



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Biotechnology

Subject Code: BE05004011

Subject Name: Molecular Biology and Genetics

w. e. f. Academic Year:	2024-2025
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	Microbiology Biochemistry
Rationale:	Molecular Biology and Genetics explore the molecular basis of life, focusing on genes, DNA, and the mechanisms of inheritance. This subject helps students understand how genetic information controls cellular functions and variation, forming the foundation for advances in medicine, biotechnology, and research.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Understand the mechanism of central dogma of molecular biology	25
CO-2	Explain the molecular mechanisms of gene expression, control, and regulation	25
CO-3	Comprehend the concept of Mendelian inheritance and deviations from Mendelism	25
CO-4	Describe the basics of human molecular genetics and evolutionary genetics	25

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/ CA (I)	PBL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200

Content:

Sr. No.	Content	Total Hrs
1	Genes in Action DNA as the genetic material: structure and organization of genes, DNA, and chromosomes. Chromatin structure and epigenetic regulation: histone modifications, chromatin remodeling complexes, and DNA methylation. DNA replication: detailed mechanism (leading and lagging strand synthesis), role of enzymes (DNA polymerases, helicases, topoisomerases), topological constraints during replication, end-replication problem and telomerase function. DNA mutations: types of mutations (point mutations, insertions, deletions), mechanisms of DNA damage, and various DNA repair pathways (base excision repair, nucleotide excision repair, mismatch repair, double-strand break	10



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	repair via homologous recombination and non-homologous end joining). Mobile genetic elements: structure and function of transposons and retrotransposons.	
2	Genes to Proteins Transcription: initiation, elongation, and termination mechanisms; regulation of transcription via transcription factors and regulatory elements (promoters, enhancers, silencers). RNA processing: 5' capping, polyadenylation, splicing mechanisms, alternative splicing and its role in proteome diversity, RNA editing. Genetic code: features, universality, degeneracy. Translation: mechanisms involving tRNA, ribosomes, translation initiation, elongation, and termination; control and regulation of translation (e.g., via upstream ORFs, miRNAs). Post-translational modifications: phosphorylation, glycosylation, ubiquitination, and their biological roles. Advanced regulation of gene expression: epigenetic control, RNA interference (RNAi), microRNAs and long non-coding RNAs (lncRNAs).	10
3	Mendelism and Chromosomal Theory Classical genetics: Principles of inheritance, Mendelian ratios, extensions and deviations from Mendelism (incomplete dominance, co-dominance, multiple alleles, polygenic inheritance). Chromosomal theory of inheritance: evidence from linkage and recombination studies. Linkage analysis and gene mapping: genetic distance, recombination frequency, two-point and three-point test crosses, construction of genetic linkage maps. Sex linkage and sex-limited traits. Pedigree analysis for tracing inheritance patterns in humans. Mutation types: somatic, germline, spontaneous, and induced mutations. Extranuclear inheritance: mitochondrial and chloroplast DNA inheritance, maternal effects.	05
4	Human Molecular Genetics and Evolutionary Genetics Human genetic diseases: single-gene disorders, multifactorial diseases, chromosomal abnormalities. Human gene therapy: approaches (somatic vs. germline), methods of delivery (viral and non-viral vectors), ethical issues. DNA fingerprinting/profiling and forensic applications. Population genetics: Hardy-Weinberg equilibrium, forces affecting allele frequencies (mutation, selection, genetic drift, migration). Molecular evolution: patterns and processes, molecular clocks, neutral theory. Speciation: genetic basis, pre-zygotic and post-zygotic barriers. Comparative genomics: genome organization across species and insights into evolution and function.	10
5	Plant Molecular Genetics: Life cycle of plants: alternation of generations, importance in genetic manipulation. Techniques of plant transformation: Agrobacterium-mediated transformation, biolistic (gene gun) methods, genome editing techniques (CRISPR-Cas9, TALENs, ZFNs). Plant defense responses: molecular mechanisms underlying biotic (pathogens) and abiotic (drought, salinity) stress responses. Gene regulation in plants: transcriptional control, epigenetics, and hormone signaling pathways. Advanced plant biotechnology: development of stress-tolerant, pest-resistant, and high-yield crops. Molecular breeding approaches: marker-assisted selection (MAS), genomic selection	10
TOTAL		45



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Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	20	20	20	10	10

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

The syllabus of Advanced Power Electronics directly contributes to

SDG 3	The syllabus contributes to understanding genetic disorders, molecular diagnostics, gene therapy, and genome editing technologies for improved disease prevention, diagnosis, and treatment.
SDG 2	Plant molecular genetics and genome editing techniques contribute to the development of stress-tolerant, pest-resistant, and high-yield crops for food security.
SDG 4	The subject strengthens scientific literacy and interdisciplinary learning by integrating genetics, molecular biology, genomics, and biotechnology concepts.
SDG 9	Molecular biology and genetics support innovation in gene editing, molecular diagnostics, recombinant technologies, and biotechnology industries.
SDG 12	Advanced molecular tools enable sustainable crop development and efficient biotechnological production systems with reduced environmental impact.
SDG 15	Molecular genetics and plant biotechnology contribute to biodiversity conservation, crop improvement, and sustainable ecosystem management.

