MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

(Formerly West Bengal University of Technology)

Syllabus of B.Sc. in Biotechnology

SIXTH SEMESTER

B.Sc. Biotechnology

Sl.	Subject Type	Code	Subject Name	Credits			Total Credits
				L	T	P	
1.	DSC	BMBT 6301	Plant and Animal Biotechnology	4	0		4
2.		BMBT 6302	Developmental Biology	4	1	0	5
3.		BMBT-6303 BMBT-6393	Agriculturaland Environmental Biotechnology	3	0	2	5
4.	DSE	MIC601	Web Development with HTML and CSS	3	1	0	4
5.		MIC602 A/B	Internet and Networking /ERP	3	1	0	4
Total Credit							22

Course Name: Plant & Animal Biotechnology **Code: BMBT 6301**

Credits: 4 **Total hours: 60**

Aim of the course: To acquaint students with basics of Plant and Animal Biotechnology

Course objectives:

To provide students with knowledge and practical understanding of modern biotechnological tools and applications in plants and animals for agriculture, healthcare, industry, and conservation.

Sl	Graduate attributes	Mapped modules
CO1	To provide students with a comprehensive understanding of the fundamental principles, techniques, and applications of plant tissue culture.	M1
CO2	To develop technical proficiency thorough understanding of the principles, tools, and techniques of plant genetic engineering and their applications in modern biotechnology.	M2
CO3	To acquaint students with the fundamental concepts, methodologies, and applications of animal cell culture.	M3

CO4	To develop analytical competence in students along with comprehensive knowledge of the principles and practices of animal reproductive biotechnology.	M4
CO5	To equip students with knowledge of molecular markers and their applications in genetic analysis and crop improvement.	M5

Learning outcome

1. Demonstrate an understanding of core concepts, techniques, and applications of plant and animal biotechnology.
2. Apply molecular and cellular tools such as tissue culture, genetic engineering, molecular markers, and genome editing in experimental and applied contexts.
3. Analyze the role of biotechnological approaches in crop improvement, livestock production, healthcare, conservation, and industry.
4. Evaluate ethical, environmental, and biosafety issues associated with plant and animal biotechnology.
5. Develop problem-solving and research-oriented skills for addressing real-world challenges in agriculture, medicine, and environmental sustainability.

Module Number	**Content**	**Total hours**	**% of questions**	**Bloom level (applicable)**	**Remarks, if any**
THEORY					
M1	**Plant tissue culture**	**10**	**25%**	**2,3**	**NA**
M2	**Plant genetic manipulation**	**10**	**25%**	**3,4**	**NA**
M3	**Animal cell culture**	**10**	**25%**	**1,2**	**NA**
M4	**Animal reproductive biotechnology**	**8**	**15%**	**4**	**NA**
M5	**Molecular mapping and marker assisted selection**	**7**	**10%**	**2,3**	**NA**
Total Theory		**45**	**100**		

Detailed Syllabus

Module 1:

Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production.

(Total Hours: 10)

Module 2:

Plant genetic manipulation: Genetic engineering: Agrobacterium plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation – Agrobacterium mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

(Total Hours: 10)

Module 3:

Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

(Total Hours: 10)

Module 4:

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology;

transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species.

(Total Hours: 8)

Module 5:

Molecular mapping and marker assisted selection: Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic

(Total Hours: 7)

Suggested Readings:

1. Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.

2. Razdan, M. K. (2003). *Introduction to Plant Tissue Culture*. Enfield, NH: Science.

3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.

4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons

5. Glick, B. R., & Pasternak, J. J. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, D.C.: ASM Press.

6. Brown, T. A. (2006). *Gene Cloning and DNA Analysis: an Introduction*. Oxford: Blackwell Pub.

7. Primrose, S. B., & Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.

8. Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.

Course Name: Developmental Biology **Code: BMBT 6302 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).

