Gyanmanjari Innovative University

Syllabus
Gyanmanjari Science College
Semester-3 (B.Sc.)

Subject: Microbial Metabolism- BSC1EM13309

Type of course: Major

Prerequisite: Basic knowledge of growth, cultivation, metabolism of microorganisms and inhibitory compounds.

Rationale: This course is designed to help students understand the growth, metabolic activities, growth factors, and enzymes of microorganisms. It also covers various chemotherapeutic agents that inhibit microorganisms, along with their biotechnological applications.

Teaching and Examination Scheme

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
2	0	4	4	100	100	200

Legends: CI-Class Room Instructions; T – Tutorial; P - Practical; C – Credit; SEE - Semester End Evaluation; LWA - Lab Work Assessment; V – Viva voce; CCE-Continuous and Comprehensive Evaluation; ALA- Active Learning Activities.

GYANMANJARI INNOVATIVE UNIVERSITY BHAVNAGAR

Course Content:

<table>
<tr><th>Sr. No</th><th>Course Content</th><th>Hrs.</th><th>% Weightage</th></tr>
<tr><td>1</td><td>
Basics of Metabolism
• Introduction to metabolism: anabolism, catabolism
• Introduction to primary and secondary metabolism & Metabolites: primary & secondary metabolites
• Characteristics and significance of primary and secondary metabolic pathways
• Role of ATP, reducing power, precursor metabolites

Practical
1. To qualitatively and quantitatively estimate reducing sugars present in a given sample using Benedict's reagent or DNS method.
2. To determine the protein concentration in a given sample by the Biuret method.
3. To determine microbial growth by measuring the optical density of the culture using a spectrophotometer.
4. To study the effect of different substrate concentrations on the growth of microorganisms and correlate substrate availability with growth rate.

Evaluation method
<table>
<tr><th>Sr. No</th><th>Evaluation Methods</th><th>SEE</th><th>CCE</th></tr>
<tr><td>1</td><td>Metabolic Concept Mapping: Faculty will assign a subtopic. Students will prepare a concept map linking biomolecules, ATP, and metabolism and upload it on the GMIU web portal.</td><td></td><td>10</td></tr>
<tr><td>2</td><td>Biomolecule Analysis Practical: Students will perform qualitative or quantitative test (reducing sugars, proteins, lipids), analyze the results and interpret their biological significance.</td><td>20</td><td></td></tr>
<tr><td>3</td><td>Journal</td><td></td><td>5</td></tr>
<tr><td>4</td><td>Short Assignment: Students will write a structured note comparing primary and secondary metabolism</td><td></td><td>5</td></tr>
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</td><td>T:P 6:12</td><td>20</td></tr>
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		with suitable microbial examples and upload it on the GMIU web portal.				
		Total	20	20		
2	**Microbial Enzymes** • Physical & Chemical properties of Enzymes • Structure of enzyme (Prosthetic groups, apoenzyme, cofactor, coenzyme) • Enzyme localization: Intracellular and Extracellular Enzymes • Nomenclature and classification of enzymes : IUB classification of enzymes **Practical** 5. To determine the ability of bacteria to produce extracellular amylase by hydrolyzing starch on starch agar medium. 6. To determine the ability of *Bacillus* spp. to produce catalase enzyme by detecting the breakdown of hydrogen peroxide. 7. To determine the ability of bacteria to produce cytochrome oxidase enzyme involved in the electron transport chain. 8. To determine the ability of bacteria to hydrolyze urea by the production of urease enzyme. 9. To determine the ability of microorganisms to produce gelatinase enzyme and hydrolyze gelatin. **Evaluation method** Sr. No | Evaluation Methods | SEE | CCE 1 | **Enzyme Classification Chart (IUB System):** Students will prepare a chart illustrating major enzyme classes with examples, highlighting its function. The chart must include labeled diagrams and should be uploaded to the GMIU web portal in PDF format. | | 5 2 | **Practical Examination: Enzyme Identification Practicals:** Students will perform any one of the following tests: catalase, starch hydrolysis test or gelatin hydrolysis test and interpret | 10 |	**T:P 6:12**	**20**

		results in terms of enzyme localization and function.				
	3	**Spotting:** Students will identify the given specimen/spot and provide a brief description based on their observation.	10			
	4	Journal		5		
	5	**Case Study:** students will be given a topic on Industrial enzyme application and they will analyse the case study and upload it on the GMIU portal		10		
		Total	2	20		
3	**Enzyme Kinetics** • Mechanism of enzyme action: Lock & key, Induced fit model, Transition state complex and activation energy. • Factors affecting the enzyme activity • Michaelis–Menten (M–M) equation, Michaelis constant (Km) and maximum velocity (Vmax). • Enzyme inhibition : Reversible (Competitive, Non-competitive and Uncompetitive) & Non-reversible inhibition **Practical** 10. To study the effect of temperature on enzyme activity and determine the optimum temperature for enzyme function. 11. To study the effect of pH on enzyme activity and determine the optimum pH for enzyme function. 12. To study the effect of substrate concentration on enzyme activity and correlate substrate concentration with the rate of enzyme-catalyzed reaction. 13. To study the effect of enzyme concentration on the rate of an enzyme-catalyzed reaction. 14. To demonstrate the effect of reversible (competitive, non-competitive, uncompetitive) and non-reversible inhibitors on enzyme activity using substrate analogs. **Evaluation method**				**T:P 6:12**	**20**

