MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

(Formerly West Bengal University of Technology)

Syllabus of B.Sc. in Genetics

SIXTH SEMESTER

Sl.	Subject Type	Code	Subject Name	Credits			Total Credits
				L	T	P	
1.	DSC	BMGN 6301	Human Molecular Genetics	3	1	0	4
2.		BMGN 6302	Developmental Genetics	4	1	0	5
3.		BMGN 6303 BMGN 6393	Plant Molecular Genetics	3	0	2	5
4.	DSE	MIC601	Web Development with HTML and CSS	3	1	0	4
5.		MIC602A/B	Internet and Networking /ERP	3	1	0	4
Total Credit							22

Course Name: Human Molecular Genetics **Code: BMGN 6301**

Credits: 4 **Total hours: 60**

Aim of the Course: To develop an understanding of molecular pathology by interpreting mutation nomenclature, functional consequences of mutations, and mechanisms linking genes to diseases.

Course objectives: To develop the ability to analyze and interpret genetic mapping, disease gene identification, complex trait susceptibility, and molecular pathology for understanding the genetic basis of human diseases.

Sl	Graduate attributes	Mapped modules
CO1	To apply genetic mapping tools, including recombinants, markers, and fine mapping, for analyzing inheritance patterns of Mendelian traits.	M1

CO2	To employ strategies such as positional cloning and chromosomal analysis to identify, validate, and characterize human disease genes.	M2
CO3	To evaluate genetic susceptibility to complex diseases using family-based studies, linkage analysis, and association approaches.	M3
CO4	To interpret mutation nomenclature, assess functional consequences of mutations, and link genetic alterations to disease mechanisms.	M4

Learning outcome: Students will be able to apply genetic mapping techniques to study Mendelian and complex traits, identify human disease genes through modern strategies, and interpret molecular pathology by linking mutations to disease mechanisms. This will equip them with analytical and research skills essential for understanding the genetic basis of human diseases.

Module Number	**Content**	**Total hours**	**% of questions**	**Bloom level (applicable)**	**Remarks, if any**
THEORY					
M1	Genetic Mapping of Mendelian Characters	**13**	**29%**	**2,3**	**NA**
M2	Identifying Human Disease Genes	**9**	**20%**	**3**	**NA**
M3	Mapping and Identifying Genes	**12**	**27%**	**3**	**NA**
M4	Molecular Pathology	**11**	**24%**	**3**	**NA**
Total Theory		**45**	**100**		
Tutorial		**15**			
TOTAL		**60**			

Detailed Syllabus

Module 1:

Genetic Mapping of Mendelian Characters: Recombinants, Non-recombinants, Genetic markers, two-point mapping - LOD score analysis, Multipoint mapping, Homozygosity mapping, Fine mapping using extended pedigrees and ancestral haplotypes.

(Total Hours: 13)

Module 2:

Identifying Human Disease Genes: Principles and strategies in identifying disease genes, Position-independent and positional cloning, Use of chromosomal abnormalities, Confirming a candidate gene: mutation screening, testing in animal models, various ways of identifying disease genes, Whole Genome and Exome Sequencing

(Total Hours: 9)

Module 3:

Mapping and Identifying Genes: Genes conferring susceptibility to complex diseases: Deciding whether a non-Mendelian character is genetic: the role of family, twin and adoption studies, Linkage analysis of complex characters, Association studies and linkage disequilibrium, Identifying the susceptibility alleles, Examples that illustrate the varying success of genetic dissection of complex diseases

(Total Hours: 12)

Module 4:

Molecular Pathology: Rules for nomenclature of mutations & databases of mutations, Loss of function mutations, Gain of function mutations, Molecular pathology from gene to disease, Instability of the human genome: Pathogenicity associated with repeat sequences, Molecular pathology from disease to gene, Molecular pathology of chromosomal disorders.