(Total hours: 6)

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: 8)

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: 9)

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: Agriculture & Environmental Biotechnology **Code: BMBT 6303**

Credits: 3 **Total hours: 45**

Aim of the course: To acquaint students with basics of Agriculture & Environmental Biotechnology

Course objectives:

To introduce the concepts of biotechnology with a focus on agriculture and environmental applications and to understand the role of microorganisms in these arena

***Learning Outcome**:*

The candidates should demonstrate the comprehensive knowledge and practical skills in the domain of agriculture and environmental biotechnology. They will be able to analyze the use of biotechnology in bioremediation and pollution control and support sustainable environmental management through biotechnological Innovations

Module Number	**Content**	**Total hours**	**% of questions**	**Bloom level (applicable)**	**Remarks, if any**
THEORY					
M1	Introduction to Soil Microbiology & types of crops	**10**	**15%**	**2,3**	**NA**
M2	Microbial Metabolism	**12**	**25%**	**3**	**NA**
M3	Beneficial microorganisms in Agriculture	**8**	**20%**	**3**	**NA**
M4	Scope and role of biotechnology in environmental protection	**5**	**15%**	**3**	**NA**
M5	Bioremediation and Phytoremediation	**5**	**10%**	**2,3**	**NA**
M6	Sustainable and Emerging Technologies	**5**	**15%**	**2,3**	**NA**
Total Theory		**45**	**100**		

Detailed syllabus

Module 1:

Introduction to Soil Microbiology: Stages of Soil Formation, Soil characteristics: soil texture, pH, conductivity etc. Microbial groups in soil, microbial transformations of carbon, nitrogen, phosphorus and sulphur, Biological nitrogen fixation. Microflora of rhizosphere and phyllosphere, microbes in composting.

Origin, geographic distribution, economic importance, soil and climatic requirement, varieties and yield of kharif crops: Cereals, Pulses; Oilseeds, Fibre crops and Forage crops.

Origin, geographical distribution, economic importance, soil and climatic requirements, varieties and yield of rabi crops: Cereals, Pulses, Oilseeds, Sugar crops, Medicinal and aromatic crops, Commercial and Forage crops

(Total Hours: 10)

Module 2:

Microbial Metabolism: Biological N_2-fixation by Free living anaerobic (Clostridium), facultatively anaerobic (Azospirillum) and aerobic (Azotobacter), N_2-fixers associated with stem, root and leaf, Symbiotic N2-fixation in legumes and non- legumes by Rhizobium and Frankia, N_2-fixation by cyanobateria. Requirement of ATP, O2-sensitivity and inhibition by ammonia and nitrogenous substance in the case of nitrogenase, The peculiarity of alternate nitrogenase of Streptomyces thermoautotrophicus.

(Total Hours: 12)

Module 3:

Beneficial microorganisms in Agriculture: Biofertilizer (Bacterial, Cyanobacterial and Fungal), Microbial insecticides, Microbial agents for control of plant diseases, Biodegradation, Biogas production, Biodegradable plastics, Plant-Microbe interactions.

Phosphate solubilizing bacteria. Potash mobilizing bacteria, PGPR, Mycorrhiza, Soil anerobic methanogens in rice field. Integrated nutrient management.

Eco-friendly Microbes and their utilisation in Agriculture, Ice minus bacteria and microbial pesticides

(Total Hours: 08)

Module 4:

Definition, scope and role of biotechnology: In environmental protection, Microbial diversity in natural and polluted environments.

Waste Treatment Technologies: Microbial degradation of organic pollutants. Biotreatment of solid and liquid wastes. Anaerobic digestion and composting.

(Total Hours: 05)

Module 5:

Bioremediation and Phytoremediation: In-situ and ex-situ bioremediation. Role of microbes and plants in degradation. Use of genetically engineered organisms.

Environmental Monitoring Tools: Biosensors– types, design and application. Bioindicators. Molecular tools, PCR, DNA probes.

(Total Hours: 05)

Module 6:

Sustainable and Emerging Technologies: Bioplastics, biofuels, microbial fuel cells. Environmental genomics and metagenomics.

(Total Hours: 05)

Suggested Readings

1. Environmental Biotechnology: Principles and Applications, Bruce E. Rittmann & Perry L. McCarty, McGraw-Hill

2. Textbook of Environmental Biotechnology, Mohapatra P.K., I.K. International Publishing

3. Fundamentals of Agriculture, K P Singh, Kalyani Publishers

4. Biotechnology Innovations and Sustainability for Zero Hunger, CRC Press

Course Name: Lab on Agriculture & Environmental Biotechnology **Code: BMBT 6393**

Credits: 2 **Total Hours: 30**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Sowing of different monocot and dicot seeds
2. Analysis of soil types & their physicochemical parameters
3. Enumeration of bacterial population in soil
4. Enumeration of fungal population in soil
5. To know the cultural characteristics of microorganisms
6. Compost preparation and quality analysis
7. Isolation of Blue Green Algae (BGA)
8. Gram staining and microscopic examination of soil microbes