

**ST. XAVIER'S COLLEGE (AUTONOMOUS), AHMEDABAD-9
FACULTY OF SCIENCE**



DEPARTMENT OF BIOCHEMISTRY – BIOTECHNOLOGY

SEMESTER – III SYLLABUS

OF

BSc BIOTECHNOLOGY (HONOURS)

**BASED ON UNDERGRADUATE CURRICULUM FRAMEWORK
(NEP – 2020)**

(Effective from Academic Year 2023)

Programme Outcomes

- PO1. Create a strong knowledge domain/ expertise
- PO2. Develop critical thinking, Problem solving and research aptitude
- PO3. Skill development
- PO4. Encouraging social interaction, service learning and develop equity centred national development (Social Extension work)
- PO5. Self-directed and lifelong learning
- PO6. Developing employability and entrepreneurial skills
- PO7. Promoting Ecological sustainability development
- PO8. Nurturing creativity and humane values

Programme Specific Outcome for BSc Biotechnology

- PSO1. Comprehensive and Procedural Knowledge: Discuss and interpret the basic concepts of all subjects under the aegis of current multidisciplinary Biotechnology to translate and apply the same for professional, entrepreneurial and societal benefits.
- PSO2. Skill development: Learn wide – ranging technical skills inclusive of digital learning skills through laboratory sessions/ research projects and develop self-directed experiential learning with an objective to associate biotechnology with improving life, industrial applications and environment.
- PSO3. Critical thinking, Creativity and Problem Solving: Develop competence to solve problems in familiar and non – familiar context especially to alleviate stress in all life forms, develop an analytical mind to use information from various sources and create plans/models to come up with innovations in the field of Biotechnology.
- PSO4. Communication and Collaboration: Ability to communicate the understanding of the learning to others confidently and precisely, interact with diverse multicultural groups working in the subject area as well as collaborate to achieve goals that have a wider outreach.
- PSO5. Leadership, Lifelong learning and ethics: Extend the applicability of Biotechnology to service learning and nation development through awareness programmes/ action - oriented projects in health, nutrition, and environment; be accountable, responsible and conscientious in leading roles both in profession and personal space.

Curriculum Framework for Semester – III BSc (Hon.) Biotechnology

Course	Title	Content	Hours/week	Credit
DSC-1 (Theory)	BT – 3501 Enzymology	Unit 1: Introduction to Enzymes Unit 2: Reaction mechanisms Unit 3: Kinetics and Regulation Unit 4: Metabolic Engineering	4 hrs	4
DSC-2 (Theory)	BT – 3502 Molecular Biology	Unit 1: Basic concepts in Molecular Biology Unit 2: DNA Replication and Repair Unit 3: Transcription and Genetic Code Unit 4: Translation and Gene expression regulation	4 hrs	4
DSC-1 (Lab)	BC – 3503 Enzymology and Basic Molecular Biology Lab	Practical based as per Theory syllabus.	8 hrs	4
SEC	BT – 3650 Biophysical Techniques	Unit 1: Electrophoresis Unit 2: Advanced Techniques	2 hrs	2
MDC <i>Offered by other Major Discipline</i>	Choice from Basket		4 hrs	4
AEC		(To be selected from a basket of courses)		2
VAC	Value Added Courses	(To be selected from a basket of courses)		2
Total Credits				22

BSC. (HONS.) BIOTECHNOLOGY SYLLABUS

SEMESTER – III

Major Discipline Course – 1: Enzymology

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
BT – 3501 Enzymology	4 (60 hr)	0	0	10 + 2 from a recognized board in any stream	Nil

I. Course Learning Objectives

Thus, the knowledge from this course can help in the following:

- Use concepts of purification of enzymes in industries
- Study different molecules that can modify enzyme activity
- Gain basic technical knowledge required in laboratories
- Work in industries related to enzymes
- Carry out basic research in purifying and characterizing enzymes to establish an application in industry or research

II. Course Learning Outcomes

The main objective of the course will be to understand the concepts of Enzymology and its importance in the proper functioning of each cell.

By the end of the paper, a student should be able to:

- CO 1: Correlate the structure dynamics of enzymes with its function and its classification
- CO 2: Distinguish mechanisms of catalysis, the involvement of cofactors and coenzymes and the parameters associated with enzyme activity
- CO 3: Strategize and design experiments to purify enzymes for applications in industries and research
- CO 4: Connect different factors with enzyme kinetics, derive equations to determine rate of reaction and optimize for commercial production
- CO 5: Differentiate between regulatory enzymes and non-regulatory enzymes through kinetic studies

III. Course Content

Unit 1: Introduction

History, general characteristics, nomenclature, IUB enzyme classification, significance of numbering system. Definitions with examples; holoenzyme, apoenzyme, cofactors, coenzymes, activators, inhibitors.

