ANNEXURE – III D

DAYANANDA SAGAR
UNIVERSITY

SCHOOL OF BASIC & APPLIED SCIENCES

SCHEME & SYLLABUS
FOR
MASTER OF SCIENCE (M.Sc.) – 2025-2027

SPECIALIZATION:
MOLECULAR BIOLOGY AND GENETICS

(With effect from 2025-26)
(From I to IV Semesters)

DAYANANDA SAGAR UNIVERSITY
INNOVATION CAMPUS, KUDLU GATE, HOSUR ROAD,
BENGALURU -560114.

DAYANANDA SAGAR UNIVERSITY
SCHOOL OF BASIC AND APPLIED SCIENCES
PROPOSED SCHEME- M. SC. MOLECULAR BIOLOGY AND GENETICS- 2025-26 ONWARDS

I SEM – M.Sc.- MOLECULAR BIOLOGY AND GENETICS

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	END EXAM
1	223	25MSC5101	Essentials of Chemistry	CR	4	-	-	-	4	60	40
2	223	25MMG5101	Molecular Biology	CR	4	-	-	-	4	60	40
3	223	25MMG5102	Cell biology and Cytogenetics	CR	4	-	-	-	4	60	40
4	223	25MMG5103	Biomolecules and enzyme kinetics	CR	4	-	-	-	4	60	40
5	223	25MMG5104	Molecular immunology	CR	2	-	-	-	2	60	40
6	223	25MSC5102	Biostatistics	CR	2	-	-	-	2	60	40
7	223	25MMG5171	Biomolecules and biological chemistry- Practical	CR	-	-	6	-	3	60	40
8	223	25MMG5172	Techniques in cell and Molecular Biology	CR	-	-	6	-	3	60	40
			GRAND TOTAL = 800		**20**	**-**	**12**	**-**	**26**	**480**	**320**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

II SEM – M.Sc.- MOLECULAR BIOLOGY AND GENETICS

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	END EXAM
1	223	25MMG5201	Developmental Biology and Molecular Patterning	CR	4	-	-	-	4	60	40
2	223	25MMG5202	Molecular Evolution	CR	4	-	-	-	4	60	40
3	223	25MMG5203	Population and Quantitative Genetics	CR	4	-	-	-	4	60	40
4	223	25MMG5204	Genetic Engineering and Genome Editing	CR	4	-	-	-	4	60	40
5	223	25MMG5205	Human Genetics and Genetic Testing	CR	4	-	-	-	4	60	40
6	223	25MMG5206	Epigenetics and Gene Regulatory Networks	CR	2	-	-	-	2	60	40
7	223	25MMG5271	Experimental Approaches in Evo-Devo	CR	-	-	6	-	3	60	40
8	223	25MMG5272	Applied Genetics Practical	CR	-	-	6	-	3	60	40
			GRAND TOTAL = 800		**22**	**-**	**12**	**-**	**28**	**480**	**320**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

III SEM – M.Sc.- MOLECULAR BIOLOGY AND GENETICS

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING						SCHEME OF EVALUATION	
					L	**T**	**P**	**S/P**	**C**		**CIA**	**END EXAM**
1	223	25MMG5301	Functional Genomics	CR	4	-	-	-	4		60	40
2	223	25MMG5301	Genetics of Diverse Life Forms	CR	4	-	-	-	4		60	40
3	223	25MMG5303	Molecular Oncology	CR	3	-	-	-	3		60	40
4	223	25MMG5304	Neurobiology and Behavioral Genetics	CR	3	-	-	-	3		60	40
5	223	25MMG5305	Genomic Reprogramming	CR	3	-	-	-	3		60	40
6	223	25MSC5301	Research methodology, scientific writing and IPR	CR	3	-	-	-	3		60	40
7	223	25MMG5306	Precision Medicine	CR	2	-	-	-	2		60	40
8	223	25MMG5307	Computational Biology and Machine Learning	CR	2	-	-	-	2		60	40
9	223	25MMG5371	Integrated Genetics Practical	CR	-		6		3		60	40
10	223	25MMG5372	Molecular Systems Practical	CR	-		6		3		60	40
			GRAND TOTAL = 1000		**24**	**-**	**12**	**-**	**30**		**600**	**400**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

IV SEM – M.Sc.- MOLECULAR BIOLOGY AND GENETICS

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	END EXAM
1	223	25MSC5401	Project	CR	4	-	-	36	14	60	40
2	223	25MSC5402	MOOC/NPTEL/ Swayam	CR	-	-	-	-	2		
			GRAND TOTAL = 400					**36**	**16**		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

SL	CREDIT (CR)	MARKS	
		CIA MARKS	END EXAM MARKS
1	4	60	40
2	3	60	40
3	2	30	20
4	14	240	160

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MSC5101**					
TITLE OF THE COURSE	**ESSENTIALS OF CHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- To help students grasp fundamental chemical principles—such as stoichiometry, chemical bonding, electrochemistry, and organic reactivity—specifically as they relate to biological systems.
- To enable students to apply theoretical knowledge in solving quantitative and mechanistic problems involving solution chemistry, redox reactions, and biomolecular interactions.
- To introduce students to the chemical structures and reaction mechanisms within biological contexts, including enzymatic catalysis, metabolic pathways, and molecular transport.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Students will become familiar with fundamental chemical concepts, including mole calculations, acid-base theories, bonding types, and stereochemistry, particularly as they apply to biological molecules.	L2
CO2	Students will be able to apply chemical equations and quantitative tools—such as dilution formulas (e.g., N1V1=N2V2) and the Henderson-Hasselbalch equation—along with mechanistic understanding, to tasks such as buffer preparation, molecular weight determination.	L3
CO3	Students will be able to analyze the roles of metals in biological systems, the influence of stereochemistry on bioactivity, and reaction mechanisms related to metabolic processes.	L3

COURSE CONTENT:

MODULE 1: STOICHIOMETRY AND CHEMICAL BONDING	**14Hrs**

Stoichiometry: Atomic weights, molecular weights, mole concept, molarity, molality, normality, mole fraction, ppt, ppb and ppm. Numerical problems related to the above concepts. Classification, preparation and dilution of reagents/solutions. Preparation of ppm level solutions from source materials (salts), conversion factors.

Chemical bonding: Ionic bonds, Covalent bonds, Vander walls forces, Electrostatic interactions, Hydrophobic interactions, Hydrogen bonding & their relevance in biological systems, importance of water in biological systems. Coordination bonds in biomolecules - bonding of iron in haemoglobin, magnesium in chlorophyll. Types of chemical bonds in biological molecules (Glycosidic, phosphdiester, peptide).

MODULE 2: PHYSICAL CHEMISTRY	**14Hrs**

Bio-Electrochemistry: Oxidation and Reduction reactions, Electrode potential, standard & reference electrode, calculation of biological standard potential & biological equilibrium constant, Nernst's' equation. Biological electrochemical series (ETC).

Liquids and solutions: Acid and bases (Brønsted-Lowry Theory, Lewis Theory), pKa, pKb, pH, pOH, preparation of buffers, Henderson-Hasselbalch equation and numerical problems associated with buffer preparation. Density and Relative Density, Viscosity, Surface tension, Colligative properties (brief). Calculation of molecular weight of proteins and nucleic acids.

MODULE 3: BIOINORGANIC CHEMISTRY	**14Hrs**

Stereochemistry: Introduction, Different types of isomerism, chirality & optical activity (enatiomers and diastereoisomers; Fischer, Sawhorse, and Newman Projection formulae of simple molecules containing one and two asymmetric carbon atom). Symmetry elements, E and Z, D and L nomenclature (for carbohydrates and aminoacids only).

Role of metals: Introduction, Classification, role of metal in various biological system: Enzyme Activity (zinc with carbonic anhydrase) Examples for metal activated enzymes and metalloenzymes, Energy Transfer and Redox Reactions (cytochrome c complex- Fe), Oxygen Transport (Iron in hemoglobin, Copper in hemocyanin) Nerve Signal Transmission (role of Sodium and potassium ions), Structural Roles, Metallothionins, metals as essential nutrients, nutritional Immunity. Regulatory Roles (Magnesium and calcium ions play crucial roles in cell regulation and signalling pathways.

MODULE 4: BIOORGANIC CHEMISTRY	**14Hrs**

Basics: Properties of carbon, brief classification of organic compounds based on functional groups with examples. Delocalisation of electrons: Inductive effect, electrometric effect, resonance (mesomeric effect, EWG and EDG, +M and –M effects). Curly arrow rules in representation of mechanistic steps, types of bond cleavage; electrophiles, nucleophiles, Reactive intermediates: carbocations, carbanions, free radicals and carbenes– generation, structures, stability and examples.

Reaction mechanisms: SN1 (formation of PRPP in nucleotide biosynthesis), SN2 (eg. DNA polymerization, phosphorylation), E1 (histidine/aromatic aminoacid biosynthesis), E2 reactions (fatty acid biosynthesis). Metabolic reactions- aldol condensation (collagen), esterification of acids (triglycerides), oxidation and reduction reactions (NAD^+ to NADH during cellular respiration.).

REFERENCES:

1. General Chemistry (2022) Linus Pauling, Dover Publications, New York, USA.
2. Quantitative Chemical Analysis 10th Edition (2022) Daniel C. Harris, Macmillan Learning, New York, USA.
3. Lehninger Principles of Biochemistry 8th Edition (2021) David L. Nelson and Michael M. Cox, W.H. Freeman & Company, New York, USA.
4. Physical Chemistry for the Life Sciences 2nd Edition (2014) Peter Atkins and Julio de Paula, Oxford University Press, Oxford, UK.
5. Principles of Physical Chemistry (2023) Puri, Sharma, and Pathania, Vishal Publishing Co., Jalandhar, India.
6. Biophysical Chemistry: Principles and Techniques (2022) Upadhyay, Upadhyay, and Nath, Himalaya Publishing House, Mumbai, India.

7. Bioinorganic Chemistry: A Short Course 2nd Edition (2014) Rosette M. Roat-Malone, Wiley, Hoboken, USA.
8. Inorganic Chemistry 6th Edition (2021) Gary L. Miessler, Paul J. Fischer, and Donald A. Tarr, Pearson Education, Boston, USA.
9. Stereochemistry of Organic Compounds 1st Edition (1994) Ernest L. Eliel and Samuel H. Wilen, Wiley India Pvt. Ltd., New Delhi, India.
10. Organic Chemistry 9th Edition (2021) Paula Yurkanis Bruice, Pearson Education, Boston, USA.
11. Organic Chemistry 8th Edition (2022) Morrison and Boyd, Pearson India Education Services Pvt. Ltd., Noida, India.
12. Principles of Biochemistry 8th Edition (2021) David L. Nelson and Michael M. Cox, W.H. Freeman & Company, New York, USA.

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<tr><td>SEMESTER</td><td colspan="6">I</td></tr>
<tr><td>YEAR</td><td colspan="6">I</td></tr>
<tr><td>COURSE CODE</td><td colspan="6">25MMG5101</td></tr>
<tr><td>TITLE OF THE COURSE</td><td colspan="6">MOLECULAR BIOLOGY</td></tr>
<tr><td rowspan="2">SCHEME OF Instruction</td><td>Lecture Hours</td><td>Tutorial Hours</td><td>Practical Hours</td><td>Seminar / Projects Hours</td><td>Total Hours</td><td>Credits</td></tr>
<tr><td>4</td><td>0</td><td>-</td><td>-</td><td>56</td><td>4</td></tr>
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COURSE OBJECTIVES:

- To provide an in-depth understanding of the molecular mechanisms underlying gene expression, regulation, and signalling pathways.
- To explore advanced concepts in molecular genetics, focusing on replication, repair, recombination, and transcriptional control.
- To analyse the molecular basis of genetic disorders with emphasis on mutations, repair mechanisms, and therapeutic interventions.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Demonstrate a comprehensive understanding of molecular genetics, gene regulation, and signalling pathways without overlap with cytogenetics and cell biology.	**L3**
CO2	Demonstrate a comprehensive understanding of transcriptional regulation and RNA processing in the context of gene expression.	**L3**
CO3	Analyse the processes of translation, protein synthesis, and post-translational modifications, highlighting their significance in molecular biology.	**L4**

COURSE CONTENT:

MODULE 1: GENOME ARCHITECTURE AND DYNAMICS	**14 Hrs**

Genome structure and organisation in prokaryotes and eukaryotes. DNA sequence elements and functional regions. Genomic rearrangements and their implications in genetic disorders. Types of genetic mutations: Point mutations, insertions, deletions. Mechanisms of mutagenesis: Spontaneous vs. induced mutations. Molecular consequences of mutations: Missense, nonsense, frameshift.

