



**SARDAR PATEL UNIVERSITY**

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCBIT01	Microbial Genetics	4-0-1	120	04

**Course Learning Outcomes:**

On completing the course, the students will be able to:

- CLO1** Describe molecular basis of mutation, DNA damage, and repair mechanisms.
- CLO2** Compare and contrast homologous, site-specific, and transposition recombination.
- CLO3** Explain regulation of plasmid copy number, segregation, and compatibility.
- CLO4** Design genetic mapping experiments using transformation, transduction, conjugation.
- CLO5** Analyse fungal genetics using tetrad and mitotic recombination analysis
- CLO6** Integrate molecular genetics tools in synthetic biology and genome engineering.

Unit	Course Content	Learning Pedagogies*	CLO(s)
<b>I</b>	<b>Genome Stability, Mutation and DNA Repair, Pedigree Analysis</b> Molecular basis of spontaneous & induced mutations. Mutation rate determination, fluctuation test, Ames test. DNA repair pathways: MMR, BER, NER, recombinational repair, SOS response, adaptive response, oxidative damage repair. Role of repair in cancer biology and microbial survival.	Classroom Lectures  Flipped classroom Seminars	<b>1</b>
<b>II</b>	<b>Phage genetics, Mobile Genetic Elements and Recombination</b> Phage genetics: T-series bacteriophages and lambda phage biology Plasmids: types, incompatibility, copy number control, partitioning systems. Transposable elements: Tn5, Tn3, Mu, Tn7, IS911, Integrons, conjugative transposons. Homologous recombination: Holliday model, RecBCD pathway, eukaryote meiosis. Site-specific recombination: Serine and tyrosine recombinases, mating type switching. Phage therapy applications	Classroom Lectures Flipped classroom Seminars Case studies	<b>2,3</b>
<b>III</b>	<b>Horizontal Gene Transfer and Genetic Mapping</b> Transformation: Natural competence (Bacillus, Streptococcus, Haemophilus), artificial competence, linkage mapping. Transduction: Generalized (P1, P22, Mu) and specialized (lambda); co-transduction mapping. Conjugation: F-plasmid, Hfr, F', interrupted mating, mapping, mobilizable plasmids. Synthetic biology applications, gene drives, and HGT in antimicrobial resistance spread.	Classroom Lectures Seminars Computational tools and virtual laboratories	<b>4</b>



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<b>IV</b>	<b>Phage genetics, Molecular Genetics Tools and Interkingdom Systems</b> Agrobacterium genetics: Ti plasmid, vir regulon, T-DNA transfer, integration, plant genetic engineering. Biology of Restriction-Modification systems Fungal genetics: Tetrad analysis, mitotic recombination, gene conversion	Classroom Lectures Flipped classrooms Case studies, Computational tool	<b>5,6</b>
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● **Assessment Methodologies**

**(A) Internal Assessment**

**a. Internal Formative assessment (30 marks)**

- (a) **Quiz (2 quizzes): 10 marks**
- (b) **Seminar: 05 marks**
- (c) **Assignment: 05 marks**
- (d) **Regularity: 05 marks**
- (e) **Group Learning: 05 marks**

**b. Internal Summative Assessment: Mid-term tests (20 marks)**

**(B) External Assessment: End of Term Examination (50 marks)**

● **Weightage of Learning Efforts for External Assessment**

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/Analyse & above (A)	
<b>I</b>	<b>1</b>	30	01	01	11	13
<b>II</b>	<b>2,3</b>	40	01	01	12	14
<b>III</b>	<b>4</b>	30	01	01	10	12
<b>IV</b>	<b>5,6</b>	20	01	01	09	11
		<b>120</b>	<b>04</b>	<b>04</b>	<b>42</b>	<b>50</b>

● **CLOs – PLOs Matrix**

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
<b>CLO 1:</b>	3	1	2	2	1	1	-	1	1	1	-	1
<b>CLO 2:</b>	3	2	2	1	1	1	-	1	1	1	-	1
<b>CLO 3:</b>	3	2	2	1	2	1	-	1	1	1	-	1
<b>CLO 4:</b>	2	3	3	2	3	1	-	3	2	1	-	2
<b>CLO 5:</b>	3	3	3	2	1	1	-	2	2	1	-	1
<b>CLO 6:</b>	2	3	3	3	3	2	2	3	3	2	2	3



**Master of Science in Biotechnology (Semester-II)**

Values to **CLO-PLO** matrix are assigned by **judging the importance of the particular CLO** in relation to the PLOs.