(Total Hours: 11)

TUTORIAL

Credit: 1 **Total Hours: 15**

(The principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. GFP Cloning
2. Southern Hybridization.
3. PCR Application: Single Nucleotide Polymorphism (SNP)
4. DNA Fingerprinting (Using RAPD techniques)
5. Seminar on different related topics
6. Assignments

Suggested Readings

1. Strachan & Read (2011). Human Molecular Genetics. Garland Edition. 4th Edition.
2. Pasternak (2005). An Introduction to Molecular Human Genetics.Fritzgerald. 2ndEdiition.
3. Mange and Mange (1999). Basic Human Genetics.Sinauer Assoc. 2nd Edition.
4. Lewis (2007). Human Genetics. WCB & McGraw. 7th Edition.
5. Sudbery (2010). Human Molecular Genetics. Prentice-Hall. 3rd Edition.
6. Davies (1993). Human Genetic Disease Analysis. 2nd Edition. IRL
7. Haines &Pericak (2006). Approaches to Gene Mapping in Complex Human Diseases. Wiley
8. Nussbaum et al (2015). Genetics in Medicine. Saunders. 8th Edition.
9. Rimoin et al (2013). Principles & Practice of Medical Genetics, Vol I-III. Churchill .6th edition

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Course Name: Developmental Genetics **Code: BMGN6302**

Credits: 4+1 **Total hours: 45**

Aim of the course: To unravel the intricate journey from a single cell to a complex, multicellular organism.

Course objectives:

Students will be able to analyze and interpret the mechanisms of cell fate specification, pattern formation, and morphogenesis, and apply this knowledge to contemporary challenges in regenerative medicine, evolutionary biology, and disease etiology.

Sl	Graduate attributes	Mapped modules
CO1	Explain how multicellular organisms form from a single cell zygote, integrating genetic, cellular, and molecular factors.	M1
CO2	Critically appraise fertilization, cleavage, gastrulation, and the mechanisms that guide embryogenesis across model organisms.	M2
CO3	Evaluate processes such as pattern formation, morphogenesis, organ and tissue differentiation, supported by experimental evidence from vertebrates and invertebrates.	M3, M4
CO4	Describe major post-embryonic processes, including metamorphosis, regeneration, and aging, and their implications for biology and medicine.	M5
CO5	Critically assess how genetic mutations and environmental agents (e.g., teratogens) impact development and contribute to developmental disorders.	M6
CO6	Illustrate the significance of stem cell biology, therapeutic applications, and bioethical considerations in developmental genetics and modern research.	M7

Learning outcome:

The course in developmental biology equips students with a deep understanding of how multicellular organisms develop from a single cell, integrating concepts of genetics, molecular signaling, and embryological processes. Learners gain analytical skills to investigate and explain key events such as fertilization, gastrulation, tissue differentiation, and organ formation across a spectrum of animal models. Through exposure to topics including pattern formation, regeneration, stem cell biology, and metamorphosis, students develop the ability to critically assess both normal and abnormal development, including the impact of genetic mutations and environmental factors. The course also prepares students to explore contemporary challenges and advances, such as therapeutic applications, bioethical dilemmas, and the implications of genome editing, fostering the scientific reasoning necessary for research and lifelong learning in modern biology

Module Number	Content	Total hours	% of questions	Bloom level (applicable)	Remarks, if any
THEORY					
M1	The Foundation: Principles and Modern Tools of Developmental Biology	**08**	**18%**	**2,3,4**	**NA**
M2	Gametogenesis, fertilization, and early development	**06**	**13%**	**3,4**	**NA**
M3	Morphogenesis and organogenesis in animals	**06**	**13%**	**3,4,5**	**NA**
M4	Morphogenesis and organogenesis in plants	**06**	**13%**	**3,4**	**NA**
M5	Post-Embryonic Development and Metamorphosis	**06**	**13%**	**2,3,4**	**NA**
M6	Stem Cells, Cell Death, and Adult Tissue Maintenance	**06**	**13%**	**3,4**	**NA**
M7	Developmental Genetics, Bioethics, Biosafety, and IPR	**07**	**17%**	**3,4,5,6**	**NA**
Total Theory		**45**	**100**		

Detailed Syllabus

Module 1:

The Foundation: Principles and Modern Tools of Developmental Biology; Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development

(Total hours: 4)

Module 2:

Gametogenesis, fertilization, and early development: 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.

(Total hours: 6)

Module 3:

Morphogenesis and organogenesis in animals PCR: Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

(Total hours: 6)

Module 4:

Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*

(Total hours: 6)

Module 5:

Post-Embryonic Development and Metamorphosis: Metamorphosis: hormonal regulation in amphibians and insects., Regeneration types: epimorphosis, morphallaxis, Aging and tissue repair mechanisms, Environmental influence and teratogenesis (malformations, disruptions).

