Course of Study
M. Sc. in Molecular & Human Genetics
DISTRIBUTION OF DIFFERENT COURSES AND CREDITS IN VARIOUS SEMESTERS

Semester-I		
Course Code	**Title**	**Credits**
MGM101	Transmission Genetics	3
MGM102	Population & Evolutionary Genetics	3
MGM103	Basic Human Genetics	3
MGM104	Biotechniques	3
MGM105	Biochemistry and Metabolism	3
MGM106	Lab work based on courses MGM101 &MGM102	2
MGM107	Lab work based on courses MGM103 & MGM104	2
MGM108	Lab work based on courses MGM105	2
	Total	**21**
Semester-II		
Course Code	**Title**	**Credits**
MGM201	DNA Technology & Genetic Engineering	3
MGM202	Cell Biology	3
MGM203	Model Genetic Systems	2
MGM204	Immunogenetics	3
MGM205	Human Genome	3
MGM206	Molecular Genetics	3
MGM207	Lab work based on courses MGM201 & MGM202	2
MGM208	Lab work based on courses MGM203 & MGM204	2
MGM209	SWAYAM/MOOCS Course-I Compulsory (Biostatics/Introduction to Biostatistics / Foundation of data science/data science using Python/Basic statistics using R / Foundation of R software, and any other related course)	2
	Total	**23**
Semester-III		
Course Code	**Title**	**Credits**
MGM301	Human Molecular Genetics	3
MGM302	Clinical Genetics	3
MGM303	Genomic Instability and Cancer	3
MGM304	Developmental Genetics	3
MGM305	Lab work based on courses MGM301 & MGM302	2
MGM306	Lab work based on courses MGM303 & MGM304	2
MGM307	Dissertation Part-1(Proposal and Techniques)	2
MGM308	SWAYAM/MOOCS Course-II Compulsory (Computer aided drug design/ fundamentals of Artificial intelligence/ Introduction to machine learning/ AI and medicine and any other related course)	2
	Total	**20**
Semester-IV		
Course Code	**Title**	**Credits**
MGM401	Neurogenetics	3
MGM402	Genetic Counseling and Intellectual Property Rights	2
MGM403	Lab work based on course MGM401	1
MGM404	Seminar & Formulation of Research Project	2
MGM405	Comprehensive Viva-voce	2
MGM406	Dissertation Part-II	6
	Total	**16**
	Grand Total	**80**

SEMESTER - I

MGM101: Transmission Genetics — Credits: 3

	Lecture hours
1. Introduction to Genetics	2
2. Classification of chromosome	4
2.1 Holocentric and Supernumerary chromosomes	
2.2 Giant chromosomes	
2.3 Polytene chromosomes	
2.4 Lampbrush chromosomes.	
3.Mendelism	5
3.1 Mendel and his experiments	
3.2 Law of segregation	
3.3 Law of independent assortment	
3.4 Application of laws of probability (product rule, sum rule)	
3.5 Chromosomal basis of segregation and independent assortment	
4.Chi-square test and its application in analysis of genetic data	2
5. Extensions of Mendelism	9
5.1 Allelic variation and gene function- Dominance relationships, basis of dominant and recessive mutations	
5.2 Multiple allelism, allelic series	
5.3 Testing gene mutations for allelism: complementation test, intragenic complementation	
5.4 Visible, sterile and lethal mutations	
5.5 Genotype to phenotype: effect of the environment on phenotype developmentPenetrance and expressivity, phenocopy	
5.6 Gene interactions and modifying genes	
5.7 Pleiotropy	
6.Sex-linked inheritance, Linkage and crossing over	4
6.1.Genetic recombination and construction of genetic maps in *Drosophila*	
6.2.Interference and coincidence	
6.3.Cytological demonstration of crossing over in *Drosophila*	
7. Cytoplasmic inheritance, maternal effects, inheritance due to parasites and symbionts	3

Recommended Books

1. Hartl and Jones (1998). Genetics – Principles and Analysis. Jones & Bartlett
2. Snustad et al (6th Edition, 2011). Principles of Genetics. Wiley and sons
3. Strickberger (1985). Genetics. Mcmillan
4. Brooker (2012). Genetics – Analysis and Principles, 4th edition. Benjamin/Cumings

Suggested Reading

1. Atherly et al (1999). The Science of Genetics. Saunders
2. Fairbanks et al (1999). Genetics. Wadsworth
3. Gardner et al(2006). Principles of Genetics. 8th ed. John Wiley
4. Griffiths et al (2002). Modern genetic Analysis. Freeman
5. Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
6. Tamarin (2001). Principles of Genetics. 7th ed. WCB

MGM102: Population & Evolutionary Genetics — Credits:3

	Lecture hours
1.Concept and theories of evolution	2
2.Microevolution in Mendelian population	6
2.1. Mendelian Population	
2.2. Allele frequencies and genotype frequencies	
2.3. Hardy-Weinberg equilibrium and conditions for its maintenance	
3.Elemental forces of evolution	6
3.1. Mutation	
3.2. Selection (Types of selection, selection coefficient, selection in natural populations)	
3.3. Genetic drift	
3.4. Migration	
4.Chromosomal, DNA and allozyme polymorphism in natural population	5
4.1. Adaptive genetic polymorphism	
4.2. Balanced polymorphism and heterosis	
4.3. Genetic coadaptation and linkage disequilibrium	
5.Isolating mechanisms	2
6.Concept of species and modes of speciation: sympatric, allopatric, stasipatric	4
7.Molecular population genetics	4
7.1. Molecular evolution (neutral theory, punctuated equilibrium)	
7.2. DNA-based phylogenetic trees	
8.Nonrandom breeding	2
8.1. Inbreeding and assortative mating	
8.2. Path diagram construction and inbreeding coefficient, allelic identities by descent	
9.Human phylogeny	6
9.1. Hominid evolution: anatomical, Geographical, Cultural	
9.2. Molecular phylogenetics of Homo sapiens	
9.3. Peopling of continents (Europe, Africa, Asia)	
10.Population Substructure	3
10.1. Hierarchical population structure	
10.2. Isolate breaking: The Wahlund principle	