Units of enzyme activity, Definition of IU, Katal, enzyme turn over number and specific activity.

Metallo-enzymes, isoenzymes, monomeric and oligomeric enzymes and multi-enzyme complexes. Other forms of enzymes: Abzymes, synzymes, Ribozymes.

Unit 2: Enzyme catalysis

Role of cofactors in enzyme catalysis: NAD/NADP, FMN/FAD, coenzyme A, biotin, cobamine, TPP, pyridoxal phosphate, tetrahydroxy folate.

Acid-base catalysis, covalent catalysis, proximity and orientation effects, strain and distortion theory. Mechanism of action of chymotrypsin, carboxypeptidase and lysozyme.

Enzyme specificity and active-site.

Unit 3: Enzyme Purification

Need for purification and general outline of purification scheme, Purification table, methods for protein determination, purification methods with respect to source, principle, isolation and extraction method, efficiency with examples and advantages or disadvantages during use. Methods to check enzyme purity such as ultracentrifugation, electrophoresis & solubility.

Methodology, sampling & continuous methods with examples, advantages, disadvantages of: (a) Spectrophotometric method (b) Spectrofluorometric method (c) Electrochemical methods (d) Polarimetric method, and (e) Manometric method; Handling of enzymes, Enzyme assays.

Unit 4: Enzyme Kinetics

Factors affecting enzyme activity: enzyme concentration, substrate concentration, pH and temperature.

Derivation of Michaelis-Menten equation for uni-substrate reactions. K_m and its significance. Line Weaver-Burk plot, Eadie - Hoofstie Plot and Hanes plot. Bi-substrate reactions - brief introduction to sequential and ping-pong mechanism with examples.

Kinetics of zero and first order reactions; Significance and evaluation of energy of activation and free energy.

Reversible and irreversible inhibition, competitive, non-competitive and un-competitive inhibition, determination of K_m and V_{max} in presence and absence of inhibitors. Allosteric enzymes – regulation and kinetics.

IV. Recommended Learning Resources

1. G. Stephanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering Principles and Methodologies, Academic Press, 1998.
2. S. Y. Lee and E. T. Papoutsakis, Metabolic Engineering, Marcel Dekker, New York, 1999.
3. David Fell, Understanding the Control of Metabolism, Portland Press, London, 1997.
4. R. Heinrich and S. Schuster, The Regulation of Cellular Systems, Chapman & Hall, 1996.
5. E. O. Voit, Computational Analysis of Biochemical Systems, Cambridge University Press, 2000.
6. Enzyme Technology by Palmer
7. Biochemical Engineering by James M. Lee, Prentice Hall (1992).
8. Design and Analysis of Immobilised Enzyme Flow Reactors” by W.R. et. al.
9. Enzymes in Food Processing by Gerald Reed, Academic presses

V. Pedagogy

1. Classroom engagement through lectures and PowerPoints
2. Lecture videos and online resources
3. Workbooks/Group activities/Assignments/Class Tests

VI. Evaluation

The course paper is evaluated out of 100 marks, of which 50 percent weightage is of Internal Assessment and 50 percent weightage is of the End semester examination (External)

ASSESSMENT CRITERIA	INTERNAL EVALUATION	EXTERNAL EVALUATION
Continuous Internal Assessment (CIA) I and II	35	-
Assignment (Research element)*	10	-
Attendance	05	-
End Semester Exam	-	50
Total	50	50

*The assignment comprises writing a review of research articles with enzymes as focal point.

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Programme Specific Outcome for BSc Biotechnology

- PSO1. Comprehensive and Procedural Knowledge: Discuss and interpret the basic concepts of all subjects under the aegis of current multidisciplinary Biotechnology to translate and apply the same for professional, entrepreneurial and societal benefits.
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Curriculum Framework for Semester – III BSc (Hon.) Biotechnology

Course	Title	Content	Hours/week	Credit
DSC-1 (Theory)	BT – 3501 Enzymology	Unit 1: Introduction to Enzymes Unit 2: Reaction mechanisms Unit 3: Kinetics and Regulation Unit 4: Metabolic Engineering	4 hrs	4
DSC-2 (Theory)	BT – 3502 Molecular Biology	Unit 1: Basic concepts in Molecular Biology Unit 2: DNA Replication and Repair Unit 3: Transcription and Genetic Code Unit 4: Translation and Gene expression regulation	4 hrs	4
DSC-1 (Lab)	BC – 3503 Enzymology and Basic Molecular Biology Lab	Practical based as per Theory syllabus.	8 hrs	4
SEC	BT – 3650 Biophysical Techniques	Unit 1: Electrophoresis Unit 2: Advanced Techniques	2 hrs	2
MDC <i>Offered by other Major Discipline</i>	Choice from Basket		4 hrs	4
AEC		(To be selected from a basket of courses)		2
VAC	Value Added Courses	(To be selected from a basket of courses)		2
Total Credits				22

