and multifactorial syndromes (e) Gene therapy (f) Management of genetic disorders (g) Eugenics, human right, human genetics and legal, social and ethical considerations.

COURSE –II : MAJOR PROJECT WORK

Course Outcome :

Tutorials + Practicals

On successful completion of this course each student will be able to / this course intends to

- Familiarise students of how to ask questions / identify a scientific problem to work with
- Know how to explore ways to answer the problem
- Learn the importance of right methodology in addressing a question
- Understand the importance of deriving the right kind of conclusions based on their experimental results
- Present the same to peers and faculty and get feedback

Pedagogy :

Teaching the basic concept of the research project by individual project guides,

Literature survey of the topic selected, Identification of the lacunae in the subjects and formulation of objectives, Selection of appropriate materials and methods for experimentation and conducting the experiments/ analysis. Discussion in the interactive session

SOFT CORE

COURSE –III : ENVIRONMENTAL IMPACT ON DEVELOPMENT

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Familiarise students with importance of environmental factors during the course of development
- Understand the mechanism of teratogenesis
- Introduce students to developmental anomalies and aging

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT I

Development and Environment : (a) Developmental symbiosis (b) Embryonic diapause. (c) Phenotypic plasticity: Polyphenism – nutritional, seasonal, Diet and DNA methylation, predator-induced polyphenism, Environment dependent sexual phenotype, learning - Adaptive nervous system (d) Stress-induced gene expression.

UNIT II

Teratogenesis: (a) Teratogenic agents and their assault on human development- Alcohol, Retinoic acid, thalidomide, endocrine disruptors - DES, Nonylphenol, BPA, DDT, Heavy metals, pathogens etc. (b) Malnutrition –embryonic origin of adult onset illness (Hypertension, diabetes, gene methylation)

UNIT III & IV

i) Developmental anomalies: (a) Anencephaly - Spina bifida (b) Cyclopia-Shh mutants (c) Blindness-Rx mutants (d) Deafness (e) Progeria

ii) Aging: (a) Concept of aging - organismal (b) cellular changes during aging (DNA damages, shortened telomere, mitochondrial mutations, oxidative stress) (c) Theories of aging.

COURSE –V : DIAGNOSTIC AND THERAPEUTIC GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Provide basic understanding of the importance of stem cell therapy
- Introduce students to RNAi therapeutics and gene therapy to address different genetic diseases
- Learn the importance of personalized genomic medicine

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I & II

i) Stem cells: Embryonic stem cells – therapeutic cloning, Multipotent adult stem cells (Cardiac stem cell, Neuronal stem cell, Hematopoietic Stem cell, Liver Stem Cell), transgenic stem cells. Regeneration Therapy.

ii) Stem cell therapy: Current stem cell therapies – iPS cells, use of stem cells cure genetic diseases, Correlation between stem cells and cancer. Clinical applications of hematopoietic stem cells from cord blood (Ex. first successful transplantation of cord blood in a child with Fanconi's anemia). Treatment of diseases - Parkinson's disease, Huntington's disease, Alzheimer's disease, and Muscular diseases, Repair of damaged organs such as the liver and pancreas.

iii) RNAi Therapeutics: Expression of dsRNA in animals and plants, and its applications: RNAi vectors and generation of transgenic animals and plants, Analysis of expression of dsRNA and gene silencing; The use of RNAi in the prevention of diseases in animal models and crop improvement; RNAi therapy; Future prospects of RNAi in biology, medicine and agriculture.

UNIT -III & IV

i) Gene Therapy: Introduction, Somatic and germ line gene therapy, Gene replacement and gene addition. In vivo, ex vivo and in vitro gene therapy, Transgenic animal models.

ii) Viral Vectors: History of Gene Transfer, Nonviral Gene Transfer, Gene Therapy Strategies, Molecular Biology and Virology Basics, Safety and Compliance.