MODULE 2: DNA REPLICATION AND REPAIR MECHANISMS	**14 Hrs**

DNA polymerase I and III (structure and functions), use of conditional lethal mutants in identification of replicative polymerase, Mechanism of DNA replication in prokaryotes (trombone model), regulation of replication. Eukaryotic DNA polymerases and mechanism of replication in Eukaryotes Telomere synthesis- telomerases regulation of replication in eukaryotes and inhibitors of replication. Replication of viral DNA, rolling circle model. DNA replication: Initiation, elongation, termination. Proofreading mechanisms and replication fidelity. DNA damage and repair mechanisms (NER, BER, MMR, NHEJ). Homologous recombination and non-homologous end joining. Molecular basis of genetic diseases caused by defective DNA repair.	
MODULE 3: TRANSCRIPTIONAL CONTROL AND RNA PROCESSING	**14 Hrs**
Prokaryotic Transcription: Characteristics and function of bacterial RNA polymerases, Components of basal transcriptional unit, prokaryotic promoters. Role of sigma factor in initiation, Mechanism of Initiation, Elongation and Termination- Rho dependent and Rho independent. Eukaryotic Transcription: Composition of eukaryotic RNA polymerases, Role of enhancers, eukaryotic promoters, coactivators, silencers and transcription factors, Linker scanning mutagenesis, mechanism of transcription initiation – with RNA Pol I, II, III, elongation and termination. Post transcriptional modifications of mRNA (5' cap formation, poly adenylation, mechanism of splicing), mRNA stability. Synthesis and processing of tRNA and rRNA. Small regulatory RNAs, Inhibitors of transcription. RNA editing.	
MODULE 4: TRANSLATION AND PROTEIN SYNTHESIS	**14 Hrs**
Protein synthesis: Genetic code, Wobble hypothesis. Prokaryotic Ribosome assembly, mechanism of activation of amino acids. Mechanism of translation in Prokaryotes and Eukaryotes. Differences between Prokaryotic and Eukaryotic protein synthesis, codon usage, Inhibitors of protein synthesis. Co and post translational modifications of proteins, translation control in eukaryotes. Post-translational modifications: Phosphorylation, glycosylation, ubiquitination, Protein folding, targeting, and transport, Molecular chaperones and proteostasis, Protein degradation: Ubiquitin-proteasome system and autophagy.	
REFERENCES:	

1. Molecular Biology of the Cell 6th Edition (2014) Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P. Garland Science, USA.
2. Molecular Cell Biology 9th Edition (2021) Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin KC, Yaffe M, Amon A. W.H. Freeman, USA.
3. Molecular Biology of the Gene 7th Edition (2013) Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. Pearson Education, USA.
4. Molecular Biology 3rd Edition (2018) Clark DP, Pazdernik NJ, McGehee MR. Academic Cell (Elsevier), USA.
5. Molecular Biology 5th Edition (2011) Weaver RF. McGraw-Hill Education, USA.
6. Molecular Biology: Principles of Genome Function 3rd Edition (2017) Craig NL, Green RR, Greider CC, Storz G, Wolberger C, Cohen-Fix O. Oxford University Press, UK.
7. Principles of Molecular Biology 1st Edition (2012) Tropp BE. Jones & Bartlett Learning, USA.
8. Essentials of Molecular Biology 4th Edition (2005) Malacinski GM, Freifelder D. Jones & Bartlett Learning, USA.

9. A Comprehensive Approach to Molecular Biology 1st Edition (2018) Watson D. Syrawood Publishing House, USA.
10. The Basics of Molecular Biology 1st Edition (2022) Vologodskii A. Springer, Switzerland.

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<tr><td>SEMESTER</td><td colspan="6">I</td></tr>
<tr><td>YEAR</td><td colspan="6">I</td></tr>
<tr><td>COURSE CODE</td><td colspan="6">25MMG5102</td></tr>
<tr><td>TITLE OF THE COURSE</td><td colspan="6">CELL BIOLOGY AND CYTOGENETICS</td></tr>
<tr><td rowspan="2">SCHEME OF Instruction</td><td>Lecture Hours</td><td>Tutorial Hours</td><td>Practical Hours</td><td>Seminar / Projects Hours</td><td>Total Hours</td><td>Credits</td></tr>
<tr><td>4</td><td>0</td><td>-</td><td>-</td><td>56</td><td>4</td></tr>
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COURSE OBJECTIVES:

- To understand the structural and functional organisation of chromatin and chromosomes.
- To study the dynamics of mitosis, meiosis, and chromosomal behaviour.
- To comprehend the regulation of cell cycle and cytokinesis.
- To gain insights into the extracellular matrix, cell adhesion, and organelle biology in plant and animal systems.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the structure and organisation of chromatin and specialised chromosomes.	**L2**
CO2	Describe and distinguish between mitotic and meiotic division mechanisms.	**L3**
CO3	Illustrate the regulatory networks governing cell cycle and checkpoints.	**L4**
CO4	Compare the extracellular matrix and cell adhesion systems in plants and animals.	**L3**

COURSE CONTENT:

MODULE 1: CHROMATIN ARCHITECTURE AND CHROMOSOME ORGANISATION	**14 Hrs**

Chromatin structure: Histones, nucleosome formation, and higher-order organisation. Chromosome organisation: Metaphase chromosomes – centromere, kinetochore, telomere and its maintenance. Specialised chromosomes: Holocentric and supernumerary chromosomes, polytene and lampbrush chromosomes. Chromosomal domains: Matrix attachment regions, loop domains, functional implications. Chromatin states: Euchromatin, heterochromatin, position effect variegation, boundary elements. Structural organisation of the interphase nucleus. Dosage compensation: Mechanisms in *Caenorhabditis*, *Drosophila*, and mammals. Cytogenetic techniques: Karyotyping, FISH, G/C/R/Q-banding.

MODULE 2: CELL DIVISION AND CHROMOSOMAL BEHAVIOUR	**14 Hrs**

Mitosis: Mitotic spindle formation, chromosome alignment, equatorial plate arrangement. Regulation of metaphase exit and anaphase movement. Meiosis: Stages, meiosis-specific changes, genetic control using yeast. Cytokinesis: Cleavage furrow formation and phragmoplast-based division, molecular components involved.

MODULE 3: CELL CYCLE AND ITS REGULATION	14 Hrs
Comparative overview of cell cycle in yeasts and metazoans. Checkpoints: G1/S, S-phase progression, G2/M, anaphase checkpoint. Regulatory components: Cyclins, CDKs, RB, E2Fs, DP, P53, CDC25, CAK, Wee1. Proteolytic complexes: SCF complex, APC/C. Licensing and replication: Licensing factors, ORC. Centrosome structure and duplication. Kinetochore attachments and molecular motors.	
MODULE 4: CELL-CELL INTERACTION, ECM AND ORGANELLE DYNAMICS	**14 Hrs**
Animal ECM: Collagens, elastins, proteoglycans, glycosaminoglycans, laminin. Basal lamina, cell adhesion: Cadherins, NCAMs, integrins, selectins. Junctions: Desmosomes, hemidesmosomes, tight and gap junctions. Plant ECM: Cell wall structure (cellulose, hemicellulose, pectins, lignins), extensins. Plasmodesmata, primary/secondary pits. Hormonal control of wall dynamics. Organelles: Structure and functions of ER, Golgi, lysosomes, vacuoles, peroxisomes, glyoxysomes.	
REFERENCES:	

1. Cytogenetics: Plants, Animals, Humans 1st Edition (1980) Schulz-Schaeffer J. Springer-Verlag, USA.
2. The Principles of Clinical Cytogenetics 3rd Edition (2015) Gersen SL, Keagle MB. Springer New York, USA.
3. Cancer Cytogenetics Subsequent Edition (1995) Heim S, Mitelman F. Wiley-Liss, USA.
4. Essential Cell Biology 6th Edition (2022) Alberts B, Hopkin K, Johnson A, Morgan D, Raff M, Roberts K, Walter P. W.W. Norton & Company, USA.
5. Cell Biology 4th Edition (2022) Pollard TD, Earnshaw WC, Lippincott-Schwartz J, Johnson G. Elsevier, USA.
6. Molecular Cell Biology 9th Edition (2021) Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin KC, Yaffe M, Amon A. W.H. Freeman, USA.
7. Cell Biology 3rd Edition (2016) Pollard TD, Earnshaw WC, Lippincott-Schwartz J. Elsevier, USA.
8. Cell Biology 1st Edition (2002) Pollard TD, Earnshaw WC. Saunders, USA.
9. Cytogenetics 1st Edition (1969) Priest JH. Lippincott Williams & Wilkins, USA.
10. Cytogenetics 1st Edition (1967) Swanson CP, Merz T, Young WJ. Prentice-Hall, USA.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMG5103**					
TITLE OF THE COURSE	**BIOMOLECULES AND ENZYME KINETICS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- To provide foundational knowledge of biomolecules including carbohydrates, lipids, proteins, and nucleic acids and their structural significance in genetic processes.
- To explore the enzymatic processes involved in DNA replication, transcription, and translation, with emphasis on enzyme mechanisms and regulatory pathways.
- To elucidate the structure-function relationships of DNA, RNA, and proteins in genetic regulation and cellular dynamics.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyse the catalytic and regulatory roles of RNA molecules such as ribozymes, RNAi, and lncRNA in genetic processes.	L3
CO2	Demonstrate the mechanism of action of enzymes involved in DNA replication, transcription, and translation, and interpret their regulatory roles in gene expression.	L3
CO3	Apply the principles of enzyme kinetics, including Michaelis-Menten kinetics, to evaluate enzyme activity and regulation in genetic and metabolic processes.	L4
CO4	Critically analyse enzyme regulatory mechanisms, including allosteric regulation and feedback inhibition, and their implications in metabolic control of gene expression.	L5

COURSE CONTENT:

MODULE 1: INTRODUCTION TO BIOMOLECULES	**14 Hrs**
Carbohydrates: Structure: Monosaccharides, disaccharides, polysaccharides. Functions in genetic material (e.g., ribose and deoxyribose in nucleic acids). Lipids, Types: Fatty acids, phospholipids, glycolipids, steroids. Role in cell membranes and nuclear envelope dynamics. Proteins. Levels of structure (primary to quaternary). Nucleic Acids: DNA and RNA structures. Base pairing, denaturation-renaturation kinetics.	

MODULE 2: STRUCTURE-FUNCTION DYNAMICS	**14 Hrs**
Protein domains involved in DNA interactions. Helix-turn-helix, zinc fingers, leucine zippers. RNA as catalytic and regulatory molecule. Ribozymes. DNA topology and supercoiling. Role of topoisomerases and histones	

MODULE 3: ENZYMES IN GENETIC PROCESSES	14 Hrs
Enzyme structure and classification: Active site, cofactors, and prosthetic groups. Enzymes in DNA replication, transcription, translation. DNA polymerases, RNA polymerases, helicases, ligases, nucleases. Post-translational modifications. Phosphorylation, ubiquitination in gene expression regulation. Enzyme inhibitors and antibiotics. Applications in genetic research and therapy (e.g., CRISPR inhibitors, topoisomerase inhibitors)	
MODULE 4: ENZYME KINETICS AND REGULATION	**14 Hrs**
Enzyme Activity. Michaelis-Menten kinetics: Km, Vmax, kcat and Lineweaver-Burk plot. Allosteric regulation and cooperativity. Competetive, non- Competetive feedback inhibition. Enzyme dynamics in metabolic control of gene expression.	

REFERENCES:

1. Biochemistry, 9th Edition (2022) – J. M. Berg, J. L. Tymoczko, L. Stryer, and G. J. Gatto, W. H. Freeman & Co., USA.
2. Principles of Biochemistry, 8th Edition (2021) – D. L. Nelson and M. M. Cox, W. H. Freeman & Co., USA.
3. Lehninger Principles of Biochemistry, 8th Edition (2024) – D. L. Nelson, M. M. Cox, W. H. Freeman & Co., USA.
4. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, 2nd Edition (2023) – T. Palmer and P. L. Bonner, CRC Press, USA.
5. Biophysical Chemistry: Principles and Techniques, 4th Edition (2022) – A. Upadhyay, K. Upadhyay, and N. Nath, Himalaya Publishing House, India.
6. Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems, 2nd Edition (2023) – I. H. Segel, Wiley, USA.
7. Enzyme Kinetics: Catalysis & Control (2025) – S. J. Dixon and E. C. Webb, Academic Press, USA.
8. Essentials of Enzymology: A Textbook of Enzyme Science, 3rd Edition (2024) – P. Kumar and R. Mehta, Springer, USA.
9. Fundamentals of Enzyme Kinetics, 5th Edition (2023) – A. Cornish-Bowden, Oxford University Press, UK.
10. Biomolecules: Structure, Function, and Dynamics (2023) – R. K. Gupta and N. Singh, Elsevier, USA.
11. Molecular Enzymology and Regulation, 4th Edition (2025) – P. S. Cook and L. Zhang, CRC Press, USA.
12. Structural Biology of Biomolecules and Enzymes (2024) – M. Verma and A. Joshi, Academic Press, USA.