Recommended Books

1. Hartl& Clark (3rd Edition; 2017). Principles of Population Genetics.Sinaur
2. Hartl and Jones (1998). Genetics. Principles and Analysis. Jones and Bartlet
3. Hedrich, Philip W (2011). Genetics of Populations. 4th edition. Jones and Bartlett Publishers
4. R Brooker (2024). Genetics: Analysis and Principles, 8th Edition. Mc Graw Hill
5. Monroe W. Strickberger, Brian K. Hall, Benedikt Hallgrimsson (2007). Strickberger's Evolution. Jones and Barlett

Suggested Reading

1. Brown (2007). Genomes. Bios
2. Jobling et al (2004). Human Evolutionary Genetics. Garland
3. Moody (1964). Evolution. Harper and Row
4. Roberts &DeStefano (1986). Genetic Variation and its Maintenance. Cambridge Univ
5. Smith (1998). Evolutionary Genetics. Oxford
6. Strickberger (2000). Evolution. Jones and Barlett

MGM103: Basic Human Genetics — Credits: 3

	Lecture hours
1. History of Human Genetics	1
2.Pedigrees- gathering family history, pedigree symbols, construction of pedigrees, presentation of molecular genetic data in pedigrees	1
3. Monogenic traits	12
3.1 Autosomal inheritance-dominant, recessive	
3.2 Sex-linked inheritance	
3.3 Sex-limited and sex-influenced traits	
3.4 Mitochondrial inheritance	
3.5 MIM number	
3.6 Complications to the basic pedigree patterns- nonpenetrance, variableexpressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparentaldisomy, spontaneousmutations, mosaicism and chimerism, male lethality, X-inactivation	
3.7 Risk assessment; application of Bayes' theorem	
3.8 Allele frequency in population	
3.9 Consanguinity and its effects	
4.Complex traits	10
4.1 Approaches to analysis of complex traits- 'Nature -nurture' concept, role ofFamily and shared environment, monozygotic and dizygotic twins and adoptionstudies	
4.2 Polygenic inheritance of continuous (quantitative) traits, normal growth charts, Dysmorphology	
4.3 Polygenic inheritance of discontinuous (dichotomous) traits- threshold model,liability and recurrence risk	
4.4 Genetic susceptibility in multifactorial disorders (alcoholism, diabetes mellitus, obesity)	
4.5 Estimation of genetic components of multifactorial traits: empiric risk, heritability, coefficient of relationship	
5. Human cytogenetics	15
5.1 Metaphase chromosome: centromere and kinetochore, telomere and itsmaintenance	
5.2 Techniques in human chromosome analysis	
5.3 Human karyotype: banding, nomenclature of banding	
5.4 Pathology of human chromosomes	
5.5 Nomenclature of aberrant karyotypes	
5.6 Common syndromes due to numerical chromosome changes	
5.7 Common syndromes due to structural alterations (translocations, duplications,deletions, microdeletion, fragile sites)	
5.8 Common chromosome abnormalities in cancer	
5.9 Genetics of fetal wastage	

Recommended Books

1. Mange and Mange (2005). Basic Human Genesdtics.SinauerAssoc
2. Gersen&Keagle (2nd Edition; 2005). The Principles of Clinical Cytogenetics. Humana
3. Gersen & Keagle (3rd Edition; 2013). The Principles of Clinical Cytogenetics. Springer
4. ISCN 2020 (Eds. Jean McGowan-Jordan; Ros J. Hastings; Sarah Moore). Karger
5. Strachan & Read (5th Edition; 2019). Human Molecular Genetics. Garland Edition.

Suggested Reading

1. Connor & Smith (2011). Essentials of Medical Genetics.6th edition. Blackwell
2. Davies (1993). Human Genetic Disease Analysis. IRL

3. Emery and Mueller (1992). Elements of Medical Genetics. ELBS
4. Jorde et al (2005). Medical Genetics. Elsevier
5. Korf (2006). Human Genetics. Blackwell

6. Lewis (2006). Human Genetics. WCB
7. Maroni (2001). Molecular and Genetic Analysis of Human Traits. Blackwell
8. Nussbaum et al (2004). Genetics in Medicine. Saunders

MGM 104: Biotechniques

Credits: 3
Lecture hours

1.Basic knowledge of principles and applications of the following microscopy techniques 8

- 1.1 Light Microscopy
- 1.2 Dark-field Microscopy
- 1.3 Phase-contrast Microscopy
- 1.4 Fluorescence Microscopy
- 1.5 Confocal Microscopy
- 1.6 Electron Microscopy
- 1.7 Photography, Digital imaging and image Processing.

2. Biochemical techniques 15

- 2.1 Colorimetry and spectrophotometry: Beer-Lambert law; absorption spectrum,fluorescence spectrum, Introduction to mass spectrometry
- 2.2 Centrifugation: types of rotors, clinical, highspeed and ultracentrifuges
- 2.3 Chromatography: Paper, Thin layer chromatography; Columns: ion-exchange,gel-filtration, HPLC and affinity columns
- 2.4 Electrophoresis: Agarose-gel electrophoresis, Native and SDS- PAGE, 2D Electrophoresis, 2D-DIGE, Western blotting, Immunoprecipitation
- 2.5 Basic principle of Flowcytometry
- 2.6 Tracer techniques: Properties and units of radioactivity; half-life; measurement of radioactivity by GM counter,radio-immunoassay

3. Omics8

- 4.1 High throughput Sequencing technologies: Genomic and transcriptome analysis by NGS
- 4.2 Metabolomics: Introduction and overview of metabolites, applications of non-tracer and tracer-based techniques, application of metabolomics

4. Biosafety 8

- 5.1 Introduction of bio-safety
- 5.2 Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world with special emphasis on Indian concerns.
- 5.3 Primary Containment for Biohazards
- 5.4 Biosafety practices in laboratory: laboratory associated infections and other hazards
- 5.5 Assessment of biological hazards and level of biosafety
- 5.6 Bio safety regulation: Special procedures for recombinant DNA based product production & handling of rDNA products and process in industry and in institutions (Indian context).
- 5.7 Roles of Institutional Biosafety Committee