<b>CLO – PLO correlation</b>	<b>e</b>
<b>Strong</b>	<b>3</b>
<b>Moderate</b>	<b>2</b>
<b>Low</b>	<b>1</b>
<b>No correlation</b>	<b>-</b>

● **Assessment and Evaluation**

Sr.No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Written Exam, Class Regularity, Group learning	50%
2	End-Semester Examination	Written Exam	50%

● **Suggested Learning Materials Books:**

Sr.No.	Title	Author(s)	Edition/Year	Publisher
1	Molecular Biology of the Gene	Watson et al.	7, 2017	Pearson.
2	Snyder & Champness Molecular Genetics of Bacteria	Henkin & Peters	5, 2020	ASM Press
3	Lewin's Genes XII	Krebs, Goldstein, Kilpatrick	2017	Jones & Bartlett
4	Gene Cloning and DNA Analysis	Brown, T. A.	8, 2021	Wiley
5	A Crack in Creation: CRISPR and the Future of Genetics	Doudna & Sternberg	2017	
6	Principles of Genetics	Snustad, P. D., Simmons, M	6, 2011	Wiley
7	Modern microbial genetics	Streips, U. N., & Yasbin, R. E	Vol. 344, 2002	New York: Wiley-Liss.
8	Microbial genetics	Maloy, S. R., Cronan, J. E., & Freifelder, D.	1994	Jones & Bartlett Learning.
9	Molecular Genetics	Stent, G. S., & Calendar, R.	1978	

● **Online Resources (Open Source)**

Sr.No.	Description of Resource(s)	Weblink
1	NPTEL – Molecular Genetics	<a href="http://www.digimat.in/npTEL/courses/video/102104052/102104052.html">http://www.digimat.in/npTEL/courses/video/102104052/102104052.html</a>
2	CRISPR-Cas9 animation (McGovern Institute)	<a href="https://mcgovern.mit.edu/2014/11/05/genome-editing-with-crispr-cas9/">https://mcgovern.mit.edu/2014/11/05/genome-editing-with-crispr-cas9/</a>
3	BioNumbers, EcoCyc, SGD (Saccharomyces Genome Database)	<a href="https://bionumbers.hms.harvard.edu/search.aspx?trm=veast&amp;pi=6;">https://bionumbers.hms.harvard.edu/search.aspx?trm=veast&amp;pi=6;</a> <a href="https://frontend.ga.veastgenome.org/">https://frontend.ga.veastgenome.org/</a>



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**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCBIT02	Enzyme Technology	4-0-1	120	04

**Course Learning Outcomes:**

On completing the course, the students will be able to:

- CLO1** Analyze enzyme kinetics and inhibition mechanisms using appropriate mathematical models to interpret enzyme behaviour under different conditions.
- CLO2** Apply standard and advanced techniques for enzyme production, purification, and characterization to obtain functionally active and stable enzymes.
- CLO3** Evaluate enzyme immobilization and engineering strategies to enhance enzyme stability, activity, and reusability for industrial applications.
- CLO4** Apply enzymes in industrial and biotechnological sectors such as pharmaceuticals, food, and environmental biotechnology.
- CLO5** Design and apply enzyme engineering approaches using computational and bioinformatics tools to improve enzyme structure, function, and efficiency.