Reference Books:

1. Bruce Alberts, Molecular Biology of the Cell, Garland Science, 2014, 6th Edition
2. D. Peter Snustad, Michael J. Simmons, Principles of Genetics, Wiley, 2016, 7th Edition
3. Benjamin A Pierce, Genetics A conceptual approach, W. H. Freeman and Co, 2017, 6th Edition.
4. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, Pearson Education, 2017, 7th Edition
5. Strickberger M.W., Genetics, Prentice Hall India, 2008, 3rd Edition
6. Robert H. Tamarin, Principles of genetics, McGraw-Hill Company, 2001, 7th Edition

List of Experiments / Practical Demonstrations

1. Isolation, Quantification, and Visualization of Genomic DNA
2. Polymerase Chain Reaction (PCR) Amplification of a Target Gene
3. Restriction Digestion and Analysis of DNA Fragments
4. Bacterial Transformation Using Recombinant Plasmid DNA
5. Protein Extraction and SDS-PAGE Analysis



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6. Study of Gene Expression Using β -Galactosidase (Lac Operon) Assay
7. Blood Group Inheritance Study in Humans.

Major Equipment

1. Micropipettes and Tips
2. Centrifuge (Refrigerated and Bench-top)
3. PCR Thermocycler
4. Gel Electrophoresis Unit and Power Supply
5. UV Transilluminator or Gel Documentation System
6. Spectrophotometer or NanoDrop

Open-Source Software / Learning Websites

1. NCBI (National Center for Biotechnology Information) – <https://www.ncbi.nlm.nih.gov>
2. EMBL-EBI (European Bioinformatics Institute) – <https://www.ebi.ac.uk>
3. Khan Academy – Biology & Genetics Modules – <https://www.khanacademy.org>
4. HHMI Biointeractive – <https://www.biointeractive.org>
5. MIT OpenCourseWare – Molecular Biology Courses – <https://ocw.mit.edu>
6. Coursera – Genetics and Genomics Courses – <https://www.coursera.org>
7. OpenWetWare – <https://openwetware.org> (for lab protocols and experiments)

List of suggested activities for Project Based Learning (PBL):

Sr. No.	PBL Category	Name of the Activity	No. of Hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Visit to molecular biology laboratory / genomics research institute / genetic diagnostic center / biotechnology company	Visit = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Based on report submitted. Report should contain observations on PCR, DNA sequencing, molecular diagnostics, gene expression studies, and genetic analysis techniques.
2	Video Based Learning	Technical video-based learning related to DNA replication, transcription, translation, gene regulation, CRISPR-Cas9, molecular genetics, and plant molecular biology (MOOC/NPTEL Video)	Duration of video = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Report/presentation based on video learning outcomes and understanding of molecular biology and genetics concepts.
3	Assignment / Technical Writing / Research	Numerical and theory-based assignments related to DNA replication, gene	5 assignments of 2 hrs each Total = 10 hrs	Based on assignment submitted, scientific understanding, interpretation, and technical depth.



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	Writing	expression, Mendelian inheritance, pedigree analysis, gene mapping, and molecular genetics		
4	Complex Problem-Solving targeting relevant SDGs / Mini Project	Comparative analysis of gene editing approaches (CRISPR-Cas9, TALENs, ZFNs) or inheritance pattern analysis of a genetic disorder	15 hrs	Based on problem-solving ability, scientific understanding, innovation, and technical feasibility.
5	Research Paper Review / Analysis	Discussion on research paper related to molecular genetics, gene therapy, DNA repair, epigenetics, genome editing, or plant molecular biotechnology (SCOPUS Indexed / reputed Journal)	5 research papers = 20 hrs	Summarize research paper and evaluate critical scientific parameters and advancements.
6	Poster / Chart / PowerPoint Presentation	Poster/chart/power point preparation on topics such as Central Dogma, DNA Replication, Gene Expression, CRISPR-Cas9, Human Genetic Disorders, Plant Molecular Genetics	Duration = 6 hrs	Based on poster/chart preparation, scientific understanding, technical depth, and presentation skills.
7	Micro Project / Mini Project	Working/non-working model of DNA structure, PCR workflow, gene expression mechanism, pedigree analysis, or plant transformation system	5 hrs 10 hrs	Based on internal/external evaluation, innovation, scientific understanding, and technical relevance.
8	Group Discussion / Quiz / Simulation	Group discussion on emerging topics such as Genome Editing, Personalized Medicine, Epigenetics, Synthetic Biology, and Molecular	Duration = 1 hr each	Based on participation, scientific understanding, technical knowledge, and communication skills.



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		Diagnostics		
9	Case Study / Analysis / Seminar	Real-world case study on human genetic disorders, gene therapy, forensic DNA fingerprinting, or plant genetic improvement	Data collection/study = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Based on in-depth scientific study, technical depth, fact-finding, and conclusions.
10	Other	Patent Search and Innovation Gap Identification in gene therapy, CRISPR technology, molecular diagnostics, or plant genome engineering	10 hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. Mini Project – 10 Marks , Micro Project – 5 Marks
2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