Recommended Books

1. Alberts et al (2008). Molecular Biology of the Cell. Garland
2. Cooper (2007). The Cell: A Molecular Approach. ASM Press
3. Locquin and Langeron (1983). Handbook of Microscopy.Butterwaths
4. Zubay et al (1995). Principles of Biochemistry. WCB

5. Boyer (1993). Modern Experimental Biochemistry. Benjamin
6. Clark & Switzer (2000). Experimental Biochemistry. Freeman
7. Freifelder (1987). Physical Biochemistry. Freeman
8. Boyer 2007 (2007). Concept of Biochem. 3rd Ed
9. Keith Wilson and John Walker. Principles and Techniques of Biochemistry and Molecular Biology
10. Laboratory Biorisk Management: Biosafety and Biosecurity - CRC Press, Reynolds M. Salerno, Jennifer Gaudioso, 2015
11. Biological Safety: Principles And Practices (Biological Safety: Principles & Practices) 4th Edition, by Diane O. Fleming (Editor), Debra L. Hunt (Editor), 2006

MGM105: Biochemistry and Metabolism — Credits: 3 Lecture hours

1. Nucleic Acids — 10
   - 1.1. Structure & constitution of nucleic acids (purines, pyrimidines, nucleoside)
   - 1.2. Features of double helix DNA, structure and types, and composition of RNA & DNA, unusual structures
   - 1.3. Nucleic acid chemistry: Biosynthesis of nucleotides and its metabolism, Non-enzymatic transformation and methylation
2. Enzymes — 12
   - 2.1. General characteristics of enzymes, classification and nomenclature, chemical nature of enzymes, mechanism of enzyme action
   - 2. 2. Enzyme kinetics: Factors affecting rates of enzyme-catalyzed reactions, single substrate reactions, Steady State kinetics, Michaelis-Menten's equations, Significance of Km, Catalytic efficiency and Turnover number
   - 2.3. Lineweaver-Burk plot, the concept of cooperativity, Hills plot, multi-substrate enzyme kinetics
   - 2.4. Enzyme catalysis**:** Enzyme specificity and concept of Active site, Theories on the mechanism of catalysis, Proximity and orientation effects, general acid-base catalysis, concerted acid-base catalysis
   - 2.5. Enzyme Inhibition: Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive inhibitors, determination of Inhibitor constants
   - 2.6. Enzyme regulation: Regulatory and allosteric enzymes; reversible covalent modification, irreversible covalent modification, Isoenzymes, Coenzymes
   - 2.7 Application of enzymes: Diagnostic importance and its pattern in various diseases
3. Bioenergetics — 6
   - 3.1. Law of thermodynamics, Gibbs free energy, Concept of free energy, Standard free energy, Determination of ΔG for a reaction, Endergonic & Exergonic reactions
   - 3.2. Relationship between equilibrium constant and Standard free energy change, Biological standard state & Standard free energy change in coupled reactions
   - 3.3. High energy compounds– introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG energy change
4. Overview of metabolic pathways; — 5
   - 4.1 Carbohydrate
   - 4.2 Lipid

4.3 Protein

5. Mitochondrial Respiration: ETC, OXPHOS, Chemiosmotictheory, ATP Synthase 4

6. Hormones 7

- 6.1 Characteristics
- 6.2 Mechanism of action of peptide hormones
- 6.3 Mechanism of action of steroid hormones and gene expression
- 6.4 Hormonal regulation of fuel metabolism

7. Vitamins 3

- 7.1 Structure
- 7.2 Dietary sources, biochemical functions, requirements of water- and lipid-soluble vitamins (vitamin B complex, C and A, D, E & K vitamins)
- 7.3 Recommended dietary allowances, nutritive value, Requirement of vitamins under different physiological states- infancy, childhood, adolescence, pregnancy, lactation and ageing
- 7.4 Deficiency diseases

Recommended Books

1. Nelson et al (2021). Lehninger's Principles of Biochemistry 8th ed. McMillan
2. Devlin (2022). Biochemistry: with clinical correlations 7th ed. Wiley
3. Jeremy et al (2023). Biochemistry 10th ed. Freeman

Suggested Reading

1. Berg et al (2006). Biochemistry. Freeman
2. Voet&Voet (2006). Biochemistry Vol. 1 and 2. 6th ed. Wiley
3. Zubay et al (2020). Principles of Biochemistry 5th ed. WCB
4. Rodney Boyer (2006): Concepts in Biochemistry, Wiley

MGM106	**Lab work based on courses MGM101 &MGM102**	**Credits: 2**
MGM107	**Lab work based on courses MGM103 & MGM104**	**Credits: 2**
MGM108	**Lab work based on courses MGM105**	**Credits: 2**

SEMESTER – II

MGM201:DNA Technology & Genetic Engineering **Credits: 3**

	Lecture hours
1.Enzymes used in DNA technology	4
1.1 Nucleases and their types	
1.2 Restriction and modification enzymes	
1.3 Polymerases	
1.4 Ligase, kinases and phosphatases	
2.Cloning vectors	6
2.1 Plasmids	
2.2 Phages	
2.3 Cosmids	
2.4 Artificial chromosomes	
2.5 Shuttle vectors	
2.6 Expression vectors	
3. Construction of genomic and cDNA libraries	2
4.Screening and characterization of clones	5
4.1 Preparation of probes	
4.2 Principles of hybridizations and hybridization-based techniques (colony, plaque,Southern, Northern and in situ hybridizations)	
4.3 Expression based screening	
4.4 Interaction based screening: yeast two-hybrid system	
5.Basic principles and applications of the following techniques	4
5.1 DNA sequencing	
5.2 Oligonucleotide synthesis	
5.3 Polymerase Chain Reaction	
5.4 Microarray	
6.Promoter characterization: promoter analysis through reporter genes, electrophoretic mobility shift assay, DNA foot-printing,ChIP, Chromatin mapping	4
7. Mutagenesis	3
7.1 Site-directed mutagenesis	
7.2 Transposon mutagenesis	
7.3 Construction of knock-out mutants.	
8.Gene transfer techniques	5
8.1 Electroporation and microinjection	
8.2 Transfection of cells: Principles and methods	
8.3 Germ line transformation in *Drosophila* and transgenic mice: Strategies and methods	
9. Genome editing system: Cre-Lox, ZFN, CRISPR/Cas9, HDR	4
10.Applications of Recombinant DNA Technology	3
10.1. Crop and live-stock improvement	
10.2. Gene therapy: somatic and germ line gene therapy	
10.3. DNA drugs and vaccines	

Recommended Books

1. Ausubel et al (2002). Short Protocols in Molecular Biology. Wiley
2. Brown (2000). Essential Molecular Biology VI. AP
3. Brown (2000). Essential Molecular Biology VII. AP
4. Brown (2020). Gene Cloning and DNA Analysis - An Introduction. 8th edition Blackwell
5. Glick and Pasternak (2010). Molecular Biotechnology. 4th editionASM Press
6. Kracher. Molecular Biology - A Practical Approach.

7. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten (2009). Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition. ASM
8. Micklos and Freyer (1990). DNA Science. CSHL
9. Primrose (2001). Molecular Biotechnology. Panima
10. Robertson et al (1997). Manipulation & Expression of Recombinant DNA. AP
11. Sambrook et al (2001). Molecular Cloning. CSHL
12. Twyman (1999). Advanced Molecular Biology. Viva
13. Watson et al (1992). Recombinant DNA. Freeman
14. Primrose and Twyman (2006). Principles of Gene Manipulation and Genomics. Blackwell

MGM202: Cell Biology

Credits: 3
Lecture hours

1.Plasma Membrane: organization and dynamics transport across membrane; mechanisms of endocytosis and exocytosis 4

2.Endomembrane system 5

- 2.1 General organization of protein transport within and outside the cell
- 2.2 Protein sorting and secretion
- 2.3 Mechanism of intracellular digestion

3.Cytoskeleton 4

- 3.1 Microfilaments: Structural organization, cell motility and cell shape
- 3.2 Microtubule: Structural and functional organization, cilia, flagella, centriole
- 3.3 Intermediate filaments

4.Mitochondria: Ultrastructure, dynamics, division, turnover and transport 4

5.Structure and function of peroxisome 1

6. Architecture of Nucleus;Structure & function, nuclear chore complexes and transport. Nucleolus and biosynthesis of ribosome 4

7.Cell cycle and its regulation:centromere and kinetochore

- 7.1 Mitosis 4
  - 7.1.1 Mitotic spindle and arrangement of chromosomes on equator
  - 7.1.2 Regulation of exit from metaphase
  - 7.1.3 Chromosome movement at anaphase
- 7.2 Meiosis 4
  - 7.2.1 Overview of the process
  - 7.2.2 Meiosis-specific cellular changes
  - 7.2.3 Genetic control of meiosis (example: yeast)

8.Cell-Cell Interaction 6

- 8.1 Cell adhesion molecules
- 8.2 Cellular junctions
- 8.3 Extracellular matrix

9.Signal transduction 8

- 9.1 Intracellular receptor and cell surface receptors
- 9.2 Signalling via G-protein linked receptors (PKA, PKC, CaM kinase)
- 9.3 Enzyme linked receptor signaling pathways
- 9.4 Network and cross-talk between different signal mechanisms

10.Programmed cell death and autophagy 3

Recommended Books

1. Alberts et al (2020). Molecular Biology of the Cell 7th ed. Garland
2. Cooper (2022). The Cell: A molecular Approach 8th ed. ASM Press
3. Lodish et. al. (2023) Molecular Cell Biology

Suggested Reading

1. Gilbert (2023). Developmental Biology 13th ed. Sinauer
2. Jeremy et al (2023). Biochemistry 10th ed. Freeman
3. Karp (2020). Cell and Molecular Biology 9th ed. John Wiley
4. Lewin et al. (2017). Lewin's Genes XII. Jones & Bartlett Learning, 2017
5. Lodish et al (2021). Molecular Cell Biology 9th ed. Freeman.
6. Pollard & Earnshaw (2023). Cell Biology 4th ed. Saunders
7. Tobin and Morcel (1997). Asking about Cells. Saunders
8. Wilson & Hunt (2002). The Cell: A Problems Approach. Garland
9. Locquin and Langeron (1983). Handbook of Microscopy.Butterwaths
10. Tobin and Morcel (1997). Asking about Cells. Saunders

MGM203: Model Genetic Systems — Credits: 2

	Lecture hours
1. *Dictyosteliumdiscoideum*:	2
1.1. An overview: life cycle	
1.2. Use of *Dictyostelium*as a model system	
2. Yeast:	3
2.1. Tetrad analysis, yeast mating type switch	
2.2. Use as a model system to study cell cycle, genetic recombination	
3. *Caenorhabditis elegans*:	3
3.1. Isolation & identification of mutants	
3.2. Study of cell lineage, apoptosis	
3.3. RNA interference	
4. *Drosophila*:	7
4.1. Advantages in genetic analysis	
4.2. Nomenclature of gene mutation, Balancer chromosomes	
4.3. Mutagenesis and isolation of new variants	
4.4. Generation of somatic and germline mosaics	
4.5. Targeted overexpression of genes	
4.6. *Drosophila* genome, online databases and other resources	
4.7. Use of *Drosophila* as a model organism to study human genetic disorders and for drug screening	
5. Zebrafish:	5
5.1. Isolation and identification of mutants, use of Morpholinos	
5.2. Zebrafish as a model system for the study of human diseases	
5.3. Zebrafish genome and online resources	
6. Mouse:	6
6.1. Relationship between human and mouse chromosomes	
6.7. Advantages to use as a model organism	
6.3. Understanding gene function by transgenic and knockout studies	
6.4. Mouse genome database	
6.5. Humanized mice	
7. Cellular model system, iPSCs, organoid models of human	

Recommended Books

1. Ashburner (1989). *Drosophila* - A Laboratory Handbook.CSHL Press
2. Hood (1988) The Nematode: *C. elegans*. CSHL Press
3. Gilbert (2023). Developmental Biology. 13th ed. Sinauer

4. Monk (1987). Mammalian Development – A Practical Approach. IRL
5. Wolpert (2019). Principles of Development. 6th ed. Oxford