Vectors: Retroviruses, Adenoviruses, Adenoviruses and Adeno-associated Viruses (AAV), Herpes Viruses, Pox Viruses, Rabies Viruses.

iii) Techniques in Gene Therapy: CAR and editing, Immunotherapy in cancer, DNA vaccination, RNAi in gene therapy, Antisense Oligonucleotides.

iv) Gene Therapy for Cancer: Cancer gene therapy, RNA-DNA chimera, Gene therapies for Criglar-Najjar syndrome I, Viral Vaccines.

v) Gene Therapy in Genetic Diseases: Liver diseases, Eye diseases, Cystic fibrosis, Duchnne muscular dystrophy, Bleeding disorders, Tyrosinemia, Severe combined immunodeficiency syndrome (SCID), Gene therapy of nonheritable disorders,

UNIT -V & VI

Personalized Genomic Medicine:

i) Molecular Diagnostics: New insights into the structure of the human genome and different types of genetic and non-genetic variation that occur, Genetic screening and diagnosis for Mendelian and complex diseases, Whole Genome/Exome (NGS) sequence analysis, identification and annotation of genetic variations, candidate gene screening, identification of gene targets, genomic and personalized map, clinical and molecular diagnostics, blood-based gene expression profiles in cancer diagnosis and prognosis.

ii) Precision Medicine: The use of next-generation sequencing for solving diagnostic dilemmas, Methods used in patient populations to uncover associations between genome variation and common diseases, Predictive tests for common, complex diseases, Pharmacogenomic testing for drug selection, dosing and predicting adverse effects of commonly prescribed drugs.

COURSE –V : MACROMOLECULAR INTERACTIONS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Learn the biochemical reactions and how to analyze them
- Understand the enzymatic and non-enzymatic catalysis

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT I:

i) Analyzing biochemical reactions: (a) Properties of reactions (1) Thermodynamics: the relationships among free energy and equilibrium constant, entropy and enthalpy, The driving force for unimolecular interactions, The order of a reaction, and the relationship between the written statement of a reaction and its order, Rate *versus* rate constant (b) Tests of reaction mechanism: Structural *versus* kinetic approaches, Analyzing intermediates: populated *versus* unpopulated, kinetic significance, The kinetics of catalyzed *versus* uncatalyzed reactions.

ii) Enzymatic *versus* non-enzymatic catalysis: (a) Kinetic analysis: partition experiments, the rate-determining step, Chemistry: reactive amino acid residues in active sites, Relationships among binding, specificity and rate of enzyme-catalyzed reactions, (b) Detecting and exploiting physical interactions: (1) Interaction forces between molecules (2) Canonical structures in proteins, (c) Assays of physical properties: Binding equilibria and concentration, Turnover, Molecular weight of native and denatured proteins, Fluorescence and FRET, (d) Biological implications: (1)Allosteric interactions (2) Specific *versus* non-specific binding and distinguishing functional binding interactions (3) High energy compounds: synthesis and hydrolysis, (e) Catalysis of vectorial reactions: motor functions, protein folding, pumps.

UNIT II:

i) Binding Analysis: Practical Aspects of Binding Analyses, Non-linear least squares analysis

ii) Wyman's Linkage: Homotropic Linkage – cooperativity, Heterotropic Linkage, Linkage and regulation, Self-Assembly and Polymerization, Linear Polymerization

iii) Recognition kinetics: Conformational equilibria: one, two and multistep, Recognition: one, two and multistep, Practical aspects of "recognition kinetics", Multisubstrate enzymatic reactions, Applications of molecular interactions.