Unit	Course Content	Learning Pedagogies*	CLO(s)
<b>I</b>	<b>Introduction to Enzymology and enzyme kinetics</b> History, Classification, Properties of enzyme, coenzymes, cofactors, multienzyme complex Practical enzymology—Assay, activity, progress curve, factor affecting enzyme activity Principles of enzyme kinetics, Michaelis–Menten kinetics, Linear transformation methods for kinetic analysis, Enzyme inhibition kinetics Primary and secondary plots, multi-substrate enzyme reactions, Alberty's general rate equation, Sequential and ping-pong reaction mechanisms Kinetic data analysis using statistical and computational tools	Lecture, ICT, Seminars, Inquiry based learning, SDL, Group Discussion	<b>1,5</b>
<b>II</b>	<b>Production and Recovery of Enzymes</b> Fermentation technology for enzyme production [Submerged fermentation (SmF), Solid-state fermentation (SSF)], Media optimization and culture conditions for enzyme production, Scale-up strategies in enzyme production, Sustainable enzyme production and green chemistry principles, Use of renewable substrates and agro-industrial wastes Recovery and Purification, test of purifications, case studies	Lecture, ICT, PBL, Group Discussion, Seminar, Industrial visit	<b>2,4</b>



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<b>III</b>	<p><b>Enzyme Immobilization and Enzyme Engineering</b> Principles and advantages of enzyme immobilization, Support materials and carriers used for immobilization, Methods of enzyme immobilization, Kinetic behavior of immobilized enzymes, Stability and reusability of immobilized enzymes. Immobilized enzyme reactors, Applications, Case studies</p> <p>Introduction to enzyme engineering, protein structure, structure-function relation and rational enzyme designing. Directed evolution techniques (random mutagenesis, DNA shuffling), High-throughput screening methods, Strategies for improving enzyme stability, substrate specificity and catalytic activity, Case studies of engineered enzymes</p>	Lecture, Programme based learning, Industrial visit, Research oriented, Group Discussion, Seminar	<b>3</b>
<b>IV</b>	<p><b>Applications of Free and Immobilized Enzymes, Biosensors</b> Enzymes in food processing industries (starch processing, dairy and baking), detergent industry (proteases, lipases, amylases), textile industry (desizing, biopolishing, bleaching), pharmaceutical and medical industry, biofuels</p> <p>Principles of enzyme-based biosensors, Components of biosensors (bioreceptor, transducer, signal processor), Applications of biosensors</p>	Lecture, Programme based learning, Industrial visit, Research oriented, Seminar,	<b>4</b>
<b>V</b>	<p><b>Protein Computational Biology</b> Biological databases for enzyme sequence and structure analysis, Sequence similarity, Multiple sequence alignment and phylogenetic analysis, Protein structure databases (PDB), Structural visualization tools for proteins, Prediction of enzyme active sites and binding pockets, Comparative modelling of enzymes, Molecular docking for enzyme–substrate interaction, Abzymes, Synzymes, Isoenzymes, Ribozymes</p>	Lecture, Course based learning, Programme based learning, Industrial visit, Project based	<b>5</b>

- **Assessment Methodologies**

**(A) Internal Assessment**

**a. Internal Formative assessment (30 marks)**

- (a) **Quiz (2 quizzes): 10 marks**
- (b) **Seminar: 05 marks**
- (c) **Assignment: 05 marks**
- (d) **Regularity: 05 marks**
- (e) **Group Learning: 05 marks**

**b. Internal Summative Assessment: Mid-term tests (20 marks)**

**(B) External Assessment: End of Term Examination (50 marks)**



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● **Weightage of Learning Efforts for External Assessment**

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/Analyse & above (A)	
I	1, 5	28	01	02	08	11
II	2, 4	28	01	02	08	11
III	3	24	01	02	07	10
IV	4	20	01	02	06	09
V	5	20	01	02	06	09
		<b>120</b>	<b>5</b>	<b>10</b>	<b>35</b>	<b>50</b>

● **CLOs – PLOs Matrix**

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO 1:	3	2	3	1	2	1	-	2	1	1	-	1
CLO 2:	3	2	2	1	3	1	-	3	1	1	-	2
CLO 3:	3	3	3	2	2	2	-	2	2	2	1	3
CLO 4:	3	2	2	2	1	3	1	1	3	1	1	3
CLO 5:	2	3	3	2	3	1	-	2	2	2	-	3