Suggested Reading

1. www.flybase.org
2. www.zfin.org
3. www.jax.org
4. Research papers

MGM204: Immunogenetics

Credits: 3
Lecture hours

1	Biology of the immune system. 1.2 Biology of Immune cells: Dendritic cells monocytes and macrophages, Granulocytes, Natural killer cells, Lymphocytes 1.3 Organs of the immune system	2
2	Innate Immunity, 2.1 Characteristics, components and functions, 2.2 Toll like receptors and other immune receptors. 2.3 Newborn Immunology	3
3	Adaptive Immunity 3.1 Humoral and Cell mediated Immune responses 3.1.1 Antigens 3.1.2 Structure and function of immunoglobulins and T cell receptors 3.4 B and T cell receptors and coreceptors 3.5 Antigen-antibody interactions	3
4.	Advanced Immunological Techniques Principles and modalities of Immunodiffusion techniques, Agglutination, ELISPOT, RIA, ELISA, Western blotting Immunoprecipitation, Immuno-histochemistry, Basis and advancedFlow-cytometry	2
5.	B cell receptor genes (Immunoglobin) 5.1 Organization of Ig gene loci 5.2 Molecular mechanisms of generation of antibody diversity 5.3 Expression of Ig genes 5.4 Regulation of Ig gene transcription 5.5 Monoclonal Antibody and expression using recombinant DNA technologies	4 2
6.	T cell receptor genes 6.1 Organization of TCR gene loci 6.2 Generation of TCR diversity	
7.	The HLA complex 7.1 Organization of HLA complex 7.2 Structure of class I and II HLA molecules 7.3 Expression of HLA genes	3

7.4 HLA polymorphism

8 Generation and regulation of immune responses 12
8.1 Antigen processing and presentation
8.2 MHC-restriction
8.3 Cytokines
8.4 T Cell Maturation, activation and differentiation
8.5 B Cell Generation, Activation and differentiation
8.6 Clonal selection and immunological memory
8.7 Complement system
8.8 Cell mediated cytotoxic responses
8.9 Regulation of immune responses
8.10 Regulation of immune responses

9 Disorders of Human Immune System 4
9.1 Immunological Tolerance and Autoimmune diseases
9.2 Allergy and hypersensitivity
9.3 Cytokine-related diseases
9.4 Immunodeficiencies

10 Dynamics of the immune response in health and disease 4
10.1 Experimental models,
10.2 Immunotherapeutics and Drug targeting
10.3 Vaccines
10.4 Transplantation immunology

Recommended Books

1. Janeway&Traver's Immunobiology (2022), Taylor & Francis
2. Abbas et al, Cellular and Molecular Immunology (2021), Saunders
3. Barrett, Text Book of Immunology (1988), Mosloy,
4. Benjamin et al, Immunology – A Short Course (2012), Wiley-Liss
5. Kuby, Immunology (2023), MacMillan,
6. Roitt, Essential Immunology (2017), Blackwell,

MGM205: Human Genome

Credits: 3
Lecture hours

1.The Genome project 8 1.1. History, organization and goals of human genome project
1.2. Mapping strategies, current status of various maps; DNA segment nomenclature
1.3. Human genome diversity

2.Organization of human genome 8
2.1. Mitochondrial genome
2.2. Gross base composition of nuclear genome
2.3. Gene density
2.4.CpG islands
2.5. RNA-encoding genes
2.6.Functionally identical/similar genes
2.7. Diversity in size and organization of genes
2.8 Annotation

3.Gene families 8

3.1 Multigene families – Classical gene families, families with large conserved domains, families with small conserved domains
3.2 Gene superfamilies
3.3 Gene families in clusters
3.4 Pseudogenes
3.5 Repetitive DNA and transposable elements
3.6 Origin of gene families

4.Comparative Genomics 7

4.1.Overview of prokaryotic and eukaryotic genomes
4.2.C-value, number of genes and complexity of genomes
4.3.Conservation and diversity of genomes
4.4. Comparative genomics as an aid to gene mapping and study of human disease genes

5.Functional genomics 5

5.1.Transcriptome and its analysis
5.2. Proteome and Proteomics
5.3.Gene silencing: siRNA, shRNA, anti-sense RNA

6. Disease and genomics, Pharmacogenetics and ecogenetics 3

Recommended Books

1. Strachan and Read (2018). Human Molecular Genetics 5th Ed. Wiley
2. Pasternak (2005). An Introduction to Molecular Human Genetics.2nd ed. Fritzgerald

Suggested Reading

1. Sudbery (2002). Human Molecular Genetics. Prentice Hall
2. Lewin et al. (2017). Lewin's Genes X. Jones & Bartlett Learning, 2017
3. Brown (2023). Genomes. 5th ed. CRC Press
4. Coleman and Tsongalis (2005). Molecular Diagnostics. 2nd ed. Humana
5. Dale & Schantz (2011). From Genes to Genomes: Concepts and Applications of DNA Technology 3rd ed.
6. Hawley and Mori (2011). The Human Genome: A User's Guide. 3rd ed. Academic

MGM206: Molecular Genetics Credits: 3

Lecture hours

1.Properties and evolution of genetic material, central dogma of molecular biology 3

2. Eukaryotic genome organization;Chromatin structure 6

2.1 Histones, DNA
2.2 Nucleosome and higher-level organization.
2.3 Chromosomal domains (matrix, loop domains) and their functional significance
2.4 Heterochromatin and euchromatin, position effect variegation, boundaryelements

3.Replication: Prokaryotic and Eukaryotic 7

3.1. DNA polymerases
3.2. Replicons, origin and termination
3.3. Replisome
3.4. Genes controlling replication

4. DNA binding motifs and transcription factors 3

5. Transcription 7

5.1 Prokaryotic RNA polymerase, sigma factors, initiation and termination
5.2 Eukaryotic RNA polymerases and their promoters

5.3 Processing of transcripts

6. Regulation of gene expression 10

6.1. Regulation of transcription initiation

6.1.1. Operon and regulon

6.1.2. Positive and negative regulation

6.1.3. Enhancers and promoters

6.1.4. Transcription factors: types, DNA binding motifs

6.2. Regulation by attenuation and anti-termination

6.3. Post-transcriptional regulation

6.3.1. Alternative splicing

6.3.2. Transport and targeting of RNA

6.3.3. Post-transcriptional gene silencing

7. Translation 6

7.1 General mechanism

7.2 Role of rRNA in translation

7.3 Translational control and targeting of proteins

Recommended Books

1. Watson et al. (2024). Molecular Biology of the Gene. 8th Edition
2. Lewin et al. (2017). Lewin's Genes XII. Jones & Bartlett Learning, 2017
3. Weaver RF Molecular Biology (2012), 5th Edition, McGraw Hill Higher Education
4. Jocelyn E. Krebbs, Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's Genes X. 10th ed., 2009
5. Lodish et al (2021). Molecular Cell Biology. 9th ed. Freeman.