Sr. No	Evaluation Methods	SEE	CCE

	1	**Mechanism of Enzyme Action Analysis:** Students will prepare a comparative explanation of the lock and key model and induced fit model using diagrams. They will also include a brief note on transition state and activation energy. The activity should be uploaded in the form of a short report and submitted to the GMIU portal.		10			
	2	**Enzyme Kinetics:** Students will perform an experiment to study the effect of factors such as temperature, pH, or substrate concentration on enzyme activity, record observations, and interpret results based on enzyme kinetics.	10				
	3	Oral-Examination	10				
	4	Journal		5			
	5	**Problem-Based Outcomes:** Students solve scenarios involving enzyme inhibition (competitive/non-competitive) and predict outcomes. The outcome notes must be uploaded to the GMIU portal.		5			
		Total	20	20			
4	**Carbohydrate Metabolism** • Glycolysis Pathway overview (Embden–Meyerhof pathway) • Fermentation pathways (Lactic acid fermentation, Alcoholic fermentation, Mixed acid fermentation pathway) • Aerobic vs anaerobic metabolism (Electron transport chain and oxidative phosphorylation) **Practical** 15. To determine the ability of bacteria to ferment carbohydrates with the production of acid and gas using the Durham tube method.					**T:P 6:12**	**20**

16. To determine the ability of bacteria to produce acidic acid as an end product through mixed acid fermentation using the Methyl Red test.
17. To determine the ability of bacteria to produce acetoin as an end product of glucose fermentation using the Voges–Proskauer test.
18. To determine the ability of bacteria to utilize citrate as the sole carbon source.
19. To determine the ability of microorganisms to produce extracellular amylase and hydrolyze starch.
20. To determine the oxygen requirement of bacteria and classify them as obligate aerobes, obligate anaerobes, facultative anaerobes, microaerophiles, or aerotolerant anaerobes using thioglycollate medium.

Evaluation method:

Sr. No	Evaluation Methods	SEE	CCE
1	**Glycolysis Pathway Flowchart:** Students will prepare a detailed flowchart of glycolysis, highlighting key steps, enzymes involved, and ATP/NADH generation. The flowchart should clearly depict energy investment and payoff phases and uploaded on the GMIU portal.		5
2	**Interpretation of Biochemical Test Results:** Students will perform or analyze results from carbohydrate fermentation tests (e.g., sugar fermentation, MR-VP test) and interpret the metabolic pathway followed by the microorganism.	10	
3	**Fermentation Pathway Case Study:** Students will be given a case scenario (e.g., yeast fermentation or lactic acid production) and will identify the type of fermentation pathway involved. They will explain the process, end products, and its biological or industrial significance.	10	

	4	Journal		5		
	5	**Report preparation:** Students will create a comparative table distinguishing aerobic and anaerobic metabolism based on oxygen requirement, end products, energy yield, and examples. The activity should include proper explanation and should be uploaded to the GMIU portal.		10		
		Total	20	20		
5	**Nitrogen and Lipid Metabolism** • Nitrogen assimilation pathways & GS-GOGAT pathway • Ammonification and nitrate reduction (Assimilatory and dissimilatory) • Denitrification and significance of nitrate reductase • β-oxidation of fatty acids and its significance • Fatty acid biosynthesis and regulation **Practical** 21. To determine the ability of bacteria to reduce nitrate to nitrite or other nitrogenous compounds using the nitrate reduction test. 22. To detect the production of ammonia by microorganisms through deamination of amino acids using peptone broth and Nessler's reagent. 23. To determine the ability of microorganisms to hydrolyze casein through the production of extracellular protease enzymes. 24. To determine the ability of microorganisms to hydrolyze lipids by detecting lipase production on tributyrin agar medium. 25. To determine the ability of microorganisms to produce gelatinase enzyme and hydrolyze gelatin. 26. To demonstrate extracellular lipase activity and lipid degradation by microorganisms. **Evaluation method**			**T:P 6:12**	**20**