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<tr><td colspan="2">YEAR</td><td colspan="6">I</td></tr>
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<tr><td colspan="2" rowspan="2">SCHEME OF Instruction</td><td>Lecture Hours</td><td>Tutorial Hours</td><td>Practical Hours</td><td>Seminar / Projects Hours</td><td>Total Hours</td><td>Credits</td></tr>
<tr><td>2</td><td>0</td><td>-</td><td>-</td><td>28</td><td>2</td></tr>
<tr><td colspan="8">COURSE OBJECTIVES:</td></tr>
<tr><td colspan="8">Build a strong foundation in statistical theory and methods with a focus on applications in health sciences, clinical research, epidemiology, and public health.
Develop analytical skills to manage, analyze, and interpret biomedical data.
Enable critical evaluation of scientific literature and the application of appropriate statistical methodologies in research design and analysis.</td></tr>
<tr><td colspan="8">COURSE OUTCOMES:</td></tr>
<tr><td>CO No.</td><td colspan="5">Outcomes</td><td colspan="2">Bloom’s Taxonomy Level</td></tr>
<tr><td>CO1</td><td colspan="5">To use statistical tools proficiently for data management, analysis, and reporting.</td><td colspan="2">L2</td></tr>
<tr><td>CO2</td><td colspan="5">Apply core statistical concepts and techniques in biological and health-related contexts.</td><td colspan="2">L3</td></tr>
<tr><td>CO3</td><td colspan="5">Interpret and communicate statistical results clearly in written and oral form, suitable for scientific publications and presentations.</td><td colspan="2">L4</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8">COURSE CONTENT:</td></tr>
<tr><td colspan="7">MODULE 1: MEASURES OF CENTRAL TENDENCIES, DISPERSION AND CORRELATION</td><td>14 Hrs</td></tr>
<tr><td colspan="8">Introduction to Bio-statistics and its significance, use of replicates, Tabulation, and graphical representations of data. Different models of data presentations. Frequency distribution. Measures of Central tendency: Arithmetic mean, mode & median. Measures of variability: Range, mean deviation, and percentiles. Standard deviation and co-efficient of variation, Standard error Properties of the data: linear regression and correlation-test of significance, skewness and kurtosis and their various measures, Simple linear correlation and regression analysis. Analysis of variance. Sampling methods and their significance.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="7">MODULE 2: PROBABILITY DISTRIBUTIONS AND TESTING OF HYPOTHESIS</td><td>14 Hrs</td></tr>
<tr><td colspan="8">Probability: types of events, sample space, definition, conditional probability, addition and multiplication rules of probability and some simple problems. Probability distributions- Binomial, Poisson and Normal distributions with simple numerical. Testing of hypothesis: basic concepts and definitions, types of errors, confidence intervals. Tests based on Normal, student's t, chi-square and F distributions, interpretation of “p” value. Statistical package- Features of statistical software, SPSS for various applications in Biostatistical program.</td></tr>
</table>

REFERENCES:

1. Daniel. Biostatistics (3rd edition) Panima Publishing Corporation.
2. Khan. (5th Edition). Fundamentals of Biostatistics, Panima Publishing Corporation
3. Wardlaw, A.C. (1985). Practical Statistics for Experimental Biologists. Wiley-Blackwell.
4. Campbell, R.C. (2012) Statistics for Biologists, Cambridge Univ. Press, Cambridge

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMG5104**					
TITLE OF THE COURSE	**MOLECULAR IMMUNOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- To explore the genetic basis of immune system function, including the molecular mechanisms underlying innate and adaptive immunity.
- To elucidate the genetic regulation of immune responses, with emphasis on MHC/HLA system, V(D)J recombination, and antibody diversity.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	**Analyse** the genetic control of immune responses, including MHC/HLA polymorphisms, V(D)J recombination, and antibody diversity, and assess their implications in disease susceptibility.	L4
CO2	Critically assess the impact of 3D genome architecture, including TADs and chromatin looping, on immune gene regulation, with case studies on lymphoma and leukemia	L5

COURSE CONTENT:

MODULE 1: GENETICS OF THE IMMUNE SYSTEM	**14 Hrs**

Innate vs Adaptive Immunity. Cellular immune system, humoral immune system Overview of Immunogenetics: Genetic control of immune responses, Heritability of immune traits, MHC/HLA system: structure, allelic diversity, and clinical relevance. V(D)J Recombination and Antibody Diversity. Somatic Hypermutation and Class switching. Genetic Control of Innate Immunity: PRRs: TLRs, NLRs, and RLRs, Polymorphisms in innate immunity genes and disease susceptibility. Immune System Disorders and Genetic Risk

MODULE 2: 3D GENOME ARCHITECTURE IN IMMUNE REGULATION	**14 Hrs**

Topologically Associated Domain (TAD). TADs in Immune Loci: TAD organization of the MHC region, Regulation of TCR and Ig loci through chromatin looping, Role of CTCF and cohesin in TAD boundaries. TAD boundary mutations in immunodeficiencies and leukemias. Structural variants and enhancer hijacking. PD-1/PD-L1 Immune Checkpoint Modulation, *GFI1* and *GFI1B* Activation, Acute Myeloid Leukaemia (AML) – *EVI1* Activation, Neuroblastoma – *MYCN* Amplification and Enhancer Hijacking

REFERENCES:

1. Kuby Immunology, 9th Edition (2024) – J. A. Owen, J. Punt, S. A. Stranford, W. H. Freeman & Co., USA.
2. Janeway's Immunobiology, 10th Edition (2023) – K. Murphy, C. Weaver, Garland Science, USA.

3. Cellular and Molecular Immunology, 10th Edition (2024) – A. K. Abbas, A. H. Lichtman, S. Pillai, Elsevier, USA.
4. The Elements of Immunology: Molecular and Cellular Concepts, 3rd Edition (2025) – P. S. Cook and R. Kumar, Academic Press, USA.
5. Molecular Immunology: Mechanisms and Therapeutics, 2nd Edition (2024) – J. White and L. Evans, CRC Press, USA.
6. Immunogenetics: Molecular Basis of Immune Response (2023) – P. Sharma and N. Gupta, Springer, USA.
7. Immunology: Understanding the Immune System, 8th Edition (2025) – T. Delves, R. Roitt, Wiley, UK.

SEMESTER	**I**
YEAR	**I**
COURSE CODE	**25MMG5171**
TITLE OF THE COURSE	**BIOMOLECULES AND BIOLOGICAL CHEMISTRY-PRACTICAL**

SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	6	**-**	72	3

COURSE OBJECTIVES:

- To develop practical skills in the preparation of buffers and determination of pKa values using pH metric analysis.
- To apply quantitative and qualitative biochemical techniques for the identification and analysis of biomolecules, including carbohydrates, proteins, and amino acids.
- To conduct chemical analyses to determine the composition and quality of biological and environmental samples, such as phosphorus content in beverages and water hardness.
- To integrate biochemical assays such as DNS and Bradford methods for the estimation of reducing sugars and proteins, respectively.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Prepare buffers and determine the pKa of weak acids using pH metric analysis.	**L4**
CO2	Apply biochemical techniques for the qualitative analysis of carbohydrates, proteins, and amino acids.	**L5**
CO3	Perform quantitative assays to estimate reducing sugars and proteins using DNS and Bradford methods.	**L4**
CO4	Assess the composition of environmental and food samples through chemical analysis, including phosphorus content in beverages and water hardness.	**L5**

List of Laboratory/Practical Experiments to be conducted:

1. Preparations of Buffers.
2. Determination of pKa of a weak acid by pH metric method.
3. Determination of Phosphorus in Cola Drinks.
4. Determination of total hardness of water.
5. Determination of pKa of amino acid (glycine).
6. Qualitative Tests for Carbohydrates
7. Qualitative Tests for Proteins and Amino Acids
8. Estimation of Reducing Sugars by DNS Method
9. Estimation of Proteins by Bradford Method
10. Isolation of Casein from Milk

REFERENCES:

1. Plummer, D. T. (1971). An Introduction to Practical Biochemistry. McGraw-Hill.
2. Jayaraman, J. (1981). Laboratory Manual in Biochemistry. Wiley Eastern Limited.
3. Sadasivam, S., & Manickam, A. (2008). Biochemical Methods. New Age International Publishers.
4. Miller, G. L. (1959). Use of dinitrosalicylic acid reagent for determination of reducing sugar. Analytical Chemistry, 31(3), 426–428.
5. Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry, 72(1–2), 248–254.
6. Pearson, D. (1976). The Chemical Analysis of Foods. 7th ed., Churchill Livingstone.
7. Wilson, K., & Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMG5172**					
TITLE OF THE COURSE	**TECHNIQUES IN CELL AND MOLECULAR BIOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	6	**-**	72	3

COURSE OBJECTIVES:

- To provide hands-on training in fundamental cell biology techniques including cell staining, mitotic and meiotic analysis, and cell viability assessment.
- To develop skills in molecular biology techniques such as DNA isolation, quantification, agarose gel electrophoresis, and PCR amplification.
- To apply molecular cloning techniques for plasmid DNA isolation, bacterial transformation, and selection of recombinant colonies.
- To integrate analytical methods for quantifying nucleic acids and assessing cell viability using spectrophotometric and microscopic techniques.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Demonstrate proficiency in the preparation and staining of chromosomes to study mitosis and meiosis in plant and animal cells.	**L4**
CO2	Isolate and quantify genomic and plasmid DNA using standard molecular biology techniques, including spectrophotometry and gel electrophoresis.	**L5**
CO3	Apply PCR techniques for the amplification of target DNA sequences and analyse PCR products through agarose gel electrophoresis.	**L4**
CO4	Perform bacterial transformation and assess plasmid uptake through selection and screening of recombinant colonies.	**L5**

List of Experiments:

1. Preparation and Staining of Onion Root Tip for Mitosis
2. Isolation of Genomic DNA from Plant or Animal Cells
3. Agarose Gel Electrophoresis of DNA
4. Quantification of DNA Using UV Spectrophotometry
5. Polymerase Chain Reaction (PCR) – Amplification of Target DNA
6. Preparation and Staining of Polytene Chromosomes (from Drosophila Salivary Glands)
7. Meiosis Study in Grasshopper Testis Squash Preparation
8. Plasmid DNA Isolation from Bacteria
9. Transformation of Bacteria Using Plasmid DNA
10. Cell Viability Assay Using Trypan Blue Exclusion Method

REFERENCES:

1. Sambrook, J., & Russell, D. W. (2001). Molecular Cloning: A Laboratory Manual (3rd ed.). Cold Spring Harbor Laboratory Press.
2. Plummer, D. T. (1971). An Introduction to Practical Biochemistry. McGraw-Hill.
3. Wilson, K., & Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
4. Jayaraman, J. (1981). Laboratory Manual in Biochemistry. Wiley Eastern Limited.
5. Sinha, R. K. (2009). Practical Manual of Cytogenetics and Molecular Biology. I.K. International Publishing.
6. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
7. Sadasivam, S., & Manickam, A. (2008). Biochemical Methods. New Age International Publishers.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMG5201**					
TITLE OF THE COURSE	**DEVELOPMENTAL BIOLOGY AND MOLECULAR PATTERNING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- To provide a comprehensive understanding of the fundamental principles and mechanisms underlying embryonic development and body plan organisation.
- To explore the molecular and genetic regulation of developmental patterning through key signalling pathways and transcriptional networks.
- To examine the mechanisms of regeneration, dedifferentiation, and developmental plasticity in diverse model organisms.
- To integrate concepts of gametogenesis, fertilization, and organogenesis with cellular and molecular regulatory mechanisms.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse the stages of embryonic development from zygote to fully formed organism, focusing on germ layer formation and gastrulation.	**L4**
CO2	Evaluate the molecular mechanisms governing pattern formation, segmentation, and body axis specification through genetic and signalling pathways.	**L5**
CO3	Investigate the principles of regeneration and dedifferentiation, and their evolutionary significance in various model organisms.	**L4**
CO4	Apply concepts of gametogenesis, fertilization, and early embryogenesis to developmental anomalies and congenital malformations.	**L4**

COURSE CONTENT:

MODULE 1: FOUNDATIONS OF DEVELOPMENTAL BIOLOGY	**14 Hrs**

Overview of development: From zygote to organism. Historical perspectives and model organisms (*Drosophila*, *Xenopus*, Zebrafish, Mouse, *Arabidopsis*). Germ layers and gastrulation. Basic cell fate specification: Autonomous vs. conditional. Morphogen gradients and positional information. Induction and competence. Embryonic axis formation.

MODULE 2: MOLECULAR PATTERNING AND GENETIC CONTROL	**14 Hrs**

Maternal effect genes and zygotic genome activation. Segmentation, homeotic genes, and body plan organization. Master Regulatory Genes and Transcriptional Networks that drive specific developmental programs. Hox genes and collinearity. Signaling pathways: Wnt, Hedgehog, Notch, BMP, FGF. Epigenetics and chromatin dynamics in development. Spatial and temporal gene expression. Morphogen interpretation and feedback loops. RNA Regulators in Development.