Module 6:

Stem Cells, Cell Death, and Adult Tissue Maintenance: Embryonic and adult stem cells, Programmed cell death, apoptosis, Cell renewal and tissue regeneration, Therapeutic cloning potentials.

(Total hours: 6)

Module 7:

Developmental Genetics, Bioethics, Biosafety, and IPR: Molecular basis of genetic diseases and developmental disorders, CRISPR-Cas9 and genome editing approaches, Bioethical considerations in developmental biology research, Biosafety protocols, and intellectual property regulations pertinent to developmental genetics research.

(Total hours: 6)

Suggested Readings

1. Developmental Biology by Scott F. Gilbert (widely considered the gold standard textbook covering comprehensive molecular, cellular, and genetic aspects of development).
2. Principles of Development by Lewis Wolpert and Cheryll Tickle (a classic book emphasizing developmental principles and pattern formation).
3. An Introduction to Developmental Biology by Sanjib Chattopadhyay (a lucid, illustrated undergraduate-level book covering basic to advanced developmental biology topics).
4. Developmental Biology by Dr. M.A. Subramanian (a concise, well-illustrated text for fundamental concepts).
5. Developmental Biology by Vinita Shukal and K.V. Sastry (covers fundamentals with clear explanations suitable for students).
6. A Textbook of Embryology (Developmental Zoology) by N. Arumugam (for detailed embryology and developmental zoology).

Course Name: Plant Molecular Genetics **Code: BMGN 6303**

Credits: 3 **Total hours: 45**

Aim of the course: To acquaint students with basics of Plant Molecular Genetics

Course objectives: To impart the knowledge about different genetic molecular tools and application in plants

Sl	Graduate attributes	Mapped modules
COl	To acquire comprehensive knowledge of Gene that regulates the plant physiology	Ml
CO2	To develop technical proficiency in Gene that regulates Plant development	M2
CO3	To demonstrate proficiency in Genetic modification in Plant	M3
CO4	To gain analytical competence in Genetics in Breeding	M4
CO5	To gain application of molecular Genetics in plant Breeding	M5

Learning outcome

The candidates should demonstrate the structure, organization, and function of plant genomes, including nuclear, chloroplast, and mitochondrial DNA, and describe the molecular mechanisms governing gene expression, regulation, and epigenetic modifications in plants. Learners will also develop skills in designing gene cloning strategies, utilizing plant expression vectors, and performing genetic transformation through both Agrobacterium-mediated and direct gene transfer methods. They will be able to evaluate the role of molecular genetics in plant breeding and crop improvement.

Module Number	**Content**	**Total hours**	**% of questions**	**Bloom level (applicable)**	**Remarks, if any**
THEORY					
Ml		**12**	**26%**	**2,3**	**NA**
M2	Gene regulates Plant development	**12**	**24%**	**3,4**	**NA**
M3	Genetic modification in Plant	**8**	**18%**	**3,4**	**NA**

M4	Genetics in Breeding	**8**	**18%**	**3,4**	**NA**
M5	Application of Genetics in Breeding	**5**	**14%**	**2,3**	**NA**
Total Theory		**45**	**100**		

Detailed syllabus

Module 1:

Plant Gene regulation: Skotomorphogenesis and photomorphogenesis; Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants. Abiotic Stress Responses: Salt, Cold, Heat and Drought. Biotic Stress Responses. Molecular mechanism of PCD in plants, Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants; Differences and similarities in PCD and senescence.

(Total Hours: 12)

Module 2:

Gene regulates Plant development: Molecular genetics of floral development and floral organ differentiation, ABC Model of Floral Development, Hormone signal perception, transduction and regulation of gene expression during plant development; Role of mutants in understanding hormone action; Hormonal control of seed development; Seed maturation and dormancy; Hormonal control of seed germination and seedling growth; Mobilization of food reserves during seed germination.

(Total Hours: 12)

Module 3:

Genetic modification in Plant: Methods of plant transformation; Types of Vectors for plant transformation; Genetic and molecular analyses of transgenics; Target traits and transgenic crops; Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement.