Suggested Reading

1. Berg and Singer (1998). Genes and Genome.
2. Dale & Schantz (2011). From Genes to Genomes: Concepts and Applications of DNA Technology 3 rd ed.
3. Griffiths et al (2015). An Introduction to Genetic Analysis. Freeman. 11th Edition
4. Latchman (1995). Gene Regulation. Chapman & Hall. 2nd Edition
5. Maloy and Freifelder (1994). Microbial Genetics. Jones and Barlett. 2nd Edition
6. Meesfeld (1999). Applied Molecular Genetics. Wiley-Liss
7. Streips&Yasbin (2002). Modern Microbial Genetics. Wiley. 2nd Edition
8. Trun &Trempy (2004). Fundamentals of Bacterial Genetics. Blackwell. 3rd Edition
9. Hamsew and Flavell (1993). The Chromosome. Bios
10. Hawley & Walker (2003). Advanced Genetic Analysis. Blackwell
11. Hennig (1987). Structure & Function of Eukaryotic Chromosomes. Springer
12. Lewin et al. (2009). Lewin's Genes X. Jones & Bartlett Learning, 2009
13. Obe and Natarajan (1990). Chromosome aberrations - Basic and Applied Aspects. Springer
14. Risley (1985). Chromosome Structure and Function. Reinhold
15. Rooney & Czepulkowski (1987). Human Cytogenetics – A Practical Approach. IRL
16. Sumner.Chromosomes (2003). Blackwell

MGM207:Lab work based on courses MGM201 & MGM202 Credits: 2

MGM208:Lab work based on courses MGM203 & MGM204 Credits: 2

MGM209:SWAYAM Course-I Compulsory Credits: 2

(Biostatics/Introduction to Biostatistics / Foundation of data science/data science using Python/Basic statistics using R / Foundation of R software, and any other related course)

SEMESTER – III

MGM301: Human Molecular Genetics

Credits: 3

Lecture hours

1.Genetic mapping of Mendelian traits 6
- 1.1. Identifying recombinants and nonrecombinants in pedigrees
- 1.2.Genetic and physical map distances
- 1.3.Genetic markers
- 1.4. Two-point mapping- LOD score analysis
- 1.5. Multipoint mapping
- 1.6.Homozygosity mapping.

2.Genetic mapping of complex traits 6
- 2.1 Difficulties in mapping complex traits
- 2.2 Allele sharing methods- Affected sib-pair analysis
- 2.3 Allelic association, Linkage disequilibrium mapping, Transmission disequilibrium test

3. Physical mapping methods 6
- 3.1. Low resolution mapping- Cell hybrids, mini- and microcells, synteny of genes, Radiation hybrid mapping
- 3.2.Assembly of clone contigs
- 3.3. Identifying genes in cloned DNA
- 3.4. Integration of cytogenetic, genetic and physical maps

4. Identifying human disease genes 7
- 4.1. Principles and strategies
- 4.2.Position-independent and positional cloning,Candidate gene approaches, WholeGenome and Exome Sequencing
- 4.3. Confirming a candidate gene: mutation screening, testing in animal models.

5. Molecular pathology 6
- 5.1. Nomenclature of mutations and their databases
- 5.2.Loss-of-function and gain-of-function mutations in diseases
- 5.3. Instability of the human genome: Pathogenicity associated with repeat sequences

6. DNA testing 8
- 6.1. Direct testing.
  - 6.1.1. Screening for unknown mutations
  - 6.1.2.Detection of known mutations.
- 6.2. Indirect testing – gene tracking
- 6.3. DNA profiling: establishing identity and relationships
- 6.4. Population screening - ethics, organization and advantages.

7. Pharmacokinetics 3

Recommended Books

1. Strachan & Read (5th Edition; 2019). Human Molecular Genetics. Garland Edition.
2. Pasternak (2005). An Introduction to Molecular Human Genetics.Fritzgerald. 2nd Ediition.
3. Mange and Mange (1999). Basic Human Genetics.Sinauer Assoc. 2nd Edition.
4. Lewis (2022). Human Genetics. WCB & McGraw. 14th Edition.
5. Sudbery (2010). Human Molecular Genetics. Prentice-Hall. 3rd Edition.

Suggested Reading

1. Davies (1993). Human Genetic Disease Analysis. 2nd Edition. IRL
2. Haines &Pericak (2021). Genetic Analysis of Complex Disease; Wiley-Blackwell, 3rdedition
3. Nussbaum et al (2015). Genetics in Medicine. Saunders. 8th Edition.