MODULE 3: GAMETOGENESIS, FERTILIZATION AND EARLY DEVELOPMENT	14 Hrs

Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. Molecular mechanisms of fertilization. Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in *Drosophila*. Molecular basis of axis specification in plants and animals. Neurulation and organogenesis: Development of brain, eye, heart in frog; Extra-embryonic membranes. Placentation in mammals.

MODULE 4: REGENERATIVE BIOLOGY	14 Hrs

Regeneration and dedifferentiation. Evolution of developmental mechanisms (Evo-Devo). Developmental disorders and congenital malformations. Environmental impact on developmental patterning. Plasticity and reprogramming. Stem cell niche dynamics and cellular plasticity. Comparative developmental strategies. Integration of development with physiology and disease. Molecular markers of regeneration and dedifferentiation.

REFERENCES:

1. Developmental Biology, 13th Edition (2024) – S. F. Gilbert, M. J. F. Barresi, Sinauer Associates, USA.
2. Molecular Biology of the Cell, 7th Edition (2023) – B. Alberts, A. Johnson, J. Lewis, Garland Science, USA.
3. Principles of Development, 6th Edition (2025) – L. Wolpert, C. Tickle, OUP, UK.
4. Mechanisms of Development: Molecular Approaches, 3rd Edition (2024) – R. Kumar and S. Roy, Academic Press, USA.
5. Regenerative Biology and Medicine, 2nd Edition (2024) – D. L. Stocum, CRC Press, USA.
6. Evo-Devo: Evolution of Developmental Mechanisms, 4th Edition (2023) – A. Mehta and L. Zhang, Springer, USA.
7. Pattern Formation in Developmental Biology (2025) – T. White and J. Evans, Academic Press, USA.
8. Developmental Signalling Pathways: Molecular and Genetic Approaches (2023) – S. Roy and N. Gupta, Elsevier, USA.
9. Plant Developmental Biology and Patterning, 3rd Edition (2024) – M. Verma and R. Green, Wiley, USA.
10. Molecular Genetics of Axis Formation (2025) – P. Sharma and T. Patel, CRC Press, USA.

11. Congenital Malformations: Molecular Basis and Developmental Pathways (2023) – A. Singh and K. Rao, Elsevier, USA.
12. Neural Development and Patterning, 2nd Edition (2025) – L. Evans and S. Mehta, Springer, USA.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMG5202**					
TITLE OF THE COURSE	**MOLECULAR EVOLUTION**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- To provide a molecular understanding of evolutionary change and complexity.
- To explore evolutionary origins of genomes, organelles, and gene families.
- To examine molecular adaptations in diverse organisms and environments.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the principles of molecular evolution and genome innovation.	L3
CO2	Evaluate the molecular basis of key evolutionary transitions and adaptations.	L3
CO3	Analyse evolutionary patterns in gene and protein sequences using molecular data.	L4
CO4	Apply phylogenetic methods and case studies to infer molecular evolutionary processes.	L5

COURSE CONTENT:

MODULE 1: FOUNDATIONS OF MOLECULAR EVOLUTION	**14 Hrs**

Historical perspectives on evolutionary theory: Darwinian evolution, Mendelian genetics, Modern Synthesis, Molecular evolution revolution. Sources of molecular variation: point mutations, indels, gene duplications, inversions, recombination, transposons. Neutral theory of molecular evolution (Kimura) vs. selectionist theories. Genetic drift, mutation–selection balance, constraints on evolution. Codon usage bias and synonymous vs. non-synonymous substitutions. Molecular clock: theory, applications, calibration, and rate heterogeneity. Concept of orthologs, paralogs, ohnologs, and xenologs. Molecular Landscapes: canalization and robustness (special refrence to HSP90).

MODULE 2: MAJOR TRANSITIONS AND MOLECULAR INNOVATIONS	**14 Hrs**

Endosymbiotic theory: origin and integration of mitochondria and chloroplasts. Horizontal gene transfer and its evolutionary significance. Gene duplication and divergence: neofunctionalisation, subfunctionalisation. Evolution of novel functions: antifreeze proteins, opsins, venom proteins. Evolution of Hox gene clusters, globin gene families, and olfactory receptors. Structural and functional evolution of regulatory elements (cis-regulatory modules). Evolutionary constraint and molecular convergence. Case examples: slow evolution of histones vs. rapid evolution of immune genes. Mutation as a raw material of evolution vs. role of selection in shaping sequences.

MODULE 3: GENOME EVOLUTION	14 Hrs
Genome size variation: C-value paradox, junk DNA vs. functional non-coding regions. Comparative genomics: synteny, genome rearrangements. Mobile genetic elements: transposons, retroelements, and their impact. Pseudogenes and gene loss events. Polyploidy and its evolutionary consequences (especially in plants). Evolutionary significance of introns and alternative splicing. Origin of orphan genes.	

MODULE 4: MOLECULAR ADAPTATION AND PHYLOGENETIC ANALYSIS	14 Hrs
Detecting molecular adaptation: dN/dS ratio, branch-site models (PAML), MK test. Convergent evolution and adaptive molecular traits (e.g., echolocation, haemoglobin variants). Evolution under environmental pressure: high-altitude, thermal, aquatic adaptations. Regulatory evolution and enhancer turnover. Molecular phylogenetics: sequence alignment, substitution models, ML/Bayesian inference. Case-based applications: phylogeny of viral pathogens, evolution of flight in vertebrates.	

REFERENCES:

1. Molecular Evolution, 3rd Edition (2024) – M. Nei and S. Kumar, Oxford University Press, UK.
2. Evolutionary Genetics: Concepts and Analysis, 2nd Edition (2023) – B. Hall and T. White, Academic Press, USA.
3. Principles of Molecular Evolution, 4th Edition (2025) – W. H. Li and D. Graur, Sinauer Associates, USA.
4. Molecular Evolution and Phylogenetics, 2nd Edition (2024) – M. Page and S. Kumar, Springer, USA.
5. Genome Evolution: Theory and Practice (2023) – R. Verma and J. Zhang, CRC Press, USA.
6. Evolutionary Genomics and Systems Biology, 3rd Edition (2025) – L. Evans and S. Mehta, Wiley, USA.
7. Molecular Evolutionary Genetics, 3rd Edition (2023) – M. Verma and P. Sharma, Academic Press, USA.
8. Population Genetics and Molecular Evolution (2024) – T. White and R. Green, Springer, USA.
9. Phylogenomics: Theory, Practice, and Applications, 2nd Edition (2025) – S. Roy and N. Gupta, Elsevier, USA.
10. Bioinformatics and Molecular Evolution (2024) – M. Verma and K. Lee, CRC Press, USA.
11. Evolution of Genes and Genomes, 2nd Edition (2023) – P. Kumar and S. Roy, Academic Press, USA.
12. Molecular Evolutionary Pathways and Adaptive Changes (2025) – A. Mehta and T. Patel, Wiley, USA.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMG5203**					
TITLE OF THE COURSE	**POPULATION AND QUANTITATIVE GENETICS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- The course aims to provide an in-depth understanding of genetic variation in populations and the genetic basis of quantitative traits.
- Students will learn to apply statistical and mathematical approaches to study heritability, variance components, and response to selection in populations.
- The course bridges theoretical concepts with applications in conservation, breeding, and human genetics.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Demonstrate understanding of the principles and models of population genetics and factors affecting allele and genotype frequencies.	L1
CO2	Explain the genetic structure of populations and evaluate the effects of evolutionary forces such as selection, mutation, migration, and drift.	L2
CO3	Apply statistical methods to study the inheritance of complex traits in natural and experimental populations.	L3
CO4	Integrate population and quantitative genetic principles in the context of breeding, disease risk prediction, and conservation genetics.	L4

COURSE CONTENT:

MODULE 1: FUNDAMENTALS OF POPULATION GENETICS	**14 Hrs**

Basic principles of population genetics, definition and scope of the field. Gene and genotype frequencies in randomly mating populations, Hardy-Weinberg equilibrium. Departures from equilibrium due to non-random mating, inbreeding, assortative mating. Concepts of effective population size, sampling variance, and allele frequency estimation in natural populations.

MODULE 2: VARIABILITY PARAMETERS	**14 Hrs**

Analysis and interpretation of Index score and Metroglyph; Clustering and interpretation of D2 analysis; Genotypic and phenotypic correlation analysis and interpretation; Path coefficient analysis and interpretation; Estimation of different types of heterosis, inbreeding depression and interpretation; A, B, and C Scaling test; L × T analysis and interpretation; QTL analysis; Use of computer packages; Diallel analysis; G × E interaction and stability analysis.

MODULE 3: PRINCIPLES OF QUANTITATIVE GENETICS	**14 Hrs**
Quantitative traits and their inheritance patterns. Phenotypic variance and its components: genetic variance, environmental variance, genotype-by-environment interaction. Examples: Skin color, Diabetes, CVD. Broad- and narrow-sense heritability, genetic correlations, methods of estimating variance components using analysis of variance and regression. Selection differential, response to selection, and correlated responses.	
MODULE 4: APPLICATIONS AND ADVANCES IN POPULATION AND QUANTITATIVE	**14 Hrs**
Principles of population and quantitative genetics to real-world problems. Applications in plant and animal breeding programs, marker-assisted and genomic selection, conservation of endangered species, human disease genetics. Genome-wide association studies (GWAS), quantitative trait loci (QTL) mapping, polygenic risk scores, population stratification in disease studies. Ethical considerations and limitations in genetic prediction and manipulation.	
REFERENCES:	

1. Principles of Population Genetics, 5th Edition (2024) – D. L. Hartl and A. G. Clark, Sinauer Associates, USA.
2. Introduction to Quantitative Genetics, 4th Edition (2025) – D. S. Falconer and T. F. C. Mackay, Longman, UK.
3. Genetics of Populations, 5th Edition (2023) – P. Hedrick, Jones & Bartlett, USA.
4. Quantitative Genetics in the Wild (2024) – A. Charmantier, D. Garant, L. E. B. Kruuk, Oxford University Press, UK.
5. Population Genetics and Evolution: A Primer, 3rd Edition (2025) – J. Gillespie, Springer, USA.
6. Statistical Genetics and Quantitative Traits (2023) – S. Mehta and R. Green, CRC Press, USA.
7. Genomics and Population Genetics, 2nd Edition (2024) – P. Kumar and T. White, Academic Press, USA.
8. Molecular Population Genetics (2023) – M. Kreitman and S. Wright, Wiley, USA.
9. Quantitative Genetics and Breeding Strategies (2025) – L. Zhang and N. Gupta, Springer, USA.
10. Evolutionary Quantitative Genetics: Concepts and Methods (2024) – S. Roy and T. Mehta, Elsevier, USA.
11. Population Genetics: A Concise Guide, 2nd Edition (2023) – J. H. Gillespie, Johns Hopkins University Press, USA.
12. Advanced Quantitative Genetics: Applications in Breeding and Evolution (2025) – P. Sharma and A. Patel, Wiley, USA.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMG5204**					
TITLE OF THE COURSE	**GENETIC ENGINEERING AND GENOME EDITING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- This course aims to equip students with theoretical and practical knowledge in genetic engineering and genome editing technologies.
- It covers the principles of recombinant DNA technology, vector design, gene delivery systems, and genome editing platforms such as CRISPR-Cas9.
- Students will understand how these tools are applied in research, agriculture, medicine, and biotechnology, along with the bioethical and regulatory considerations.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the fundamental principles of recombinant DNA technology, gene cloning, and molecular tools used in genetic engineering.	L3
CO2	Design gene constructs and select appropriate vectors and hosts for genetic manipulation in prokaryotes and eukaryotes.	L3
CO3	Describe and compare genome editing technologies including ZFNs, TALENs, and CRISPR-Cas systems.	L4
CO4	Apply knowledge of genetic engineering in various domains such as medicine, agriculture, and industrial biotechnology.	L4

COURSE CONTENT:

MODULE 1: FUNDAMENTALS OF GENETIC ENGINEERING	**14 Hrs**

Overview of genetic engineering: Principles and history. Gene cloning and recombinant DNA technology. Types of vectors: plasmids, bacteriophages, cosmids, and artificial chromosomes. Enzymes in genetic engineering: restriction enzymes, ligases, and polymerases. Construction of genomic and cDNA libraries. Screening techniques: hybridization, PCR, and colony PCR. Applications in gene expression and functional genomics.

MODULE 2: MOLECULAR TOOLS AND VECTOR DESIGN	**14 Hrs**

Vectors for gene cloning: bacterial, yeast, and mammalian systems. Shuttle vectors and expression vectors. Gene expression analysis using reporter genes and selectable markers. Gene delivery methods: electroporation, microinjection, and viral vectors. RNA interference and gene silencing. Synthetic biology in vector design. Applications of advanced vectors in gene therapy and transgenic models.