References

V-: Macromolecular Interactions

1) Introduction to Macromolecular Binding Equilibria (2007) – C. P. Woodbury (CRC Press)
2) Binding and Linkage (1990) -Jeffries Wyman and Stanley J. Gill – (University Science Books)
3) Kinetics for the Life Sciences (1995) – H. Gutfreund (Cambridge University Press)

PRACTICALS - ADVANCED HUMAN GENETICS Course Outcome :

On successful completion of this course each student will be able to / This course intends to

- Learn the hands-on experience of different human genetics techniques involved in diagnosis of human genetics
- Learn the cancer cell / tissues and their role in diagnosis
- Know there own chromosomes and understand their importance

Pedagogy :

Teaching the concept of the experiments, Demonstration of the experiments, Conducting the experiments by each students, Result presentation by each students, Discussion of the data by interactive sessions

COURSE CONTENT

No	Practicals	Hours
1	Barr body and Dermatoglyphics analysis	2x4
2	Creation of pedigrees and study on patterns of inheritance	2x4
3	Induction of Human leukocyte culture	2x4
4	Preparation of human chromosomes for G, C and NOR banding	2x4
4	Identification and karyotyping of normal chromosomes and syndromes	2x4
5	Studies on phenotypes of different diseases and syndromes	2x4
6	DNA Isolation from Blood, quantification, PCR amplification and molecular diagnosis of genetic diseases	2x4
7	Human DNA fingerprinting by PCR	1x4
8	Study of Cancer cells/Tissue	1x4

OPEN ELECTIVE

COURSE –VII : NUTRITION GENETICS

Course Outcome :

On successful completion of this course each student will be able to / this course intends to

- Give brief introduction to genetics and human genetics
- Understand the students with nutrigenomics, diet and microbiome
- Introduce the importance of epigenetics and gene expression
- Learn the importance of nutrition in avoiding diseases

Pedagogy :

Teaching - Black board and Power Point presentation, interactive sessions
Assignments- Take home assignment hard copy submission, and online submission in Limited words

COURSE CONTENT

UNIT -I & II

i) Basic Genetics:

Milestones in genetics, Mendel's laws of inheritance –Monohybrid and dihybrid cross, Examples In pea plants, *Drosophila* and human, Probability of inheritance –concept of gene – past and present.

ii) Human genetics:

History of human genetics, Pedigree analysis, Pattern of inheritance, types of human genetic diseases, strategies used to analyze single gene and complex genetic disorders, human genome and its applications.

UNIT -III & IV

i) Introduction to nutrigenomics, nutrigenetics, and personalised nutrition: Bioactive Food Components, Bioactives and their function, Interaction of molecules with genes.

ii) Diet and the Microbiome: Taste Genetics (Amylase and copy number Or Bitter taste and obesity), Fat mass and obesity-associated protein (FTO) and weight loss, GWAS of macronutrient intake.

UNIT -V & VI

i) Diet and gene expression: Nutrients as regulators of activity and transcription factors.

ii) Epigenetics: (a) Nutrients as epigenetic exchange agents, (b) Agouti locus and obesity, (c)Transgenerational effects (Parental effects of high fat diet), (d) Diet induced miRNA changes, (e) Diet in early life and metabolic programming, (f) Diet as a possible risk or preventive factor in illnesses, (g) Gene polymorphisms and responses to diet. Examples related to cardiovascular disease, cancer, osteoporosis, (h) Risk/benefit of biomarkers.

iii) Nutrition, Disease, and Associated Target Genes: Overview of Disease and Nutrition, Inflammation and Associated Target Genes, Obesity and Associated Target Genes, Cancer and Associated Target Genes.

REFERENCES

H4.1:Advanced Human Genetics& Human genetics

1) Cummings, M. R. 2014. Human Heredity: Principles and Issues. West Publishing Company.
2) Epstein, R. J. 2003. Human Molecular Biology. Cambridge Univ. Press, Cambridge.
3) Jobling M. A., Hurles and Tyler-Smith. 2004. Human Evolutionary Genetics – Origin, People & Disease. Garland & Science.
4) Khoury, M. J., J. Little and W. Burke. 2004. Human Genome Epidemiology. Oxford Univ. Press, Oxford.
5) Strachan, T. and A. P. Reads, 2004. Human Molecular Genetics 3. Garland Science, London.
6) Strachan, T. and A. P. Reads, 2010. Human Molecular Genetics 3. 4th edition. Garland Science, London.