MGM302: Clinical Genetics — Credits: 3

	Lecture hours
1.An overview of the genetic basis of syndromes and disorders	1
2.Monogenic diseases withwell-known molecular pathology	6
2.1. Cystic fibrosis	
2.2.Tay-Sachs syndrome	
2.3.Marfan syndrome	
3.Genome imprinting Syndromes: Prader-Willi&Angelman syndromes, Beckwith-Wiedeman Syndrome	3
4.Neurofibromatosis I	2
5.Disorders of muscle	3
5.1.Dystrophies (Duchenne Muscular dystrophy and Becker Muscular Dystrophy)	
5.2.Myotonias	
5.3. Myopathies	
6.Disorders of Haemopoietic systems	5
6.1.Overview of Blood cell types and haemoglobin	
6.2.Sickle cell anemia	
6.3.Thalassemias	
6.4.Hemophilias	
7.Disorders of eye	5
7.1. Retinitis pigmentosa	
7.2. Cataract	
7.3. Glaucoma	
7.4.Colour blindness	
8.Multifactorial diseases	4
8.1.Hyperlipidemia	
8.2.Atherosclerosis	
8.3. Diabetes mellitus	
9. Mitochondrial syndromes:MELAS, MERRF, DAAD, Leigh, KERN, LHON	5
10. Inborn errors of Metabolism and their genetic basis	5
10.1. Phenylketonuria	
10.2. Maple Syrup urine syndrome	
10.3.Mucopolysaccharidosis	
10.4. Galactosemia	
11. Management of genetic disorders	2
12. Management of genetic disorder using genome editing tools.	2

Recommended Books:

1. Roderick R. McInnes and Huntington F. Willard (2007).Thompson& Thompson Genetics in Medicine.
2. Cox and Sinclair (1997). Molecular Biology in Medicine. Blackwell
3. DeGrouchy and Turleau (1984). Clinical Atlas on Human Chromosomes. Wiley
4. Jankowski and Polak (1996). Clinical Gene Analysis and Manipulation. Cambridge

MGM303: Genomic instability and Cancer — Credits: 3

	Lecture hours
1. DNA repair	8

1.1. Origins and types of DNA damage
1.2. DNA repair pathways
1.3.Error-prone repair and mutagenesis
1.4. Damage signaling and checkpoint arrest.

2.Recombination 8
2.1. Homologous recombination: models and molecular mechanisms
2.2. Gene conversion: molecular mechanisms
2.3. Site specific recombination
2.4. Transposons and transposition mechanisms.

3.Cell transformation and tumourigenesis 12
3.1. Cell cycle check point and cancer
3.2.Oncogenes
3.3.Tumour suppressor genes
3.4.DNA repair genes and genetic instability
3.5. Epigenetic modifications, telomerase activity, centrosome malfunction
3.6. Genetic heterogeneity and clonal evolution.

4.Familial cancers: Retinoblastoma, Wilms' tumour, Li-Fraumeni syndrome, colorectal cancer, breast cancer. 5

5.Genetic predisposition to sporadic cancer 3

6.Tumour progression: angiogenesis and metastasis 3

7. Tumour-specific markers 1

8.Cancer and environment: physical, chemical and biological carcinogens 2

Recommended Books

1. Errol C. Friedberg, Graham C. Walker, Wolfram Siede, Richard D. Wood, Roger A. Schultz, Tom Ellenberger (2005). DNA Repair and Mutagenesis. Wiley
2. Cowell (2001). Molecular Genetics of Cancer. Bios
3. Ehrlich (2000). DNA Alterations in Cancer. Eaton
4. Gersen&Keagle (1999). Principles of Clinical Cytogenetics. Humana
5. Meesfeld (1999). Applied Molecular Genetics. Wiley-Liss
6. Ptashne (1986). Genetic Switch. Blackwell
7. Stillman (1994). Molecular Genetics of Cancer. CSHL
8. Research papers and Review articles

MGM304: Developmental Genetics

Credits: 3
Lecture hours

1.Early development 7
1.1 Gametogenesis
1.2 Fertilization
1.3 Types of cleavage
1.4 Gastrulation: Cell movement and formation of germ layers in frog, chick and mouse
1.5 Concept of determination, competence and differentiation.

2.Development of vertebrate nervous system 7
2.1. Formation of neural tube
2.2. Formation of brain regions
2.3. Tissue architecture of the central nervous system

3. Genetics of pattern formation 14
3.1. *Caenorhabditis*: Vulva formation
3.2. *Drosophila*.
3.2.1. Maternal genes and formation of body axes
3.2.2. Segmentation genes

3.2.3. Homeotic genes function
3.2.4. Imaginal disc development.
3.3. Vertebrates
3.3.1. Axes formation and HOX genes
3.3.2. Limb formation in chick

4.Genetic determination of sex in *Drosophila* and mammals	3
6. Epigenetics in development	2
7.Regeneration	2
8.Senescence	2
9.Embryonic stem cells and their applications	2

Recommended Books

1. Alberts et al (2020). Molecular Biology of the Cell 7th ed. Garland
2. Gilbert (2023). Developmental Biology. 13th ed. Sinauer
3. Patrick et al. Mammalian development: Network,Switches and Morphogenetic Processes. CSHL
4. Kalthoff (2000). Analysis of Biological Development. McGraw Hill
5. Lewin et al. (2009). Lewin's Genes X. Jones & Bartlett Learning, 2009
6. Monk (1987). Mammalian Development – A Practical Approach. IRL
7. Wolpert (2007). Principles of Development. Oxford

MGM305 Lab work based on courses MGM301 & MGM302 Credits: 2

MGM306 Lab work based on courses MGM303 & MGM304 Credits: 2

MGM307 Dissertation Part-1 (Proposal and Techniques) Credits: 2

MGM308 SWAYAM Course-II Compulsory Credits: 2
(Computer aided drug design/ fundamentals of Artificial intelligence/ Introduction to machine learning/ AI and medicine and any other related course)

SEMESTER – IV

MGM401: Neurogenetics

Credits: 3

	Lecture hours
1. Nervous system	10
1.1. Major regions of human brain	
1.2. Cellular components of nervous tissue	
1.3. Sub cellular organization of the nervous system	
1.4. Membrane potential and action potential.	
1.5 Neurotransmitters	
2.Genetic Aspect of Learning and memory	7
2.1. Classification of different types of memory	
2.2. Models for understanding learning and memory	
2.3. Molecular basis of short time and longtime sensitization	
3.Circadian rhythms	6
3.1. Invertebrates (Drosophila)	
3.2. Mammals	
3.3. Clinical Implication	
4.Neurogenetic disorders	5
4.1. Syndromes due to triplet nucleotide expansion	
4.2.Alzheimers disease	
4.3.Parkinsons disease	
5.Nature-nurture and behaviour	
5.1. Genetic experiments to investigate animal behaviour	5
5.1.1. Selection studies	
5.1.2. Inbred strain studies	
5.2. Identifying genes for controlling behavior	
5.2.1. Induced mutations	
5.2.2.Quantitative trait loci	
5.2.3.Synteny/orthology	
5.3. Investigating the genetics of human behaviour	
5.3.1. Twin and adoption study designs, interpreting heritability	
5.3.2. Linkage and association studies	
5.4. Environmental influence- shared and non-shared environment	
6. Genetics of Psychiatric diseases	6
6.1. Schizophrenia	
6.2. Mood disorders	
6.3. Disorders of childhood.	