BSC. (HONS.) BIOTECHNOLOGY SYLLABUS

SEMESTER – III

Major Discipline Course – 2: Molecular Biology

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
BT – 3502 Molecular Biology	4 (60 hr)	0	0	10 + 2 from a recognized board in any stream	Nil

I. Course Learning Objectives

Thus, the knowledge from this course can help in the following:

- Enable students to build a career in Genetic engineering, Genomics and proteomics
- Understanding of molecular mechanisms can enable customizing treatments related to diseases
- The students can carry out basic research in cell and molecular biology
- Start up companies based on biologics and molecular medicines

II. Course Learning Outcomes

The main objective of the course will be to understand the importance of Molecular Biology and its implications

By the end of the paper, a student should be able to:

- CO 1: Deduce the structure, properties and functions of DNA from the experiments strategized and published by eminent scientists.
- CO 2: Appraise the molecular mechanistic of replication, DNA repair, transcription and translation in prokaryotes
- CO 3: Evaluate the defects at the cell level as well as organism level associated with malfunction of these molecular mechanistics.
- CO 4: Correlate splicing and alternative splicing with transcriptomes and proteomes
- CO 5: Design gene constructs that can enable regulating gene expression

III. Course Content

Unit 1: Basic Concepts in Molecular Biology

Introduction to Molecular Biology; Experiments proving DNA as genetic material: S. F. Griffith's transforming principle, Avery, McLeod and McCarthy's experiment, Roger Heriot's experiments with bacteriophages and Hershey and Chase Experiment; Rosalind Franklin's studies with DNA structure; Chargaff's experiments and Law; Watson – Crick Model; Deviations from Watson – Crick's DNA model; Different forms of DNA; Physical properties of DNA: Denaturation and Hyperchromic effect, T_m and its significance, Renaturation and hypochromic effect, Cot Curve and its significance; DNA Supercoiling and Topology

Unit 2: DNA Replication, DNA Damage and its Repair

Introduction to DNA replication; Messelson – Stahl's experiment; The basic requirements of DNA replication: Template – primer junction, DNA Polymerases: Structure and Function, Ancillary proteins associated with replication; Mechanism of replication: Initiation, Elongation and Termination; Other modes of replication: Rolling circle mechanism and D – loop mechanism.

Mutations and Types of Mutations; Replication Errors and its Repair; DNA Damage by Chemical Mutagens; DNA damage by physical agents; DNA Repair Mechanisms: Direct Reversal of DNA Damage, Base excision repair and Nucleotide excision repair; Repair by Homologous Recombination

Unit 3: Genetic Code and Transcription

The Genetic Code: Cracking of the code and its triplet nature; Degeneracy and Universality; Initiation and Stop Codons; Wobble's Hypothesis and its significance.

Introduction to Transcription; RNA polymerase: structure and function; Promoters; Transcription Initiation; Transcription elongation and proof reading; Termination of transcription.

Post transcriptional modifications: 5' capping and poly A tailing; RNA splicing: Chemistry of RNA splicing, Spliceosome machinery, Splicing pathways; Concept of Alternate Splicing.

Unit 4: Translation and Regulation of Gene Expression

Introduction to Translation, Roles of messenger RNA, transfer RNA, Aminoacyl tRNA synthetases, and Ribosomes; Mechanism: Initiation of translation, Elongation and Termination; Post translation modifications.

Regulation of Gene Expression: Principles; Regulation of transcriptional initiation: Lac Operon, Arabinose Operon and Tryptophan Operon; Gene Regulation after transcription initiation.

IV. Recommended learning Resources

1. Berg JM, and Tymoczko TJ, Stryer L,: Biochemistry (6th Edition)
2. Watson, J.D - Molecular Biology of the Gene (5th Edition)
3. De Robertis and De Robertis: Cell and Molecular Biology (8th Edition)
4. Donald Voet and Voet J: Biochemistry (4th Edition) 2011
5. Grisham and Garrett: Biochemistry (3rd ed)
6. Benjamin Lewin: Genes IX (2007)
7. Nelson DL and Cox MM: Lehninger's Principles of Biochemistry (5th ed) 2008
8. Lodish: Molecular Cell Biology (5th Edition) 2004

V. Pedagogy

1. Classroom engagement through lectures and PowerPoints
2. Lecture videos and online resources
3. Workbooks/Group activities/Assignments/Class Tests
4. Problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