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

● **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Written Exam, Class Regularity, Group learning	50%
2	End-Semester Examination	Written Exam	50%



**Master of Science in Biotechnology (Semester-II)**

● **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	The chemical kinetics of enzyme action:	K. J. Laider and P. S. Bunting	2 <sup>nd</sup> Edition, 1973	Oxford University Press, London.
2	Enzyme Structure and mechanism	Alan Fersht	2 <sup>nd</sup> Edition, 1985	Reading, USA
3	Fundamentals of Enzymology:	Nicholes C. Price and Lewis Stevens	3 <sup>rd</sup> Edition, 1999	Oxford Univ. Press
4	Enzymes	M. Dixon, E. C. Webb, CJR Thorne and K. F. Tipton,	3 <sup>rd</sup> Edition, 1979	Longmans, London
5	Enzyme Technology	Anusha Bhaskar and V.G. Vidhya	1 <sup>st</sup> Edition, 2012	MJP Publishers, Chennai, India

● **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Enzyme and Microbial Technology	Enzyme and Microbial Technology   Journal   ScienceDirect.com by Elsevier
2	Enzyme Technology and Biotransformation	3527329897 C01 - Intro to Enzyme Tech: Goals & Biocatalysts - Studocu



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**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCBIT03	Cellular and Molecular Immunology	4-0-1	120	04

**Course Learning Outcomes:**

On completing the course, the students will be able to:

- CLO1** Analyze immune system organization, lymphoid architecture, and antigen processing–presentation mechanisms.
- CLO2** Comprehend immunogenetic mechanisms including antibody diversity, TCR diversity, and immune regulation.
- CLO3** Analyze immune cell signalling pathways (BCR, TCR, cytokines) in activation and homeostasis.
- CLO4** Evaluate immune dysfunctions including hypersensitivity, autoimmunity, and transplantation responses
- CLO5** Interpret tumor–immune interactions and immune evasion mechanisms.
- CLO6** Design advanced immunological applications including monoclonal antibodies, CAR-T therapy, and vaccines.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	<p><b>Fundamentals of the Immune System</b>            Introduction to immunology, Immune Recognition and Lymphoid Architecture, Advanced lymphoid organ microanatomy (e.g., germinal centres, follicular dendritic cells), Ontogeny and lineage commitment of immune cells from HSCs. Molecular Immunogenetics and Signalling V(D)J recombination, somatic hypermutation, affinity maturation, Class switch recombination mechanisms and epigenetic regulation. TCR generation, Regulation of transcription in immune cell lineages (role of GATA3, T-bet, FOXP3). Major Histocompatibility Complex: Organisation and inheritance of MHC, Structure and function of MHC class-I and class-II, MHC genes.</p>	Classroom Lecture, Problem-Based Learning, Seminars (Student-led) Micro-Projects Collaborative Learning, ICT - Enabled Learning	1,2