Sr. No	Evaluation Methods	SEE	CCE
1.	**Nitrogen Cycle Flowchart:** Students will prepare a detailed flowchart showing nitrogen assimilation, ammonification,		5

		nitrate reduction, and denitrification with suitable microbial examples and upload it to the GMIU portal.				
	2.	**Seminar:** Each student will prepare and deliver a PowerPoint presentation on an assigned topic such as Ammonification, Denitrification, Fatty acid biosynthesis, Nitrogen assimilation pathways, etc. The presentation should include recent developments, key mechanisms, and applications and upload it to the GMIU portal.	10			
	3.	**Metabolic pathway:** Students will perform any one experiment (nitrate reduction, casein hydrolysis, or lipase activity) and interpret the results in terms of microbial nitrogen or lipid metabolism.	10			
	4.	Journal		5		
	5.	**Comparative Report Preparation:** Students will prepare a comparative report on β-oxidation and fatty acid biosynthesis, highlighting key enzymes, products, and regulatory mechanisms, and upload it to the GMIU portal.		10		
		Total	20	20		
					90	**100%**

Distribution of Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	10%	30%	20%	20%	20%	00

RUBRICS:

UNIT 1: Basics of Metabolism

Understanding of Metabolic Concepts (Anabolism/Catabolism, ATP role): 5 marks
Biomolecule Identification & Experimental Accuracy: 5 marks
Comparative Understanding (Primary vs Secondary Metabolism): 5 marks
Result Interpretation & Application (Energy flow, reducing power): 5 marks

UNIT 2: Enzymes

Understanding of Enzyme Structure (Apoenzyme, Cofactor, Coenzyme): 5 marks
Performance of Enzyme Tests (Catalase, Oxidase, etc.): 5 marks
Classification Skills (IUB system & enzyme types): 5 marks
Interpretation of Enzyme Function & Localization: 5 marks

UNIT 3: Enzyme Action

Conceptual Understanding (Lock & Key, Induced Fit, Activation Energy): 5 marks
Experimental Analysis (Effect of pH, Temperature, Substrate): 5 marks
Understanding of Enzyme Inhibition (Competitive/Non-competitive): 5 marks
Graph Interpretation & Result Analysis (Enzyme kinetics): 5 marks

UNIT 4: Carbohydrate Metabolism

Understanding of Metabolic Pathways (Glycolysis, Fermentation): 5 marks
Performance of Biochemical Tests (MR, VP, Fermentation tests): 5 marks
Comparative Understanding (Aerobic vs Anaerobic metabolism): 5 marks
Interpretation of Results & Identification of Metabolic Pathways: 5 marks

UNIT 5: Nitrogen and Lipid Metabolism

Understanding of Nitrogen Metabolism (Nitrogen assimilation, nitrate reduction): 5 marks
Performance of Biochemical Tests (Nitrate reduction, denitrification and lipase activity): 5 marks
Understanding of Lipid Metabolism (β-oxidation, fatty acid biosynthesis and regulation): 5 marks

Interpretation of Results and Metabolic Pathways: 5 marks

Seminar: Evaluation based on
Quality and Design of PPT – 3 marks
Depth of Content Knowledge and Accuracy – 4 marks
Presentation Skills and Audience Interaction – 3 marks

Course Outcome

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

	After learning this course the students must be able to:
CO1	To explain the basic concepts of metabolism including anabolism, catabolism, primary & secondary metabolites, and the role of ATP, reducing power and precursor metabolites.
CO2	To understand the physical & chemical properties, structure, classification and localization of microbial enzymes.
CO3	To analyze enzyme action mechanisms, Michaelis-Menten kinetics, factors affecting activity and evaluate different types of enzyme inhibition.
CO4	To apply knowledge of glycolysis, fermentation and aerobic metabolic pathways to interpret biochemical test results in microorganisms.
CO5	To understand nitrogen assimilation, ammonification, denitrification and lipid metabolism pathways and apply laboratory techniques to detect related microbial activities.

Instructional Method:

The course delivery method will depend upon the requirement of content and needs of students. The teacher, in addition to conventional teaching methods by black board, may also use any tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory.

The internal evaluation will be done on the basis of the Active Learning Assignment.

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in the laboratory.

Reference Books:

[1.] Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. *Brock Biology of Microorganisms* (16th ed.). Pearson.

[2.] Willey, J. M., Sherwood, L. M., & Woolverton, C. J. *Prescott's Microbiology* (11th ed.). McGraw-Hill Education.

[3.] Nelson, D. L., & Cox, M. M. *Lehninger Principles of Biochemistry* (8th ed.). W. H. Freeman & Company.

[4.] Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. *Biochemistry* (9th ed.). W. H. Freeman & Company.

[5.] Copeland, R. A. *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis* (2nd ed.). Wiley-VCH.

[6.] Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. *Microbiology* (5th ed.). Tata McGraw-Hill Education.