Recommended Books

1. Kaplan and Sadock (2014). Synopsis of Psychiatry.Williams & Wilkins. 11th Edition.
2. Plomin et al (2012). Behavioral Genetics. Worth. 6th Edition.
3. Zigmond, Bloom et al., (2012). Fundamentals Neuroscience. Academic Press. 4th Edition.
4. Kandel, Schwartz et al. (2012). Principles of Neuroscience.McGraw Hill. 5th Edition.
5. Anholt and Mackay (2010). Principles of Behavioural Genetics.Elselvier Press.

Suggested Reading

1. Pasternak (2005). An Introduction to Molecular Human Genetics.Fritzgarald. 2nd Edition.
2. Griffiths et al., (2015) Introduction to Genetic Analysis. Freeman. 11th Edition.
3. Cox and Sinclair (1997). Molecular Biology in Medicine. Blackwell. 1st Edition.
4. Rasko and Downes (1995). Genes in Medicine. Kluwer

5. Rimoin et al(2013). Principles & Practice of Medical Genetics, vol I-III. Churchill. 6th Edition.
6. Robinson and Linden (1994). Clinical Genetics Handbook. Blackwell
7. Strachan & Read - Human Molecular Genetics, 5th Edition (2019).
8. Wilson (2000). Clinical Genetics: A Short Course. Wiley-Liss. 1st Edition.

MGM402: Genetic counseling& Intellectual Property RightsCredits: 2

Section A: Genetic counseling — **Lecture hours**

1.Historical overview of genetic counseling — 2
- 1.1. Models of Eugenic, Medical/Preventive, Decision making, Psychotherapeutic counseling; current definition and goals
- 1.2. Philosophy and ethos of genetic services and counseling

2.Components of genetic counseling — 4
- 2.1.Indications and purpose
- 2.2.Information gathering and construction of pedigrees
- 2.3. Medical Genetic evaluation
  - 2.3.1. Basic components of Medical History
  - 2.3.2. Past medical history, social & family history
- 2.4. Physical examination.
  - 2.4.1. General and dysmorphology examination
  - 2.4.2. Documentation

3.Patterns of inheritance, risk assessment and counseling in common Mendelian and multifactorial disorders — 3

4.Biochemical and Molecular genetic tests — 2
- 4.1. In Children
- 4.2. Presymptomatic testing for late onset diseases (predictive medicine)

5. Bioethics in research — 2
- 5.1. Bioethics in cloning and stem cell research
- 5.2. Bioethics in human and animal experimentation, animal rights/welfare

Recommended Books

1. Baker et al (2009). A Guide to Genetic Counseling. 2nd ed. Wiley
2. Harper (2010). Practical Genetic Counseling. 7th ed. Oxford
3. Rose &Lucassen(2001). Practical genetics of primary care. Oxford
4. Young (2006). Introduction to Risk Calculation in Genetic Counseling. 3rd ed. Oxford

Section B: Intellectual Property Rights — **Lecture hours**

1. Introduction — 3
   - 1.1 Meaning, Relevance, Business Impact, Protection of Intellectual Property
   - 1.2 Copyrights, Trademarks, Patents, Designs, Utility Models, Trade Secretsand Geographical Indications
   - 1.3 Bio-diversity and IPR
   - 1.4 Competing Rationales for Protection of Intellectual Property Rights
   - 1.5 Introduction to the leading International Instruments concerning Intellectual Property Rights: the Berne Convention, Universal Copyright Convention, The Paris Convention, Patent Co-operation Treaty, TRIPS, The World Intellectual Property Organization (WIPO) and the UNESCO
2. Patents — 7
   - 2.1 Concept of Patent
   - 2.2 Product / Process Patents & Terminology

2.3 Duration of Patents- Law and Policy Consideration Elements of Patentability-Novelty and Non-Obviousness (Inventive Steps and Industrial Application, Non-Patentable Subject Matter
2.4 Procedure for Filing of Patent Application and types of Applications
2.5 Procedure for Opposition,
2.6 Revocation of Patents
2.7 Ownership and Maintenance of Patents
2.8 Assignment and licensing of Patents
2.9 Working of Patents- Compulsory Licensing
2.10 Patent Agent- Qualification and Registration Procedure

3. Patent Databases & Patent Information System 3
3.1 Patent Offices in India
3.2 Importance of Patent Information in Business Development
3.3 Patent search through Internet, Patent Databases

Recommended Books

1. IPR Biosafety & Bioethics by DeepaGoel and ShominiParashar, 2013
2. Essentials of Licensing Intellectual Property
by Alexander I. Poltorak and Paul J. Lerner, Wiley publisher, 2004
3. How to Invent and Protect Your Inventionby Joseph P. Kennedy Sr. and Wayne H. Watkins, Wiley publisher, 2012
4. Patents for Chemicals, Pharmaceuticals and Biotechnology, by Phillip W Grubb, 2016

MGM 403: Lab work based on course MGM401 Credit: 1

MGM404: Seminar & Formulation of Research Project Credits: 2

The student will deliver a comprehensive seminar on a current topic of his/her choice in the field of Molecular & Human Genetics. The topic of Seminar must be different from the topics covered in any of the courses. Each student will formulate a research proposal and present the proposal before the panel of examiners.

MGM405: Comprehensive Viva-voce Credits: 2

The understanding of the whole course content from semester-I through semester-IV will be assessed through a comprehensive viva-voce examination.

MGM406: Dissertation Credits: 6

Each student will undertake an experimental project under supervision of one of the teachers during Semester-IV and submit two copies of the dissertation which will include: a) Review of the relevant literature, b) Objectives of the study, c) Materials and Methods, d) Results/Observations (supported by figures/tables etc. as required), e) Discussion of the Results/Observations, f) Summary and g) References.