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<p><b>II</b></p>	<p><b>Regulation of Immune Response:</b>            B-cell receptor, Immunoglobulin super family; principles of cell signalling; B cell maturation, activation and differentiation; class switching and generation of antibody diversity            T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets, TCR-CD3 complex in immune activation and signal transduction pathways            Cytokines: properties, receptors, cytokine network and therapeutic uses, Cytokine signalling pathways            Antigen processing and presentation (endogenous and exogenous pathways)            Effector Immune Responses- Antibody and Cell-mediated Immunity, ADCC</p>	<p>Classroom Lecture            Problem-Based Learning,            Seminars (Student-led)            Micro-Projects            Collaborative Learning, ICT - Enabled Learning</p>	<p><b>3</b></p>
<p><b>III</b></p>	<p><b>Clinical Immunology</b>            Immunological tolerance: Central and peripheral tolerance, Mechanisms of tolerance            Tissue repair and homeostasis of the immune system.            Hypersensitivity: Types and mechanisms with suitable examples            Autoimmunity: Mechanisms and therapy            Transplantation Immunology- Principles of transplantation, therapeutic approaches to control rejection.            Tumour immunology: tumour antigens; immune response to tumours and tumour evasion of the immune system, cancer immunotherapy, and immunodeficiency disorders</p>	<p>Classroom Lecture,            Problem-Based Learning,            Seminars (Student-led)            Micro-Projects            Collaborative Learning, Case-based learning</p>	<p><b>4,5</b></p>
<p><b>IV</b></p>	<p><b>Vaccines and Immunotherapeutics</b>            Antibody genes and antibody engineering: generation of monoclonal antibodies, chimeric, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell-based vaccines, vaccine against cancer, T cell-based vaccine and therapeutic vaccine. Systems immunology and computational models of immune networks, CART therapy. T regulatory cells and applications</p>	<p>Classroom Lecture,            Problem-Based Learning,            Seminars (Student-led)            Micro-Projects            Collaborative Learning, Industrial Visit, ICT -Enabled Learning</p>	<p><b>6</b></p>



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**Master of Science in Biotechnology (Semester-II)**

- **Assessment Methodologies**

**(A) Internal Assessment**

**a. Internal Formative assessment (30 marks)**

(a) Quiz (2 quizzes): 10 marks

(b) Seminar: 05 marks

(c) Assignment: 05 marks

(d) Regularity: 05 marks

(e) Group Learning: 05 marks

**b. Internal Summative Assessment: Mid-term tests (20 marks)**

**(B) External Assessment: End of Term Examination (50 marks)**

- **Weightage of Learning Efforts for External Assessment**

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	1,2	30	01	01	12	14
II	3	30	01	01	12	14
III	4.5	30	01	01	09	11
IV	6	30	01	01	09	11
		<b>120</b>	<b>04</b>	<b>04</b>	<b>41</b>	<b>50</b>

- **CLOs – PLOs Matrix**

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO 1:	3	1	2	2	1	1	-	1	2	1	-	1
CLO 2:	3	2	3	2	1	1	-	1	1	1	-	1
CLO 3:	3	2	2	2	1	1	-	1	2	1	-	1
CLO 4:	3	2	3	1	1	2	1	1	3	1	-	2
CLO 5:	3	2	2	1	1	2	-	1	3	1	-	2
CLO 6:	2	3	3	3	3	3	2	3	3	2	2	3

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
<b>Strong</b>	<b>3</b>
<b>Moderate</b>	<b>2</b>
<b>Low</b>	<b>1</b>
<b>No correlation</b>	<b>-</b>



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● **Assessment and Evaluation**

<b>Sr. No.</b>	<b>Assessment/Evaluation</b>	<b>Component</b>	<b>Weightage (%)</b>
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Written Exam, Class Regularity, Group learning	50 %
2	End-Semester Examination	Written Exam	50 %



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### Master of Science in Biotechnology (Semester-II)

#### ● Suggested Learning Materials Books:

Sr.No.	Title	Author(s)	Edition/Year	Publisher
1	Kuby immunology	Owen, J. A., Punt, J., & Stranford, S. A.	8 <sup>th</sup> ed. 2019	WH Freeman and co. New York.
2	Cellular and molecular immunology	Abbas, A. K., Lichtman, A. H., & Pillai, S.	9 <sup>th</sup> ed. (2018)	Elsevier Health Sciences.
3	Immunology (8th Edn)	Male, D., Brostoff, J., Roth, D., & Roitt, I.	8 <sup>th</sup> ed.2012	Elsevier Health Sciences.
4	Janeway's Immunobiology	Murphy, K., & Weaver, C.	9 <sup>th</sup> ed. 2016	Garland Science.
5	Immunology, Infection and Immunity	Gerlad B. Pier, Jeffrey B. Lyczak & Lee M Wetzler	2004	ASM Press
6	Fundamentals of Immunology	William. E. Paul	7 <sup>th</sup> ed.2013	Lippincott Williams & Wilkins

#### ● Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Immunology	<a href="https://onlinecourses.nptel.ac.in/noc25_bt58/">https://onlinecourses.nptel.ac.in/noc25_bt58/</a>
2	Advanced Immunology	<a href="https://www.immunopaedia.org.za/online-courses/">https://www.immunopaedia.org.za/online-courses/</a>
3	Advanced Immunology	<a href="https://www.aai.org/Education/Courses">https://www.aai.org/Education/Courses</a>



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**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCBIT04	Microbial Genetics and Immunology Laboratory	0-8-0	120	04

**Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

- CLO1:** Perform standard molecular genetics techniques including conjugation, transformation, and transduction.
- CLO2:** Design and execute genetic mapping experiments.
- CLO3:** Analyze genetic data using computational tools.
- CLO4:** Demonstrate skills in immunological sample handling and assays including serum separation, bactericidal activity of serum, and complement fixation techniques
- CLO5:** Evaluate antigen–antibody interactions using immunological assays such as neutralization tests, hemagglutination tests, ELISA, and dot blot techniques.
- CLO6:** Apply protein separation and detection techniques including serum electrophoresis and immunofluorescence for qualitative and quantitative analysis of biomolecules.
- CLO7:** Maintain laboratory records and interpret results in the context of genetic and immunological experimental data.

Unit/ Sr.No	Course Content	Learning Pedagogies*	CLO(s)
	<ol style="list-style-type: none"> <li>1. Isolation of Bacteriophage from natural source, enrichment of lysate and enumeration of phage by plaque assay method</li> <li>2. Measurement of growth-one step growth curve using a T even phage and determination of burst size</li> <li>3. Induced mutagenesis by UV and Chemicals in <i>E. coli</i>/ <i>Serratia marcescens</i> (5-BU/NTG/EES)</li> <li>4. Transformation of <i>E. coli</i> by plasmid DNA and computation of transformation efficiency.</li> <li>5. Bacterial Conjugation (F<sup>+</sup> x F<sup>-</sup>); Analysis of Interrupted Mating data for mapping.</li> <li>6. Transduction in <i>E. coli</i> and analysis of transduction data for mapping.</li> <li>7. Agrobacterium mediated Transformation</li> <li>8. <b>Dry lab:</b> Tetrad analysis using experimental data</li> <li>9. Bactericidal action of serum</li> </ol>	Interactive lectures Problem-Based Learning Experiential learning Research-Oriented Learning Micro-Projects/Mini Research Task Industrial Visit/Institutional Visit	<b>1 To 7</b>



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	10. Complement fixation test (demonstration) 11. Neutralization test 12. Serum electrophoresis 13. ELISA, Dot Blot 14. Immunofluorescence test		
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• **Assessment Methodologies**

**(A) Internal Assessment (50 marks)**

**a. Internal Formative assessment (30 marks)**

- i. **Regularity :05 marks**
- ii. **Performance in Laboratory: 05 marks**
- iii. **Laboratory Record: 05**
- iv. **Group Learning: 05**
- v. **Spotting/Quiz: 05**
- vi. **Viva Voce: 05**

**b. Internal Summative Assessment**

**Problem based learning: 20**

**(B) External Assessment: 50 marks**

• **Weightage of Learning Efforts for External Assessment**

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
	1 to 7	120	10	10	30	50

• **CLOs – PLOs Matrix**

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO 1:	3	2	2	1	3	1	-	3	1	1	-	1
CLO 2:	3	3	3	3	2	1	-	3	2	1	-	2
CLO 3:	2	3	3	2	3	1	-	2	1	2	-	2
CLO 4:	3	2	2	1	3	2	3	3	2	1	-	1
CLO 5:	3	2	3	2	3	2	-	3	3	1	-	2
CLO 6:	3	2	2	1	3	1	-	3	1	1	-	2
CLO 7:	1	2	2	2	1	1	1	2	3	3	2	3



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**Master of Science in Biotechnology (Semester-II)**

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

● **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Laboratory Performance, Laboratory Records, Team work, Viva Voce Regularity, Problem Solving.	50%
2	End-Semester Examination	Practical Exam (Approach, Performance, Interpretation and Spots/Viva)	50%

