

**GUJARAT TECHNOLOGICAL UNIVERSITY**  
**Integrated Master of Science (Biotechnology)**

**Semester: 9**

**Subject Name: Metabolic Engineering**

**Subject Code: 1390404**

**Prerequisite:** Candidates enrolling in the Integrated MSc in Industrial Biotechnology program with an elective in Metabolic Engineering should have a solid foundation in biochemistry, molecular biology, and microbiology. Proficiency in biochemistry is essential for understanding metabolic pathways and enzyme functions, while molecular biology provides insights into genetic manipulation techniques relevant to pathway engineering

**Rationale:** Integrating an elective in Metabolic Engineering into the MSc Industrial Biotechnology curriculum is essential due to its pivotal role in optimizing microbial cell factories for the efficient production of valuable compounds. Metabolic engineering focuses on the targeted modification of metabolic pathways within microorganisms to enhance the yield and efficiency of desired products, such as biofuels, pharmaceuticals, and chemicals.

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	0	4	70	30	0	0	100

Course Content:

Module No:	Module Content	No. of Sessions	Weightage (%)
1	<b><u>Introduction</u></b> Stoichiometry, kinetics and thermodynamics of cellular reactions.	8	13
2	<b><u>Material balances and data consistency</u></b> Material balances on pathways and whole cell balances; Over and under-determined systems; Data consistency for over determined systems.	8	13
3	<b><u>Regulation of metabolic pathways</u></b> Regulation of metabolic pathways; role of enzymes, substrate, product and regulatory molecules; Hierarchical control in cellular systems.	8	13
4	<b><u>Manipulation of metabolic pathways</u></b> Pathway manipulation strategies for overproduction of various metabolites, examples of ethanol overproduction, overproduction of intermediates in main glycolytic pathway and TCA cycle like pyruvate, succinate etc.; Need for multiple genomic modifications; Modulating fluxes in desired pathways; Tools for multiple genomic modifications examples- TALENS CRISPR-Cas systems as well as	10	18

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	traditional systems of gene knock ins and knockouts and promoter engineering.		
5	<b><u>Synthetic biology</u></b> Metabolic pathway synthesis; Relation with bioprocess design; BIOBRICKS approaches; Introduction to tools of synthetic biology.	8	13
6	<b><u>Metabolic flux analysis</u></b> Metabolic flux analysis; Building stoichiometric matrix; Steady state and pseudo steady state assumptions; Using different optimizing functions to solve linear programming problem; FBA, understanding flux cone and constraints; Introducing additional constraints from thermodynamics; Brief introduction to developments in this area; MOMA (Minimization of Metabolic Adjustment), iFBA (Integrated Flux Balance Analysis) etc.	10	17
7	<b><u>Determination of metabolic flux</u></b> Experimental determination of metabolic fluxes; C <sup>13</sup> labeling, NMR and GC-MS based methods for flux determination.	8	13

**Reference Books:**

- Stephanopoulos, G.N., Aristidou, A.A., Nielsen, J., Metabolic Engineering: Principles and Methodologies., Academic Press. 1<sup>st</sup> Edition
- Smolke, C.S., Metabolic Pathway Engineering Handbook: Fundamentals, CRC press, 1<sup>st</sup> Edition

**Course Outcome:**

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
1	Identify the appropriate host and/or metabolic pathways to produce a desired product or remediate a toxin; Compare potential metabolic engineering strategies using quantitative metabolic modelling	UN
2	Explain new technologies for modelling approaches for improving pathway flux, engineered biosensors, automated cloning and strain development technologies	AN
3	Communicate concepts and ideas effectively	EL
4	Transparency, honesty and ethical reasoning in handling biomolecule for product processing	RM

\*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

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