(Total Hours: 8)

Module 4:

Genetics in Breeding: Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding. Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties /inbreds. Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection.

(Total Hours: 8)

Module 5:

Application of Genetics in Breeding: Rice: Evolution and distribution of species and forms - wild relatives and germplasm, Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding. Wheat: Evolution and distribution of species and forms - wild relatives and germplasm; cytogenetics and genome relationship; QPM and Bt maize - strategies and implications, Hybrid development and seed production - Scenario of Bt cottons, evaluation procedures for Bt cotton.

(Total Hours: 5)

Suggested Readings

1. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2015) Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA.

2. Buchanan, B. B., Gruissem, W. and Jones, R. L. (2015) Biochemistry and Molecular Biology of Plants.John Wiley & Sons and American Society of Plant Biologists, USA.

3. Hopkins, W. G. and Huner, N. P. A. (2008) Introduction to Plant Physiology. John Wiley, UK.
4. Jones, R. L, Ougham, H., Thomas, H. and Waaland, S. (2012) The Molecular Life of Plants. Wiley Blackwell and American Society of Plant Biologists, USA.
5. Srivastava, L . M. (2002) P lant Growth and Development: Hormones and Environment. Academic Press, USA.
6. Tai z, L . and Zei ger, E ., Moller, I . M. and Murphy, A (2015) Plant Physiology and Development. Sinauer Associates Inc. Publishers, USA.

Course Name: Lab on Plant Molecular Genetics **Code: BMGN 6393**
Credits: 2 **Total Hours: 30**

1. Basic Molecular Biology Techniques
Isolation of Plasmid DNA from *Agrobacterium tumefaciens*
Miniprep technique.
Quantification and Quality Assessment of DNA
Spectrophotometry (A260/A280) and Agarose Gel Electrophoresis.

2. PCR and Marker Analysis
Primer Design for Plant Genes
Using online bioinformatics tools (NCBI, Primer3).
Amplification of Plant Genomic DNA using PCR
Targeting chloroplast or nuclear genes.
Polymorphism Analysis between Plant Varieties
Using agarose/polyacrylamide gel.

3. Gene Expression Studies
RNA Isolation from Plant Tissue
Using Trizol or commercial kits.

cDNA Synthesis and Reverse Transcription PCR (RT-PCR)
Expression analysis of stress-responsive genes.
Quantitative PCR (qPCR) for Gene Expression Profiling (if equipment available).

4. Recombinant DNA and Transformation
Restriction Digestion of Plant Genomic/Plasmid DNA
Mapping and verification of constructs.
Ligation of Plant Genes into Cloning Vectors
T/A cloning or restriction-ligation method.
Agrobacterium-mediated Transformation of Model Plants*Arabidopsis thaliana* or *Nicotiana tabacum*.
Selection of Transformed Plants using Marker Genes
Antibiotic/herbicide resistance screening.

5. Use of descriptors for cataloguing - Floral biology - emasculation - pollination techniques

6. Study of range of variation for yield and yield components

7. Study of Effect of hormone in plant growth

8. Study of different factors in germination.

Suggested Readings

1. Molecular Biology of the Cell (Alberts et al.) — Chapters on DNA/RNA, transcription/translation, genetic engineering.
2. Plant Biotechnology and Genetics: Principles, Techniques, and Applications (C. Neal Stewart Jr.) — Plant transformation, gene cloning, CRISPR in plants.
3. Principles of Plant Genetics and Breeding (George Acquaah) — Good foundation on plant genetic concepts before jumping into molecular methods.
4. Molecular Cloning: A Laboratory Manual (Sambrook & Russell) — Gold standard for step-by-step cloning protocols.

5. Plant Molecular Biology: A Laboratory Manual (Mary Dixon & Robert Kirk) — Plant-specific extraction, transformation, and gene expression analysis.

6. The Arabidopsis Information Resource (TAIR) — Protocols & genetic resources for model plant research.

7. Addgene — Has free plasmid maps, plant vector info, and protocols.

8. NCBI & Ensembl Plants — For gene sequence retrieval and annotation practice.

9. Floral Dip Protocol (Clough & Bent, 1998) — Classic method for Arabidopsis transformation.