● **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Experiments in Bacterial Genetics: A Laboratory Manual	Lionello Bossi, Andrew Camilli, Angelika Gründling	2024	Cold Spring Harbor Laboratory Press
2	Molecular Cloning: A Laboratory Manual	Michael R. Green, Joseph Sambrook	4 <sup>th</sup> Edition, 2012	Cold Spring Harbor Laboratory Press
3	Short Protocols in Molecular Biology	Frederick M. Ausubel, Roger Brent , Robert E. Kingston , David D. Moore , J. G. Seidman, John A. Smith	1995	John Wiley & Sons

● **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Restriction Endonuclease Database REBASE	<a href="http://rebase.neb.com">http://rebase.neb.com</a>



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## Master of Science in Biotechnology (Semester-II)

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCBIT05	Enzyme Technology Laboratory	0-8-0	120	04

### Course Learning Outcomes (CLOs)

On completion of this course, students will be able to:

- CLO1:** Design and execute protocols for isolation, screening, and selection of enzyme-producing microorganisms from environmental samples.
- CLO2:** Analyze and optimize physicochemical (pH, temperature, incubation time) and nutritional parameters (carbon and nitrogen sources) for enhanced enzyme production.
- CLO3:** Demonstrate proficiency in enzyme production under submerged fermentation and perform downstream processing including extraction, purification (salt precipitation, dialysis), and protein quantification.
- CLO4:** Evaluate enzyme activity, reaction kinetics, and catalytic efficiency using quantitative assays, progress curves, and kinetic models (Michaelis–Menten and linear transformations).
- CLO5:** Assess the effects of environmental factors (pH, temperature) and inhibitors on enzyme activity and stability, and interpret enzyme inhibition mechanisms.
- CLO6:** Develop and compare immobilized enzyme systems with free enzymes, and critically analyze their efficiency, stability, and potential industrial applications.

Unit/ Sr.No	Course Content	Learning Pedagogies*	CLO(s)
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## Master of Science in Biotechnology (Semester-II)

	<ol style="list-style-type: none"> <li>1. Isolation and Screening of Enzyme-Producing Microorganisms from Environmental Samples</li> <li>2. Determination of Enzyme Production Potential of Selected Microbial Strains.</li> <li>3. Optimization of Culture Conditions (pH, Temperature, Incubation Time) for Enzyme Production</li> <li>4. Optimization of Nutritional Parameters (OFAT and statistical) for Enzyme Production</li> <li>5. Production of Enzymes under Submerged Fermentation Conditions</li> <li>6. Extraction of Crude Enzyme from Microbial Culture</li> </ol>	Experiential Learning, Industrial Visit/Institutional Visit, Research-Oriented Learning, Problem Based Learning, Collaborative Learning, Micro-Projects/Mini Research Tasks	<b>1 To 6</b>
	<ol style="list-style-type: none"> <li>7. Purification of Enzymes by Precipitation and Dialysis Techniques</li> <li>8. Determination of Enzyme Activity by Quantitative Assay of Reaction Products.</li> <li>9. Determination of Enzyme Reaction Progress Curve (Product Formation vs Time)</li> <li>10. Determination of Substrate Saturation Curve and Enzyme Kinetics (Michaelis–Menten and Linear Plots).</li> <li>11. Optimization of pH and Temperature for Enzyme Activity</li> <li>12. Determination of Effect of Temperature on Enzyme Stability</li> <li>13. Determination of Enzyme Inhibition Kinetics and Identification of Inhibition Type</li> <li>14. Immobilization of Enzymes and Comparative Analysis of Free and Immobilized Enzyme Activity.</li> </ol>		

- **Assessment Methodologies**

**(A) Internal Assessment (50 marks)**

**a. Internal Formative assessment (30 marks)**

- i. **Regularity :05 marks**
- ii. **Performance in Laboratory: 05 marks**
- iii. **Laboratory Record: 05**
- iv. **Group Learning: 05**
- v. **Spotting/Quiz: 05**
- vi. **Viva Voce: 05**