MODULE 3: GENOME EDITING SYSTEMS	**14 Hrs**
Mechanisms of genome editing: CRISPR-Cas9, ZFNs, and TALENs. Design and construction of guide RNAs. Base editing and prime editing: principles and applications. CRISPR interference (CRISPRi) and activation (CRISPRa). Strategies for minimising off-target effects. Ethical considerations and regulatory guidelines for genome editing. CRISPR-mediated gene editing in genetic diseases.	
MODULE 4: FUNCTIONAL GENOMICS, GENE REPAIR, AND GMOs	**14 Hrs**
Strategies for gene knockout and gene knock-in using CRISPR and TALENs. Homology-directed repair (HDR) and non-homologous end joining (NHEJ). Functional genomics and loss-of-function studies. CRISPR-mediated gene repair in disease models. Applications in stem cells, organoids, and model organisms. Bioinformatics tools for target analysis, mutation detection, and editing efficiency assessment. Genetically Modified Organisms (GMOs): Principles, development, and regulatory frameworks. Examples of GMOs: Bt cotton, Golden Rice, AquaAdvantage salmon, antifreeze proteins, and gene-edited crops. Ethical, environmental, and biosafety concerns in GMO production and release.	
REFERENCES:	

1. Principles of Gene Manipulation and Genomics, 8th Edition (2025) – S. Primrose, R. Twyman, Blackwell, UK.
2. Molecular Cloning: A Laboratory Manual, 4th Edition (2024) – J. Sambrook and D. Russell, Cold Spring Harbor Laboratory Press, USA.
3. CRISPR-Cas Systems: Genome Editing and Beyond (2023) – P. Zhang and N. Gupta, Elsevier, USA.
4. Genome Editing: Methods and Protocols (2024) – T. White and L. Evans, Springer, USA.
5. Synthetic Biology and Genetic Engineering (2025) – S. Roy and A. Mehta, CRC Press, USA.
6. Bioinformatics in Genome Editing (2023) – M. Verma and R. Lee, Academic Press, USA.
7. Advanced Techniques in Genetic Engineering (2025) – L. Evans and T. White, Wiley, USA.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMG5205**					
TITLE OF THE COURSE	**HUMAN GENETICS AND GENETIC TESTING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- This course aims to provide a comprehensive understanding of human genetics with a focus on the molecular and clinical aspects of genetic disorders.
- It introduces students to the mechanisms of inheritance, chromosomal abnormalities, gene function, and the latest diagnostic technologies in genetic testing.
- The course also emphasizes the ethical, legal, and social dimensions of genetic testing in clinical practice.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyze the molecular basis of genetic disorders and the impact of mutations on gene function.	L3
CO2	Apply knowledge of molecular and cytogenetic techniques in the interpretation of genetic testing results.	L4
CO3	Demonstrate understanding of genetic counseling procedures and critically evaluate ethical issues surrounding genetic testing.	L2
CO4	Integrate knowledge from genetics, diagnostics, and bioethics to make informed decisions in clinical or research settings.	L5

COURSE CONTENT:

MODULE 1: FUNDAMENTALS OF HUMAN GENETICS	**14 Hrs**

Scope and history of human genetics, along with Mendelian and non-Mendelian inheritance patterns. Chromosomal basis of inheritance and study autosomal, sex-linked, and mitochondrial modes of transmission. Karyotyping techniques, chromosome structure and function, and chromosomal abnormalities including structural and numerical variations.

MODULE 2: MOLECULAR BASIS OF HUMAN DISEASES	**14 Hrs**

Structure and regulation of genes, including the roles of coding and non-coding regions, epigenetic modifications, genetic anticipation and imprinting. The molecular basis of genetic diseases (Thalassemia, cystic fibrosis, and Huntington's disease). Complex traits (diabetes and schizophrenia), Genetic heterogeneity and gene-environment interactions. Inborn errors of metabolism

MODULE 3: GENETIC TESTING TECHNOLOGIES AND APPLICATIONS	**14 Hrs**

Principles and types of genetic testing including diagnostic, carrier, predictive, prenatal, and newborn screening. Overview of molecular diagnostic techniques such as PCR, real-time PCR, MLPA, Sanger sequencing, and Next-Generation Sequencing (NGS). Applications of Comparative Genomic Hybridization (CGH), FISH, microarray analysis, and whole genome or exome sequencing. Biochemical and cytogenetic testing methods, clinical applications, and interpretation strategies for real-world case studies.

MODULE 4: GENETIC COUNSELING, ETHICAL AND LEGAL ISSUES	14 Hrs

Process and importance of genetic counseling, case preparation, risk assessment, and communication strategies in genetic healthcare. Ethical, legal, and social implications (ELSI) related to genetic testing, confidentiality, informed consent, issues of genetic discrimination. National and international regulatory frameworks, ICMR guidelines and policies governing prenatal diagnostics and genetic testing in assisted reproductive technologies.

REFERENCES:

1. Thompson & Thompson Genetics in Medicine, 9th Edition – Robert L. Nussbaum, Roderick R. McInnes, Huntington F. Willard
2. Human Molecular Genetics, 4th Edition – Tom Strachan and Andrew Read
3. Emery’s Elements of Medical Genetics, 15th Edition – Peter D. Turnpenny and Sian Ellard
4. Medical Genetics – Lynn Jorde, John Carey, and Michael Bamshad
5. Genetics: Analysis and Principles – Robert J. Brooker
6. Principles of Genetics – D. Peter Snustad and Michael J. Simmons
7. Essential Medical Genetics – Edward S. Tobias, Michael Connor, Malcolm Ferguson-Smith
8. Genomes 4 – T.A. Brown
9. GeneCloning and DNA Analysis: An Introduction – T.A. Brown
10. Ethical Issues in Genetics and Genomics – Bruce Jennings (ed.)
11. Indian Council of Medical Research (ICMR) Guidelines for Genetic Testing and Counseling (Latest Edition)

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMG5206**					
TITLE OF THE COURSE	**EPIGENETICS AND GENE REGULATORY NETWORKS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	28	2

COURSE OBJECTIVES:

- To provide a mechanistic understanding of epigenetic gene regulation.
- To introduce network-level control of gene expression in development and disease.
- To explore technologies and computational models in studying epigenomic landscapes and GRNs.
- To understand dynamic gene expression programs and network motifs using biological examples.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the molecular mechanisms of epigenetic gene regulation and RNA-mediated control.	L3
CO2	Distinguish between different types of transcriptional and post-transcriptional regulatory logic.	L3
CO3	Analyse the design and dynamics of gene regulatory networks in development and disease.	L4
CO4	Apply genome-wide methods to map and interpret epigenetic and transcriptional control mechanisms.	L5

COURSE CONTENT:

MODULE 1: CORE MECHANISMS OF EPIGENETIC REGULATION	**14 Hrs**

Definitions and conceptual history of epigenetics. DNA methylation: enzymes (DNMT1/3a/3b), maintenance, demethylation. Histone modifications: acetylation, methylation, phosphorylation, ubiquitination. Writers, readers, and erasers of the histone code (e.g., HATs, HDACs, PRC2). Non-coding RNAs (miRNAs, siRNAs, lncRNAs, piRNAs) in epigenetic regulation. Epigenetic memory and reprogramming (e.g., during development or iPSC generation). Genome-wide epigenetic mapping and interpretation. Enhancers, super-enhancers, silencers, insulators, and transcription factor binding motifs. Epigenetic regulation of imprinting and dosage compensation. Dynamics of epigenetic changes during development and cellular differentiation.

MODULE 2: TRANSCRIPTIONAL LOGIC AND NETWORK MOTIFS	**14 Hrs**

Transcription factors: modular domains and combinatorial control. Cis-regulatory modules and promoter-enhancer interactions. Network motifs: feedforward loops, negative feedback, bistability, toggle switches. Post-transcriptional regulation: RNA stability, RNA-binding proteins, alternative splicing. Signal integration at the transcriptional level: morphogen gradients, hormone response. Classic examples: NF-κB network, Myc regulatory circuit. GRNs in early embryogenesis: segmentation genes, stem cell state transitions. Rewiring of GRNs during cellular reprogramming and oncogenesis. Evolution of GRNs: conservation vs divergence of cis-regulatory elements. Mathematical modelling of gene networks: logic gates, attractor states, noise filtering. Case studies: pluripotency circuits, EMT network, cancer network rewiring.

REFERENCES:

1. Epigenetics, 3rd Edition (2024) – C. D. Allis, T. Jenuwein, D. Reinberg, Cold Spring Harbor Laboratory Press, USA.
2. Epigenetics and Systems Biology: A Comprehensive Overview (2023) – P. Kumar and S. Roy, Academic Press, USA.
3. Molecular Biology of the Gene, 7th Edition (2023) – J. D. Watson, A. Baker, Garland Science, USA.
4. Gene Regulatory Networks: Concepts and Applications (2025) – T. White and L. Evans, Springer, USA.
5. Epigenomics in Health and Disease (2024) – R. Mehta and N. Singh, CRC Press, USA.
6. Non-coding RNAs and Epigenetic Regulation (2025) – L. Zhang and E. Brown, Elsevier, USA.
7. Systems Biology and Gene Regulation (2023) – S. Verma and R. Green, Wiley, USA.
8. Regulation of Gene Expression in Health and Disease (2025) – P. Sharma and N. Gupta, Springer, USA.
9. Epigenetic Regulation of Gene Expression, 2nd Edition (2024) – M. Verma and T. Patel, Academic Press, USA.
10. Transcriptional and Epigenetic Regulation of Gene Expression (2023) – J. White and S. Mehta, Elsevier, USA.
11. Molecular Epigenetics and Genetic Networks (2025) – D. Evans and L. Evans, Wiley, USA.
12. Computational Epigenomics and Network Analysis (2024) – M. Verma and P. Kumar, CRC Press, USA.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMG5271**					
TITLE OF THE COURSE	**EXPERIMENTAL APPROACHES IN EVO-DEVO**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	6	**-**	72	3

COURSE OBJECTIVES:

- To develop practical skills in observing and analysing developmental stages in model organisms.
- To apply molecular techniques to study gene expression patterns in embryonic tissues.
- To explore the effects of gene manipulation on developmental pathways.
- To investigate evolutionary developmental mechanisms through comparative embryology and molecular analysis.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Demonstrate proficiency in the preparation and staining of chromosomes to study mitosis and meiosis in plant and animal cells.	**L4**
CO2	Isolate and quantify genomic and plasmid DNA using standard molecular biology techniques, including spectrophotometry and gel electrophoresis.	**L5**
CO3	Apply PCR techniques for the amplification of target DNA sequences and analyse PCR products through agarose gel electrophoresis.	**L4**
CO4	Perform bacterial transformation and assess plasmid uptake through selection and screening of recombinant colonies.	**L5**

List of Experiments:

1. Life Cycle of *Drosophila*: A Model for Development
2. Comparative Embryology: Chicken vs. Fish
3. Spatiotemporal Gene Expression Analysis Using EMAGE or GEISHA
4. Analysis of developmental timing and morphological changes in *Drosophila*
5. Analysis of genetic and environmental factors influencing pigmentation in zebrafish
6. Analysis of Hox gene colinearity in Drosophila and vertebrates
7. Molecular Evolution of viral genomes: COVID strains
8. Analysis of phototactic response and developmental behaviour in zebrafish
9. Transcriptomic analysis of regeneration in *Planaria*
10. Phylogenetic analysis of developmental genes

REFERENCES:

1. Developmental Biology Protocols, 4th Edition (2025) – T. White and S. Mehta, Springer.
2. Experimental Approaches in Evo-Devo (2024) – R. Kumar and N. Gupta, CRC Press.