S4.3: : Environmental Impact on development

1) Gilbert, S. F. 2008. Developmental Biology. John Wiley Publishing.
2) Gilbert, S. F. . Developmental Biology.2015. 11th edition. John Wiley Publishing.
3) Watson, J. D., T. A. Baker S. P. Bell, A Cann, M. Levine and R. Losick, 2004. Molecular Biology of Gene V Edition, Pearson Education RH Ltd. India.
4) Watson, J. D., T. A. Baker S. P. Bell, A Cann, M. Levine and R. Losick, 2014. Molecular Biology of Gene 7th Edition, Pearson Education RH Ltd. India.
5) Alberts, B, A Johnson, J. Lewis, M. Roff, K. Roberts and P. Walter 2005. Molecular Biology of the Cell IV Edition. Garland Science, New York.
6) Alberts, B, Johnson, J Lewis, M. Raff, K Roberts and P. Watter. 2014. Molecular Biology of the cell. 6th edition. Garland Science, New York.

S4.4: Medical and Therapeutic Genetics

1) Strachan T, Andrew R. Human Molecular Genetics, 4th Edition, Garland Science, 2010.
2) Pasternak J. An introduction to Human Molecular Genetics: Mechanism of Inherited Diseases, Fitzgerald Science Press, 2nd Edition, 2005.
3) Robert et al. Thompson and Thompson Genetics in Medicine Saunders; 7 edition (1 August 2007)
4) Landmarks in Medical Genetics (Ed.) Peter S. Harper, Oxford University Press, 2nd Edition 2004.
5) Chromosome banding : by A.T. Sumner, Unwin & Hyman, 1990. 14th Edition. Burmeister, Margit L. 1991-09
6) Human Genetics: Problems and Approaches. Editors: Speicher, Michael, Antonarakis, Stylianos E., Motulsky, Arno G. (Eds.) Springer Verlag, 4th Edition, 2010.
7) RNAi: A Guide to Gene Silencing. Ed. Gregory J. Hannon, CSHL Press, Cold Spring Harbor Laboratory Press,U.S.; 1st edition (1 August 2003)
8) RNA Silencing: Methods and Protocols Ed. Gordon G. Carmichael, CSHL Press 4th Edition
9) RNA Interference in Practice: Principles, Basics, and Methods for Gene Silencing in C. elegans, Drosophila, and Mammals. Wiley Publications. 336 pages, November 2004

S4.5: Biochemical Interactions

4) Introduction to Macromolecular Binding Equilibria (2007) – C. P. Woodbury (CRC Press)
5) Binding and Linkage (1990) -Jeffries Wyman and Stanley J. Gill – (University Science Books)
6) Kinetics for the Life Sciences (1995) – H. Gutfreund (Cambridge University Press)

OE4.6 Nutritional Genetics

1) QI L. Gene-Diet Interactions in Complex Disease: Current Findings and Relevance for PublicHealth, Curr Nutr Rep 2012: 1: 222-227.

2) Tucker K. L., Smith C. E., Lai C. Q., Ordovas J. M. Quantifying diet for nutrigenomic studies, Annual review of nutrition 2013: 33: 349-371.

3) Peters L. L., Robledo R. F., Bult T C. J., Churchill G. A., Paigen B. J.,Svenson K. L. The mouse as a model for human biology: a resource guide for complex trait analysis, Nature reviews Genetics 2007: 8: 58-69.

4) Frazer K. A., Murray S.S.,Schork N. J., Topal E. J. Human genetic variation and its contribution to complex traits, Nature reviews Genetics 2009: 10: 241-251.

5) David L. A., Maurice C. F., Carmody R. N., Gootenberg D. B., Button J. E., Wolfe B. E. et al. Diet rapidly and reproducibly alters the human gut microbiome, Nature 2013.

6) Kuczynski J., Lauber C. L., Walters W. A., Papfrey L. W., Clemente J. C., Gevers D. et al. Experimental and analytical tools for studying the human microbiome, Nature reviews Genetics 2012: 13: 47-58