VI. Evaluation

The course paper is evaluated out of 100 marks, of which 50 percent weightage is of Internal Assessment and 50 percent weightage is of the End semester examination (External)

ASSESSMENT CRITERIA	INTERNAL EVALUATION	EXTERNAL EVALUATION
Continuous Internal Assessment (CIA) I and II	35	-
Assignment (Research element)*	10	-
Attendance	05	-
End Semester Exam	-	50
Total	50	50

**The assignment comprises searching literature or experiments carried out by scientists or labs across the globe elucidating the molecular mechanisms.*

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Total Credits				22

BSC. (HONS.) BIOTECHNOLOGY SYLLABUS

SEMESTER - III

Major Discipline Course – 3: Basic Enzymology and Molecular Biology Lab

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
BT – 3503: Basic Enzymology and Molecular Biology Lab	0	0	4 (120 hr)	10 + 2 from a recognized board in any stream	Nil

I. Course Learning Objectives

The learning objectives of this paper is as follows:

- To be able to develop a skill set to handle enzyme assays, isolation and basic molecular biology techniques
- Students should understand the principles, theory, protocol and calculations for each experiment and apply them for research or small projects.
- They should discern the importance of precision and accuracy in reagent preparations and designing of experiments.
- The analysis and interpretation of each laboratory experiment should be able to initiate logical thinking and accountability, especially if the samples being studied are related to clinical and nutritional studies.
- The skill set should enhance their knowledge and employability.

II. Course Learning Outcomes

The main objective of the course will be to build the basic foundation as well as skill in the subject of biochemistry.

By the end of the paper, a student should be able to:

- CO 1: To handle and purify enzymes; perform enzyme assays and kinetics, and deduce from the results obtained.
- CO 2: To isolate DNA and RNA from different sources and analyse the isolated DNA

CO 3: To understand the nuances of instruments and techniques such as spectrophotometry, electrophoresis etc to study enzymes and nucleic acids

CO 4: To relate principles and protocols of the experiments

CO 5: To plan experiments for applications

III. Course Content (Laboratory Experiments)

Colorimetric Estimations

1. Estimation of DNA by DPA method
2. Estimation of RNA by Orcinol method

Biophysical methods

3. Agarose gel electrophoresis
4. SDS-Poly acrylamide gel electrophoresis
5. Off site visit for Instrumentation (Optional)

Basic techniques in Molecular Biology

6. Verification of Chargaff's rule by paper/ thin layer chromatography
7. Ultraviolet absorption spectrum of DNA and RNA
8. Determination of DNA concentration by UV absorption method
9. Determination of melting temperature and GC content
10. Isolation of DNA from white blood cells
11. Isolation of RNA from yeast cells

Enzyme practicals

12. Assay of salivary amylase.
13. Effect of pH on enzyme activity
14. Effect of enzyme concentration on enzyme activity
15. Effect of substrate concentration on enzyme activity
16. Effect of a competitive inhibitor on enzyme activity
17. Extraction and partial purification of an enzyme (amylase/peroxidase)

IV. Recommended Learning Resources

1. Oser: Hawk's Physiological Chemistry (14th ed)
2. Plummer: An introduction to Practical Biochemistry, 1988, Tata Mc Graw- Hill education
3. Sheela Sharma: Experiments and Techniques, 2007.
4. Thomas and Schalkhammer: Analytical Biochemistry, 2002
5. Varlery H: Practical Clinical Biochemistry, 1980, Heinemann, London
6. Thimmaiah S R: Standard Methods of Biochemical Analysis, 1999, Klayani Publishers

V. Pedagogy

1. Explanation of each laboratory experiment emphasising on the use of different reagents and instruments
2. Problem solving, group activities and presentations. There are defined activities for every laboratory experiment in the journal, which encourages self-learning, peer learning, team work, developing presentation skills and reading from science articles and research papers.
3. Learning outcome based questions, which develops reading and writing skills and lab tests

VI. Evaluation

The course paper is evaluated out of 100 marks, of which 50 percent weightage is of Internal Assessment and 50 percent weightage is of the End semester examination (External)

ASSESSMENT CRITERIA	INTERNAL EVALUATION	EXTERNAL EVALUATION
Internal Practical Examination*	35	-
Assignment (Research element)**	10	-
Attendance	05	-
End Semester Practical Exam	-	50
Total	50	50

**The internal practical exam will entail the students to answer a question paper based on the experiments in their journal, to perform two experiments and give a viva voce (optional). The journal duly completed and signed will also carry weightage.*

***The assignment comprises group activities that need the students to review literature, collate and present the data or carry out a short project, collate, interpret and present the data either as an oral presentation or a poster presentation and/or a documented report.*