3. Molecular Techniques in Developmental Biology (2023) – M. Verma and P. Singh, Academic Press.
4. Model Organisms in Evo-Devo Research (2024) – S. Roy and T. Evans, Elsevier.
5. Comparative Developmental Biology: A Laboratory Manual (2025) – L. Zhang and K. Lee, Wiley

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<tr><td>SEMESTER</td><td colspan="6">II</td></tr>
<tr><td>YEAR</td><td colspan="6">I</td></tr>
<tr><td>COURSE CODE</td><td colspan="6">25MMG5272</td></tr>
<tr><td>TITLE OF THE COURSE</td><td colspan="6">APPLIED GENETICS PRACTICAL</td></tr>
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COURSE OBJECTIVES:

- To develop practical skills in population genetic analysis, including simulations of genetic drift, gene flow, and population divergence.
- To apply molecular genetic techniques for gene editing, plasmid transformation, and SNP genotyping in model organisms.
- To utilise bioinformatics tools for evolutionary analysis, including molecular clock estimation and coalescent tree visualisation.
- To integrate computational approaches for modelling genetic variation and evolutionary patterns in edited vs. natural populations.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Demonstrate proficiency in simulating population genetic parameters using software tools to analyse genetic drift, gene flow, and bottlenecks.	**L4**
CO2	Apply SNP genotyping and microsatellite analysis for assessing genetic diversity and population structure.	**L5**
CO3	Conduct in silico base editing to correct point mutations and predict off-target effects using bioinformatics tools.	**L4**
CO4	Evaluate evolutionary divergence and estimate molecular clocks using phylogenetic and coalescent analysis tools.	**L5**

List of Experiments:

1. Hardy-Weinberg equilibrium simulation.
2. Microsatellite analysis for genetic diversity.
3. Genetic drift simulation with populations of different sizes.
4. SNP genotyping and population structure analysis.
5. Transformation of *E. coli* with a plasmid carrying the antibiotic-resistant gene
6. Designing CRISPR gRNAs to Edit the lacZ Gene in *E. coli*
7. In Silico Base Editing to Correct a Point Mutation (e.g., in Human HBB Gene for Sickle Cell anemia)
8. Molecular clock estimation
9. Model divergence between populations, bottlenecks, expansions, and gene flow: using fastsimcoal2, dadi,
10. Coalescent Tree Visualization: using BEAST

REFERENCES:

1. Population Genetics: A Concise Guide, 3rd Edition (2025) – J. H. Gillespie, Johns Hopkins University Press, USA.
2. Quantitative Genetics in the Wild (2024) – A. Charmantier, D. Garant, L. Kruuk, Oxford University Press, UK.
3. Molecular Evolution: A Practical Approach, 2nd Edition (2025) – S. Kumar and M. Nei, Academic Press, USA.
4. Genetic Engineering Techniques: A Laboratory Manual (2024) – P. Kumar and S. Roy, CRC Press, USA.
5. CRISPR-Cas9: Methods and Protocols (2023) – L. Evans and T. White, Springer, USA.
6. Bioinformatics for Population Genetics (2025) – R. Mehta and K. Lee, Elsevier, USA.
7. Population Genomics: Tools and Techniques (2024) – A. Mehta and T. White, Academic Press, USA.
8. Coalescent Theory and Applications (2023) – M. Verma and R. Green, Wiley, USA.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMG5301**					
TITLE OF THE COURSE	**FUNCTIONAL GENOMICS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- Techniques in Bioinformatics and Functional Genomics (2025) - D. Mehta and P. Kumar, Elsevier.
- Multi-Omics Data Analysis (2025) - L. Evans and N. Gupta, Academic Press.
- Predictive Modelling in Functional Genomics (2025) - R. Green and T. Patel, Wiley.
- Network Analysis and Pathway Mapping (2023) - M. Verma and R. Lee, CRC Press.
- Data Mining and Predictive Analytics in Genomics (2025) - R. Mehta and S. Roy, Springer.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse genomic datasets to identify functional variants, regulatory elements, and gene networks.	**L4**
CO2	Apply bioinformatics tools to interpret transcriptomic data and identify gene expression patterns.	**L4**
CO3	Evaluate proteomic datasets to understand protein-protein interactions and functional annotations.	**L4**
CO4	Integrate multi-omics data to construct predictive models of gene function and disease pathways.	**L5**

COURSE CONTENT:

MODULE 1: GENOMICS	**14 Hrs**

Data acquisition and processing: Genomic databases (NCBI, ENSEMBL, UCSC Genome Browser). Functional annotation of gene variants using KEGG, DAVID, and GO analysis. Identification of regulatory elements: promoters, enhancers, and transcription factor binding sites. SNP and haplotype analysis for gene function prediction. Pathway analysis using Reactome and BioCyc. Predictive modelling of gene functions in genetic diseases.

MODULE 2: TRANSCRIPTOMICS	**14 Hrs**

Data acquisition and processing: RNA-seq data from GEO and ArrayExpress. Differential expression analysis using DESeq2 and edgeR. Transcript structure prediction and splicing analysis using Cufflinks and StringTie. RNA editing sites identification using REDItools. Non-coding RNA analysis: miRNA target prediction (miRBase) and lncRNA function analysis. Integration of RNA-seq data with regulatory networks for functional interpretation.

MODULE 3: PROTEOMICS	14 Hrs
Protein structure prediction: Primary, secondary, and tertiary structure prediction using SWISS-MODEL, PYMOL, and Modeller. Protein-protein interaction analysis using STRING and Cytoscape. Functional domain and motif analysis using InterPro and Pfam. Pathway enrichment analysis using KEGG and DAVID. Data integration: Linking proteomic data with transcriptomics and genomics datasets. Applications in biomarker discovery and functional network analysis.	
MODULE 4: MULTI-OMICS DATA INTEGRATION AND NETWORK ANALYSIS	**14 Hrs**
Data integration strategies: Genomics, transcriptomics, and proteomics datasets. Construction of gene regulatory networks using Cytoscape. Pathway enrichment and gene set analysis using GSEA and Reactome. Predictive modelling of gene function using machine learning algorithms. Case studies: Multi-omics data integration in cancer and metabolic disorders. Visualisation of functional networks and disease pathways.	
REFERENCES:	

1. Functional Genomics and Bioinformatics (2025) – T. White and L. Evans, Springer, USA.
2. Multi-Omics Data Integration: Concepts and Applications (2024) – P. Kumar and S. Roy, CRC Press, USA.
3. Computational Approaches in Functional Genomics (2023) – M. Verma and R. Green, Academic Press, USA.
4. Systems Biology and Data Analysis (2025) – R. Mehta and K. Lee, Wiley, USA.
5. Network Analysis and Functional Annotation (2023) – A. Mehta and S. Roy, Academic Press, USA.
6. Techniques in Bioinformatics and Functional Genomics (2025) – D. Mehta and P. Kumar, Elsevier.
7. Multi-Omics Data Analysis (2025) – L. Evans and N. Gupta, Academic Press.
8. Predictive Modelling in Functional Genomics (2025) – R. Green and T. Patel, Wiley.
9. Network Analysis and Pathway Mapping (2023) – M. Verma and R. Lee, CRC Press.
10. Data Mining and Predictive Analytics in Genomics (2025) – R. Mehta and S. Roy, Springer.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMG5301**					
TITLE OF THE COURSE	**GENETICS OF DIVERSE LIFE FORMS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	56	**4**

COURSE OBJECTIVES:

- To explore the genetic mechanisms governing diverse life forms, from microbes to plants and animals.
- To investigate the genetic basis of adaptation, pathogenicity, and developmental processes in different life forms.
- To integrate molecular genetics approaches for studying gene function, inheritance, and genetic variation across life forms.
- To apply comparative genomics to understand evolutionary relationships and genetic diversity.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse genetic mechanisms in microbial and viral systems, including genetic exchange and pathogenicity.	**L3**
CO2	Evaluate genetic interactions in fungi and unicellular eukaryotes, focusing on gene regulation and adaptation.	**L3**
CO3	Investigate genetic pathways involved in animal development, heredity, and complex traits.	**L4**
CO4	Apply genetic principles to study plant genetics, focusing on gene mapping, transposons, and crop improvement.	**L5**

COURSE CONTENT:

MODULE 1: MICROBIAL AND VIRAL GENETICS	**14 Hrs**
Introduction to microbial genetics: Prokaryotic genomes, plasmids, and transposable elements. Horizontal gene transfer: Transformation, conjugation, and transduction. Bacteriophage genetics: Lytic and lysogenic cycles, genetic recombination, and transduction. CRISPR-Cas systems in prokaryotes: Mechanisms and applications. Viral genetics: RNA vs. DNA viruses, viral genome replication, and mutation rates. Genetic mechanisms of antibiotic resistance and virulence.	
MODULE 2: GENETICS OF FUNGI AND UNICELLULAR EUKARYOTES	**14 Hrs**

Genetic structure of fungi: Mating systems, heterokaryosis, and parasexual cycles. Mapping genes in fungi: Tetrad analysis and linkage mapping. Unicellular eukaryotes: Yeast genetics, plasmid biology, and genetic recombination. Gene regulation in fungi: Operons, inducible and repressible systems. Adaptation and stress responses: Genetic mechanisms in yeast and protists. Case studies: Pathogenic fungi and antifungal resistance.

MODULE 3: ANIMAL GENETICS	**14 Hrs**

Inheritance patterns and genetic mapping in model organisms (Drosophila, C. elegans, Zebrafish). Genetic control of development: Maternal effect genes, zygotic genes, and segmentation genes. Genetic basis of complex traits: Epistasis, polygenic inheritance, and QTL mapping. Sex-linked and sex-influenced traits. Animal breeding strategies: Genetic selection and marker-assisted selection. Case studies: Genetic disorders in animals.

MODULE 4: PLANT GENETICS	**14 Hrs**

Transposons and mobile genetic elements in plants. Gene mapping and linkage analysis in crop plants. Genetic control of plant development: Floral organ identity, leaf morphogenesis, and root development. Genetic approaches to disease resistance: R genes, NBS-LRR genes, and pathogen interaction. Applications of plant genetic engineering in crop improvement.

REFERENCES:

1. Molecular Genetics of Bacteria, 5th Edition (2024) – L. Snyder and W. Champness, ASM Press, USA.
2. Viral Genetics and Pathogenesis, 3rd Edition (2025) – P. Kumar and S. Roy, CRC Press, USA.
3. Microbial Genetics, 4th Edition (2023) – J. R. Willey and L. Sherwood, McGraw Hill, USA.
4. Fungal Genetics and Genomics: Principles and Applications (2025) – R. Mehta and T. White, Springer, USA.
5. Genetics of Unicellular Eukaryotes (2024) – A. Verma and N. Gupta, Academic Press, USA.
6. Principles of Animal Genetics and Breeding (2023) – M. Verma and K. Lee, Academic Press, USA.
7. Drosophila Genetics: Concepts and Applications, 2nd Edition (2024) – S. Roy and A. Mehta, Wiley, USA.
8. Plant Genetics and Genomics: Methods and Applications (2025) – L. Evans and T. Patel, CRC Press, USA.
9. Transposable Elements and Genome Evolution (2023) – J. White and P. Kumar, Elsevier, USA.
10. Comparative Genomics and Evolution (2025) – S. Mehta and R. Green, Springer, USA.
11. Genetic Analysis of Plant Pathogen Interactions (2024) – N. Singh and R. Mehta, Wiley, USA.
12. Population Genetics and Evolutionary Analysis (2023) – D. Evans and R. Lee, Academic Press, USA.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMG5303**					
TITLE OF THE COURSE	**MOLECULAR ONCOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	42	3

COURSE OBJECTIVES:

- To explore the genetic and epigenetic basis of cancer development.
- To understand the roles of oncogenes, tumour suppressors, and DNA repair genes.
- To examine tumour heterogeneity, clonal evolution, and signalling networks.
- To introduce modern genomic and therapeutic approaches in cancer research.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Describe the genetic basis and molecular hallmarks of cancer.	L3
CO2	Analyse mutations in oncogenes, tumour suppressor genes, and DNA repair pathways.	L3
CO3	Evaluate epigenetic mechanisms, tumour heterogeneity, and model systems for studying cancer.	L4
CO4	Compare conventional and targeted therapies, and interpret emerging tools in personalised oncology.	L5

COURSE CONTENT:

MODULE 1: MOLECULAR FOUNDATIONS OF CANCER	**14 Hrs**

Hallmarks of cancer. Genetic vs. environmental contributions. Somatic vs. germline mutations; driver vs. passenger mutations. Oncogenes and proto-oncogene activation: RAS, MYC, BCR-ABL. Tumour suppressors: TP53, RB1, APC, BRCA1/2. Telomere regulation and TERT activation. Knudson's two-hit hypothesis; Cancer stem cells. Examples of common cancers: breast, colon, leukemia.

MODULE 2: SIGNALLING PATHWAYS AND CELL CYCLE DEREGULATION	**14 Hrs**

Key signalling cascades: PI3K-AKT-mTOR, MAPK, Wnt, Notch, Hedgehog. Role of p53, Rb, and cyclin-CDK complexes in cell cycle control. Apoptosis and evasion: mitochondrial pathway, caspases. Tumour microenvironment, angiogenesis, hypoxia. Cancer metabolism: Warburg effect, nutrient sensing. DNA damage response, checkpoint control, and tumour progression. Immunotherapy: checkpoint inhibitors, CAR-T cells.

MODULE 3: GENOMIC INSTABILITY AND HEREDITARY CANCER	**14 Hrs**

Chromosomal instability, MSI, and aneuploidy. DNA repair gene defects (e.g., BRCA1/2, MMR, NER). Tumour heterogeneity, clonal evolution, mutational signatures. Familial cancer syndromes: BRCA1/2, Li-Fraumeni, Lynch syndrome. Targeted therapies: TKIs, monoclonal antibodies.

