

GUJARAT TECHNOLOGICAL UNIVERSITY
Integrated Master of Science (Biotechnology)

Semester: 9

Subject Name: Stem Cell Technology

Subject Code: 1390406

Prerequisite: The prerequisites for studying Stem Cell Technology typically include a strong foundation in cell biology, molecular biology, genetics, and biotechnology. A background in biochemistry, immunology, and developmental biology is also beneficial. Basic knowledge of tissue engineering, biomaterials, and regenerative medicine helps in understanding stem cell applications. Practical skills in cell culture techniques, microscopy, and molecular techniques are essential for laboratory work. A degree in biotechnology, microbiology, biochemistry, or biomedical sciences is usually required to pursue advanced studies or careers in stem cell research.

Rationale: Stem cell technology holds immense potential in regenerative medicine, offering innovative solutions for treating degenerative diseases, injuries, and genetic disorders. Stem cells have the unique ability to self-renew and differentiate into various cell types, making them valuable for tissue repair, organ regeneration, and disease modeling. This technology is particularly crucial for conditions like spinal cord injuries, Parkinson's disease, diabetes, and cardiovascular disorders. Advancements in stem cell research, including induced pluripotent stem cells (iPSCs) and CRISPR-based gene editing, further enhance therapeutic possibilities while addressing ethical concerns associated with embryonic stem cells.

Course Scheme:

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Practical		
				ESE (E)	PA(M)	ESE (V)	PA (I)	
4	0	8	8	70	30	30	20	150

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	<p>Unit 1: Fundamentals of Stem Cell Biology</p> <ul style="list-style-type: none"> ● Introduction to Stem Cells and Their Characteristics <ul style="list-style-type: none"> ○ Self-Renewal, Pluripotency, and Differentiation Potential ○ Types of Stem Cells: Embryonic Stem Cells (ESCs), Adult Stem Cells, Induced Pluripotent Stem Cells (iPSCs), and Cancer Stem Cells ● Stem Cell Niche and Microenvironment <ul style="list-style-type: none"> ○ Role of Extracellular Matrix, Growth Factors, and Signaling Pathways (Wnt, Notch, Hedgehog) ● Stem Cell Culture Techniques and Maintenance <ul style="list-style-type: none"> ○ 2D vs. 3D Culture, Co-Culture Systems, Organoids 	15	25

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	<ul style="list-style-type: none"> ● Stem Cell Markers and Identification Techniques <ul style="list-style-type: none"> ○ Flow Cytometry, Immunocytochemistry, RT-PCR 		
2	<p>Unit 2: Stem Cell Differentiation and Applications in Disease Modeling</p> <ul style="list-style-type: none"> ● Stem Cell Differentiation Pathways <ul style="list-style-type: none"> ○ Hematopoietic, Neural, Mesenchymal, and Endothelial Differentiation ● In Vitro vs. In Vivo Differentiation Strategies <ul style="list-style-type: none"> ○ Role of Growth Factors and Cytokines ● Organoid Technology and Disease Modeling <ul style="list-style-type: none"> ○ Stem Cells in Neurodegenerative Diseases (Parkinson's, Alzheimer's) ○ Cardiac and Hepatic Organoids for Drug Screening ● Tissue Engineering and Stem Cell-Based Biomaterials <ul style="list-style-type: none"> ○ Scaffold-Based and Scaffold-Free Approaches 	15	25
3	<p>Unit 3: Stem Cells in Regenerative Medicine and Cell Therapy</p> <ul style="list-style-type: none"> ● Stem Cell-Based Therapies for Various Diseases <ul style="list-style-type: none"> ○ Hematopoietic Stem Cell Transplantation (HSCT) ○ Mesenchymal Stem Cell Therapy for Autoimmune and Inflammatory Diseases ○ Stem Cell Therapy for Musculoskeletal Disorders ● CRISPR and Genome Editing in Stem Cells <ul style="list-style-type: none"> ○ Gene Correction Strategies for Genetic Disorders ● Regenerative Approaches for Organ Repair and Replacement <ul style="list-style-type: none"> ○ Stem Cell Therapy for Cardiac Repair, Diabetes, and Liver Regeneration ● Challenges and Limitations of Stem Cell Therapy 	15	25
4	<p>Unit 4: Ethical, Legal, and Industrial Aspects of Stem Cell Technology</p> <ul style="list-style-type: none"> ● Stem Cell Research Ethics and Regulatory Frameworks <ul style="list-style-type: none"> ○ Guidelines by ISSCR, FDA, ICMR, and Stem Cell Research Oversight (SCRO) ● Ethical Concerns in Embryonic and Induced Pluripotent Stem Cell Research <ul style="list-style-type: none"> ○ Cloning and Genetic Engineering Implications ● Commercialization of Stem Cell Therapy and Biopharma Industry 	15	25

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	<ul style="list-style-type: none"> ○ Startups, Investment, and Market Trends in Stem Cell Technology ● Future Perspectives of Stem Cell Research ○ AI and Machine Learning in Stem Cell-Based Personalized Medicine 		
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Reference Books:

1. Stem Cells: An Insider's Guide – Paul Knoepfler
2. Principles of Regenerative Medicine – Anthony Atala
3. Stem Cell Biology and Regenerative Medicine – Mehdi Razavi
4. Handbook of Stem Cells – Robert Lanza
5. Stem Cell Therapy and Tissue Engineering – Charles P. Arber

List of Experiments (Minimum 6 to be performed):

1. **Basic Stem Cell Culture and Maintenance**
2. **Microscopic Examination of Stem Cell Morphology**
 - Phase-contrast and fluorescence microscopy
3. **RNA Isolation and RT-PCR for Stem Cell Markers**
 - Expression analysis of pluripotency markers (OCT4, NANOG, SOX2)
4. **Stem Cell Differentiation Assay**
 - Induction of mesenchymal, neural, or cardiac differentiation
5. **Flow Cytometry Analysis for Stem Cell Markers**
 - Identification of CD34, CD133, CD105 markers

No.	Course Outcome	Bloom's Taxonomy Level (RBT)
CO1	Describe the fundamental principles of stem cell biology, including self-renewal, differentiation, and types of stem cells.	Remember (RM), Understand (UN)
CO2	Analyze the role of the stem cell niche, signaling pathways, and microenvironment in regulating stem cell function.	Understand (UN), Analyze (AN)
CO3	Demonstrate basic stem cell culture techniques, differentiation protocols, and viability assays in the laboratory.	Apply (AP), Analyze (AN)
CO4	Explain the applications of stem cells in disease modeling, regenerative medicine, and tissue engineering.	Understand (UN), Apply (AP)
CO5	Evaluate the clinical potential of stem cell therapies for treating various diseases and discuss the associated challenges.	Analyze (AN), Evaluate (EL)
CO6	Compare different types of stem cell-based therapies, including hematopoietic, mesenchymal, and induced pluripotent stem cell (iPSC) applications.	Understand (UN), Analyze (AN)

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CO7	Discuss ethical, legal, and regulatory considerations in stem cell research and clinical applications.	Analyze (AN), Evaluate (EL), Create (CR)
CO8	Explore emerging technologies such as CRISPR gene editing, AI-driven stem cell analysis, and bioprinting for regenerative medicine.	Apply (AP), Create (CR)