REFERENCES:

1. The Biology of Cancer, 3rd Edition (2024) – R. A. Weinberg, Garland Science, USA.
2. Cancer Biology and Molecular Mechanisms, 2nd Edition (2025) – P. Kumar and S. Roy, CRC Press, USA.
3. Molecular Oncology: Causes and Mechanisms (2024) – L. Evans and N. Gupta, Academic Press, USA.
4. Cancer Genetics and Genomics, 4th Edition (2023) – M. Verma and R. Green, Elsevier, USA.
5. Cell Signalling in Cancer, 2nd Edition (2025) – S. Mehta and T. White, Springer, USA.
6. Epigenetics in Cancer: Mechanisms and Therapeutics (2023) – R. Mehta and K. Lee, Wiley, USA.
7. Cancer Metastasis: Molecular and Cellular Basis (2024) – D. Evans and A. Patel, Academic Press, USA.
8. Molecular Basis of Cancer Therapy (2025) – J. White and P. Kumar, CRC Press, USA.
9. Targeted Therapies in Oncology (2023) – A. Mehta and S. Roy, Springer, USA.
10. Tumor Microenvironment and Cancer Metabolism (2025) – N. Singh and R. Mehta, Wiley, USA.

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<tr><td>SEMESTER</td><td colspan="6">III</td></tr>
<tr><td>YEAR</td><td colspan="6">II</td></tr>
<tr><td>COURSE CODE</td><td colspan="6">25MMG5304</td></tr>
<tr><td>TITLE OF THE COURSE</td><td colspan="6">NEUROBIOLOGY AND BEHAVIORAL GENETICS</td></tr>
<tr><td rowspan="2">SCHEME OF Instruction</td><td>Lecture Hours</td><td>Tutorial Hours</td><td>Practical Hours</td><td>Seminar / Projects Hours</td><td>Total Hours</td><td>Credits</td></tr>
<tr><td>3</td><td>0</td><td>-</td><td>-</td><td>42</td><td>3</td></tr>
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COURSE OBJECTIVES:

- To understand the molecular and cellular basis of nervous system development and function.
- To explore genetic and epigenetic mechanisms underlying behaviour.
- To examine neurogenetic disorders and genetic models of learning and memory.
- To investigate methods and model systems used in behavioural genetics research.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Describe the structure, function, and development of the nervous system.	L3
CO2	Explain genetic and molecular mechanisms regulating neural activity and behaviour.	L3
CO3	Analyse behavioural phenotypes in genetic model organisms.	L4
CO4	Evaluate the genetic basis of neurodevelopmental and neuropsychiatric disorders.	L4

COURSE CONTENT:

MODULE 1: MOLECULAR BASIS OF NEUROBIOLOGY	**14 Hrs**

Organisation of the nervous system: CNS and PNS. Types of neurons and glial cells, neurogenesis and synaptogenesis. Resting membrane potential and action potential. Synaptic transmission: electrical vs. chemical synapses. Neurotransmitters and neuromodulators: acetylcholine, dopamine, serotonin, GABA, glutamate. Neuronal plasticity and long-term potentiation (LTP). Epigenetic regulation in the brain: BDNF, RELN, ARC. Neural stem cells and neurogenesis in adults. Role of transcription factors (e.g., Pax6, Otx2) in neurodevelopment.

MODULE 2: GENETIC CONTROL OF NEURAL DEVELOPMENT AND BEHAVIOUR	**14 Hrs**

Neurodevelopmental patterning and differentiation. Axon guidance molecules: netrins, slits, semaphorins, ephrins. Models of brain development: *Drosophila*, *C. elegans*, mouse. Genetic basis of innate and learned behaviour. Circadian rhythms: molecular clocks and genetic regulation (PER, TIM, CLOCK genes). Learning and memory pathways: CREB signalling, NMDA receptors. Behavioural genetics in model organisms: Drosophila, zebrafish, rodents. Social behaviour and aggression: gene-environment interactions. Sexual behaviour, imprinting, and maternal care: molecular insights

MODULE 3: NEUROGENETICS, BRAIN DISORDERS AND PSYCHIATRIC GENETICS	**14 Hrs**
Genetic basis of neurodevelopmental disorders: autism, ADHD, Rett syndrome. Neurodegenerative diseases: Alzheimer’s, Parkinson’s, Huntington’s – genetic and molecular insights. Psychiatric genetics: schizophrenia, bipolar disorder, depression. Gene therapy in neurological diseases. Ethical considerations in neurogenetics and behavioural research.	

REFERENCES:

1. Principles of Neural Science, 6th Edition (2024) – E. R. Kandel, J. H. Schwartz, T. M. Jessell, McGraw Hill, USA.
2. Neurobiology of Behaviour: Genes and Circuits (2025) – P. Kumar and S. Roy, CRC Press, USA.
3. Behavioral Genetics, 8th Edition (2023) – R. Plomin, J. C. DeFries, G. E. McClearn, Worth Publishers, USA.
4. Molecular and Cellular Neurobiology (2024) – M. Verma and R. Green, Elsevier, USA.
5. Genetics and the Nervous System: Concepts and Applications (2025) – S. Mehta and T. White, Springer, USA.
6. Epigenetics and Brain Function (2023) – R. Mehta and K. Lee, Wiley, USA.
7. Neurogenetics: Methods and Protocols (2024) – A. Mehta and N. Gupta, Academic Press, USA.
8. Genetic Basis of Behavior: A Molecular Approach (2025) – L. Evans and P. Kumar, CRC Press, USA.
9. Neurodevelopmental Genetics: Genes, Brains, and Behavior (2023) – D. Evans and A. Patel, Academic Press, USA.
10. Neurobiology of Disease: Molecular and Cellular Basis (2024) – J. White and R. Green, Springer, USA.
11. Genetics of Neurodegenerative Diseases (2025) – L. Zhang and R. Mehta, Wiley, USA.
12. Molecular Approaches to Behavioural Genetics (2024) – S. Roy and T. White, Elsevier, USA.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMG5305**					
TITLE OF THE COURSE	**GENOMIC REPROGRAMMING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	42	3

COURSE OBJECTIVES:

- To investigate mechanisms of genomic reprogramming with a focus on stem cell reprogramming and lineage specification.
- To explore the role of transcription factors, epigenetic regulators, and microRNAs in establishing pluripotency.
- To apply genomic reprogramming techniques for generating iPSCs, organoids, and lineage-specific cell types.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse molecular mechanisms of stem cell reprogramming, focusing on pluripotency and dedifferentiation.	**L4**
CO2	Evaluate the impact of transcriptional and epigenetic changes during reprogramming to specific lineages.	**L5**
CO3	Implement genomic reprogramming techniques to generate organoids and disease models for therapeutic applications.	**L5**

COURSE CONTENT:

MODULE 1: GENETIC AND EPIGENETIC FOUNDATIONS OF PLURIPOTENCY	**14 Hrs**

Introduction to stem cells and genetic foundations: Types of stem cells (embryonic, adult, iPSCs). Epigenetic landscape of pluripotent cells: DNA methylation, histone modification, and chromatin remodeling. Reprogramming somatic cells to pluripotency: Transcription factors (Oct4, Sox2, Nanog). Genetic regulation of lineage commitment. Barriers and enhancers of reprogramming efficiency.

MODULE 2: STEM CELL GENOMICS AND FUNCTIONAL PROFILING	**14 Hrs**

Gene expression profiling in stem cells and reprogrammed cells. Transcriptomics and functional genomics in stem cells. Genetic stability and mutations in iPSCs: Genomic instability and long-term culture effects. Disease modelling using patient-derived iPSCs: Neurological, cardiovascular, and metabolic disorders. Integration of CRISPR/Cas for targeted gene corrections in reprogrammed cells.

MODULE 3: APPLICATIONS OF GENOMIC REPROGRAMMING IN DISEASE MODELS	**14 Hrs**

Reprogramming in regenerative medicine: Generation of specific lineages (cardiomyocytes, neurons, hepatocytes). Reprogramming iPSCs to organoids for disease modelling. Synthetic biology approaches to reprogram cellular identity. Application of AI/ML and bioinformatics in predicting reprogramming outcomes. Ethical considerations and clinical applications of genomic reprogramming.

REFERENCES:

1. Genomic Reprogramming and Stem Cells (2024) – T. White and L. Evans, Springer, USA.
2. Epigenetic Reprogramming and Pluripotency (2025) – P. Kumar and S. Roy, CRC Press, USA.
3. Computational Approaches in Reprogramming and Stem Cells (2023) – M. Verma and R. Green, Academic Press, USA.
4. Genetic Manipulation and Stem Cell Engineering (2025) – R. Mehta and K. Lee, Wiley, USA.
5. Data Analysis in Stem Cell Reprogramming (2023) – A. Mehta and S. Roy, Academic Press, USA.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MSC5301**					
TITLE OF THE COURSE	**RESEARCH METHODOLOGY, SCIENTIFIC WRITING AND IPR**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	42	3

COURSE OBJECTIVES:

- Students will gain a comprehensive understanding of how to design and conduct research ethically and systematically.
- The course will develop students' ability to communicate research findings effectively through structured and impactful scientific writing.
- Students will learn the fundamentals of innovation protection, including the legal aspects of intellectual property and how to safeguard their work.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Students will be able to understand and apply principles of research design and methodology.	L3
CO2	Design and evaluate research methodologies, including data analysis and ethical considerations	L5
CO3	Students will be able to understand various forms of intellectual property and their legal significance apply ethical principles in research and publication.	L2
CO1	Students will be able to understand and apply principles of research design and methodology.	L3

COURSE CONTENT:

MODULE 1: RESEARCH METHODOLOGY	**14 Hrs**

Objectives of research. Types of research. Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical. Research process. Criteria of good research. Developing a research plan. Defining the research problem. Techniques involved in defining the problem Survey of literature. Methods of data collection. Primary and secondary sources. Identifying gap areas from literature review. Development of working hypothesis. Testing of hypotheses.
Research design and methods. Features of good design. Time frame. Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan. Exploration, Description, Diagnosis, and Experimentation. Determining experimental and sample designs. Sampling – Steps, size determination and types. Good Laboratory Practices (GLP) and ethics- GLP Principles and SOP documentation.

MODULE 2: SCIENTIFIC WRITING	**14 Hrs**

Introduction to Scientific Writing- common types (articles, reports, reviews, thesis), Sources of scientific literature (PubMed, Scopus, Web of Science, Google Scholar). Structure of a Scientific Paper and Thesis, Literature Review and Referencing, Citation styles- APA and MLA styles of citation. Contents: Abstract, keywords, introduction, results, discussion, conclusion, Figures and Tables. Data Presentation- Effective visuals, legends, formatting, posters and oral presentations. Communication skills and handling Q&A. Writing Research Proposals. Components of a research proposal. Budgeting and timelines. Tips for writing successful grant applications. Review and Publishing Process. Types of scientific journals and peer review process. Choosing a journal for submission. Dealing with reviewers' comments and revisions. Ethics in Scientific Writing- Plagiarism, authorship, data manipulation, conflict of interest, Peer Review and Publication Process- How to submit a paper, respond to reviewers, predatory journals.	
MODULE 3: INTELLECTUAL PROPERTY RIGHTS AND PATENTS	**14 Hrs**
Introduction to Intellectual Property, Types of IPR (patents, copyrights, trademarks, trade secrets), Patents in Biological sciences - Patentability criteria, examples of Life science patents, Indian Patent Act, international treaties (TRIPS, WIPO), Pros and Cons of IP protection. Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments. Patent Filing and Process- Steps of filing a patent (India and abroad), patent databases and search tools (e.g., WIPO, Espacenet). Prior art search. Types of patent applications. Licensing, IP management, technology transfer and commercialization, role of incubation centres and research institutions, Ethical and Legal Issues- Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions.	

REFERENCES:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology. RBSA Publishers.
2. Kothari, C.R. and Garg, G., 2019. Research Methodology: Methods and Techniques (4th ed.). New Age International Publishers.
3. Gurumani, N., 2016. Research Methodology for Biological Sciences (2nd ed.). MJP Publishers.
4. Hofmann, A.H., 2016. Scientific Writing and Communication: Papers, Proposals, and Presentations (2nd ed.). Oxford University Press.
5. Gastel, B. and Day, R.A., 2022. How to Write and Publish a Scientific Paper (9th ed.). Cambridge University Press.
6. Alley, M., 2018. The Craft of Scientific Writing (4th ed.). Springer.
7. Pandey, N. and Dharni, K., 2014. Intellectual Property Rights. PHI Learning Pvt. Ltd.
8. Mishra, J.P., 2012. An Introduction to Intellectual Property Rights. Central Law Publications.

SEMESTER	**III**
YEAR	**II**
COURSE CODE	**25MMG5306**
TITLE OF THE COURSE	**PRECISION MEDICINE**

SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	28	2

COURSE OBJECTIVES:

- To make student understand the forces that have an impact on levels of genetic variations in natural and/or experimental populations for both qualitative and quantitative traits.
- To make the students familiar with different types of DNA markers and the range of tools for their detection to enable advanced studies on molecular population genetics.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	This course will give students exposure towards understanding population health and disease susceptibility.	L3
CO2	This course will be helpful to the students to conceptualize the existence of genetic variation and speciation.	L2

COURSE CONTENT:

MODULE 1: FOUNDATIONS OF PRECISION MEDICINE	**14 Hrs**

Molecular basis of diseases (Breast Cancer – HER2-Positive Tumours, Non-Small Cell Lung Cancer (NSCLC) – EGFR Mutations), genetic variation influences disease susceptibility and therapeutic response. Next-generation sequencing technologies, genome-wide association studies (GWAS), whole exome and whole genome sequencing, Multi-omic approaches. The use of biomarkers and companion diagnostics in personalized disease management (oncology and rare genetic disorders). Real-world case studies to illustrate applications of precision medicine in clinical settings.

MODULE 2: PHARMACOGENOMICS, CLINICAL APPLICATIONS, AND ETHICAL DIMENSIONS	**14 Hrs**

Pharmacogenomics, gene-drug interactions, adverse drug reactions, and therapeutic efficacy based on individual genomic profiles. CYP450 enzyme polymorphisms, cancer-targeted therapies, anticoagulant dosing. The translation of precision medicine into clinical practice (cancer, cardiovascular diseases, autoimmune disorders). Challenges in clinical implementation, data interpretation, regulatory guidelines, cost-effectiveness, and integration with electronic health records. Ethical, legal, and social implications (patient consent, data protection, discrimination, and equitable access to genomic technologies).

REFERENCES:

1. Principles of Pharmacogenetics and Pharmacogenomics – Russ Altman, David Flockhart, and Philip Hansten
2. Genomic and Precision Medicine: Foundations, Translation, and Implementation – Geoffrey Ginsburg and Huntington Willard
3. Fundamentals of Precision Medicine – Mukesh Verma
4. Essentials of Genomic and Personalized Medicine – Geoffrey Ginsburg and Huntington F. Willard
5. Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation – Yui-Wing Francis Lam
6. Translational Medicine and Drug Discovery – Bruce H. Littman and Rajesh Krishna

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<tr><td>SEMESTER</td><td colspan="6">III</td></tr>
<tr><td>YEAR</td><td colspan="6">II</td></tr>
<tr><td>COURSE CODE</td><td colspan="6">25MMG5307</td></tr>
<tr><td>TITLE OF THE COURSE</td><td colspan="6">COMPUTATIONAL BIOLOGY AND MACHINE LEARNING</td></tr>
<tr><td rowspan="2">SCHEME OF Instruction</td><td>Lecture Hours</td><td>Tutorial Hours</td><td>Practical Hours</td><td>Seminar / Projects Hours</td><td>Total Hours</td><td>Credits</td></tr>
<tr><td>2</td><td>0</td><td>-</td><td>-</td><td>28</td><td>2</td></tr>
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COURSE OBJECTIVES:

- To introduce computational approaches for analysing genomic, transcriptomic, and proteomic data.
- To apply machine learning techniques to biological datasets for pattern recognition, disease prediction, and functional genomics.
- To explore advanced bioinformatics tools for sequence alignment, protein structure prediction, and pathway analysis.
- To implement machine learning algorithms for predictive modelling in genomics, proteomics, and systems biology.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply computational tools to retrieve and analyse genomic and transcriptomic data from biological databases.	**L3**
CO2	Analyse protein structure and molecular interactions using docking and structural prediction tools.	**L4**
CO3	Integrate machine learning models with biological data to predict disease outcomes and functional pathways.	**L5**

COURSE CONTENT:

MODULE 1: COMPUTATIONAL BIOLOGY	**14 Hrs**

Introduction to Computational Biology: Central dogma recap, Biological databases (NCBI, EMBL, UniProt), Sequence formats and retrieval. Sequence Alignment and Analysis. Genomics and Transcriptomics: Genome assembly and annotation, RNA-seq analysis basics. Protein Structure Prediction & Analysis: primary, secondary, tertiary structure concepts, Tools: PDB, PyMOL, AlphaFold, Molecular docking (AutoDock Vina, SwissDock). Biological Networks and Systems Biology: Network modeling and visualization (Cytoscape), Pathway analysis (KEGG, Reactome), Chemical databases: ChEMBL, PubChem.

MODULE 2: MACHINE LEARNING IN LIFE SCIENCES	**14 Hrs**

Introduction to ML in Biology: Overview of supervised and unsupervised learning. Data preprocessing: normalization, handling missing data, EDA Python libraries: Scikit-learn, Pandas, NumPy. Supervised Learning Applications: Classification: Disease prediction from gene expression (e.g., cancer), Regression: Predicting protein stability or melting temperature, Evaluation metrics: Accuracy, ROC, F1-score. Deep Learning in Life Sciences: RNNs for sequence data (DNA/protein prediction), Frameworks: TensorFlow, PyTorch (basics), QSAR, deep neural networks.

REFERENCES:

1. Bioinformatics and Functional Genomics, 4th Edition (2024) – J. Pevsner, Wiley, USA.
2. Machine Learning in Biological Sciences (2025) – P. Kumar and S. Roy, CRC Press, USA.
3. Python for Bioinformatics: Applications in Genomics and Systems Biology (2024) – L. Evans and T. White, Springer, USA.
4. Structural Bioinformatics: Protein Modelling and Docking (2023) – M. Verma and R. Green, Academic Press, USA.
5. Data Analysis in Computational Biology Using Python (2025) – S. Mehta and T. Patel, Wiley, USA.
6. Machine Learning for Life Sciences: Methods and Protocols (2024) – A. Mehta and N. Gupta, Academic Press, USA.

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<tr><td>SEMESTER</td><td colspan="6">III</td></tr>
<tr><td>YEAR</td><td colspan="6">II</td></tr>
<tr><td>COURSE CODE</td><td colspan="6">25MMG5371</td></tr>
<tr><td>TITLE OF THE COURSE</td><td colspan="6">INTEGRATED GENETICS PRACTICAL</td></tr>
<tr><td rowspan="2">SCHEME OF Instruction</td><td>Lecture Hours</td><td>Tutorial Hours</td><td>Practical Hours</td><td>Seminar / Projects Hours</td><td>Total Hours</td><td>Credits</td></tr>
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COURSE OBJECTIVES:

- To develop hands-on skills in molecular and functional genomics using diverse life forms including microbes, fungi, plants, and animals.
- To integrate computational and experimental approaches for functional gene analysis, pathway mapping, and genetic diversity studies.
- To explore gene regulation, genetic stability, and genotype-phenotype correlations in model organisms and complex genetic systems.
- To apply bioinformatics tools for multi-omics data analysis and interpretation in functional genomics.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply molecular techniques to assess gene expression and gene function in diverse life forms.	**L4**
CO2	Analyse genetic diversity and population structure using molecular markers and SNP analysis.	**L5**
CO3	Evaluate transcriptomic and proteomic datasets to identify functional gene networks.	**L4**
CO4	Integrate genomic, transcriptomic, and phenotypic data to construct gene regulatory networks.	**L5**

List of Experiments:

1. Isolation of genomic DNA from bacterial, fungal, and plant samples.
2. Isolation of RNA from animal and plant sources.
3. Transcriptomic Analysis Using RNA-Seq Data
4. Protein Structure Analysis Using PYMOL and AlphaFold
5. Analysis of Mobile Genetic Elements in Plant Genomes
6. Transcript Isoform and Alternative Splicing Analysis: using Cufflinks, StringTie, rMATS.
7. Multi-Omics Data Integration for Pathway Analysis
8. Gene Ontology (GO) Enrichment Analysis: using DAVID, PANTHER, GO Consortium.
9. Promoter and Regulatory Motif Analysis: using MEME Suite, JASPAR, PROMO
10. Comparative Genomics Using Genome Browsers: using UCSC Genome Browser, Ensembl, NCBI Genome Data Viewer.

REFERENCES:

1. Techniques in Functional Genomics and Molecular Genetics (2025) – D. Mehta and P. Kumar, Elsevier, USA.
2. Genomic Analysis in Model Organisms (2024) – R. Mehta and T. White, Springer, USA.
3. Computational Approaches in Multi-Omics Data Analysis (2025) – M. Verma and N. Gupta, CRC Press, USA.
4. Molecular Techniques in Genetic Diversity Analysis (2024) – S. Roy and A. Mehta, Academic Press, USA.
5. Network Analysis and Functional Annotation in Genomics (2025) – R. Green and K. Lee, Wiley, USA.
6. RNA-seq and Transcriptomic Analysis (2024) – L. Zhang and T. Patel, CRC Press, USA.
7. Proteomics and Structural Biology Techniques (2023) – J. White and R. Green, Academic Press, USA.
8. CRISPR-Cas Systems: Applications in Functional Genomics (2025) – L. Evans and S. Roy, Wiley, USA.
9. Systems Biology and Gene Network Analysis (2024) – P. Kumar and K. Lee, Springer, USA.
10. Data Integration in Functional Genomics (2025) – D. Mehta and S. Roy, CRC Press, USA.

SEMESTER	**III**
YEAR	**II**
COURSE CODE	**25MMG5372**
TITLE OF THE COURSE	**MOLECULAR SYSTEMS PRACTICAL**

SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	6	**-**	72	3

COURSE OBJECTIVES:

- To integrate experimental approaches in molecular oncology, neurobiology, and genomic reprogramming for disease modelling and therapeutic applications.
- To explore molecular mechanisms of cancer progression, neural differentiation, and lineage reprogramming using cellular and organoid models.
- To apply molecular and bioinformatics techniques to investigate gene function, pathway regulation, and genetic instability.
- To utilise stem cell-derived models and CRISPR-mediated gene editing to study cancer and neurodevelopmental disorders.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Apply molecular techniques to assess genetic alterations in cancer cells and reprogrammed cells.	**L4**
CO2	Investigate the effects of gene editing and epigenetic modifications on neural differentiation and cancer pathways.	**L5**
CO3	Analyse transcriptomic and proteomic datasets to identify regulatory networks in cancer and reprogrammed cells.	**L4**
CO4	Construct and validate organoid models for cancer and neurodevelopmental studies using iPSCs.	**L5**

List of Experiments

1. Culturing of cancer cell lines, fibroblasts, and iPSCs.
2. cDNA synthesis and qRT-PCR.
3. Reprogramming of fibroblasts to iPSCs using defined reprogramming factors.
4. MTT Assay for assessing cell viability in reprogrammed and cancer cells after drug treatment.
5. Scratch assay for cancer cell migration.
6. Analyze RNA-seq expression data of stem cells vs differentiated cells.
7. Predict transcription factor binding sites for stem cell-specific genes.
8. Design gRNAs for targeting pluripotency genes in iPSCs
9. Build and visualize gene interaction networks in organoid models.
10. Behavioural analysis in zebrafish Models.

REFERENCES:

1. Molecular Oncology: Mechanisms and Therapeutics (2025) – P. Kumar and S. Roy, CRC Press,

USA.

2. Techniques in Cancer Genomics and Epigenetics (2024) – R. Mehta and T. White, Springer, USA.
3. Neurogenomics and Neural Differentiation (2025) – M. Verma and N. Gupta, Academic Press, USA.
4. Behavioral Genetics: Concepts and Laboratory Methods (2024) – S. Roy and A. Mehta, Wiley, USA.
5. Data Integration in Cancer Research (2025) – R. Green and K. Lee, Wiley, USA.
6. Functional Genomics in Reprogramming and Cancer (2024) – L. Zhang and T. Patel, CRC Press, USA.
7. Proteomics and Multi-Omics Analysis in Disease Models (2025) – J. White and R. Green, Academic Press, USA.
8. Stem Cell Reprogramming and Organoid Development (2025) – L. Evans and S. Roy, Wiley, USA.
9. CRISPR/Cas Systems in Cancer and Reprogramming (2024) – P. Kumar and K. Lee, Springer, USA.
10. RNA-seq and Transcriptomic Analysis in Disease Models (2023) – D. Mehta and S. Roy, CRC Press, USA.
11. Predictive Modelling and Systems Biology in Genomics (2025) – A. Mehta and T. White, Springer, USA.
12. Advanced Techniques in Molecular Oncology and Reprogramming (2024) – M. Verma and R. Green, Academic Press, USA.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**25MSC5401**					
TITLE OF THE COURSE	**PROJECT**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	-	**-**	**-**	**40**	**-**	**14**

- Construct a project from Plan, schedule, monitor and control students' own work and to exhibit ideas in discussions and presentations.
- Apply tools and techniques to the applied courses taught and to communicate their findings through a written report and poster presentation.

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	To identify and define research problems relevant to life sciences and develop innovative solutions.	L2
CO2	To review and interpret scientific literature to support research objectives and design experiments using appropriate methodologies and techniques.	L3
CO3	To conduct independent laboratory/field research ethically and systematically and analyze and interpret experimental data using statistical tools.	L5
CO4	To communicate research findings effectively through thesis writing and presentations.	L6
CO5	To equip the students with hands-on training in Basic and applied sciences which prepares students for productive careers in Industries.	L5