**b. Internal Summative Assessment**

**Problem based learning: 20**



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## Master of Science in Biotechnology (Semester-II)

### (B) External Assessment: 50 marks

- Weightage of Learning Efforts for External Assessment

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
	1 to 6	120	10	10	30	50

- CLOs – PLOs Matrix

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO 1:	3	2	2	1	3	2	2	3	1	1	-	1
CLO 2:	3	3	3	2	3	1	-	3	2	1	-	1
CLO 3:	3	2	2	1	3	2	-	3	1	1	-	2
CLO 4:	3	3	3	2	3	1	-	3	1	1	-	1
CLO 5:	3	3	3	2	3	1	-	3	1	1	-	1
CLO6:	2	3	3	2	3	3	-	3	2	2	-	3

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Laboratory Performance, Laboratory Records, Team work, Viva Voce Regularity, Problem Solving.	50%
2	End-Semester Examination	Practical Exam (Approach, Performance, Interpretation and Spots/Viva)	50%



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## Master of Science in Biotechnology (Semester-II)

### ● Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	An Introduction to Practical Biochemistry	David T. Plummer	3rd Ed., 2001	McGraw-Hill
2	Practical Biochemistry: Principles and Techniques	Keith Wilson & John Walker	7th Ed., 2010	Cambridge University Press
3	Laboratory Manual in Biochemistry	J. Jayaraman	2nd Ed., 2011	New Age International
4	Experimental Biochemistry: A Student Companion	Beedu Sasikala	1st Ed., 2014	Academic Press
5	Methods in Enzymology (Series)	Sidney P. Colowick & Nathan O. Kaplan (Editors)	Multiple Volumes	Academic Press
6	Enzyme Assays: A Practical Approach	Robert Eienthal & Michael J. Danson	2nd Ed., 2002	Oxford University Press
7	Biochemical Methods	S. Sadasivam & A. Manickam	3rd Ed., 2008	New Age International
8	Laboratory Techniques in Biochemistry and Molecular Biology (Series)	T. S. Work & E. Work	Multiple Volumes	Elsevier
9	Principles and Techniques of Biochemistry and Molecular Biology	Keith Wilson & John Walker	7th Ed., 2010	Cambridge University Press
10	Basic Biochemical Methods	S. K. Sawhney & Randhir Singh	1st Ed., 2000	Narosa Publishing

### ● Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Step-by-step protocols for enzyme assays, protein purification, and molecular biology techniques	<a href="https://www.protocols.io">https://www.protocols.io</a>



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2	Open-access experimental protocols and methods in life sciences (includes enzyme techniques)	<a href="https://www.nature.com/protocolexchange">https://www.nature.com/protocolexchange</a>
3	Video-based demonstrations of enzyme kinetics, chromatography, electrophoresis, and lab techniques	<a href="https://www.jove.com">https://www.jove.com</a>
4	Educational resources and lab protocols for biochemistry and molecular biology techniques	<a href="https://www.bio-rad.com/en-in/applications-technologies">https://www.bio-rad.com/en-in/applications-technologies</a>
5	OpenWetWare: community-driven platform with detailed experimental protocols and lab notes	<a href="https://openwetware.org">https://openwetware.org</a>
6	NCBI Bookshelf and resources explaining experimental methods and biochemical assays	<a href="https://www.ncbi.nlm.nih.gov/books">https://www.ncbi.nlm.nih.gov/books</a>
7	LabXchange (Harvard) – interactive simulations and lab-based learning modules in biology and biochemistry	<a href="https://www.labxchange.org">https://www.labxchange.org</a>



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**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSE	P2S02NEBIT01	Biostatistics Using R	0-4-0	60	02

**Course Learning Outcomes (CLOs)**

On completing the course, the students will be able to:

- CLO1:** Demonstrate proficiency in R programming for biological data manipulation, cleaning, and preprocessing.
- CLO2:** Construct advanced biological visualizations including bar plots with error bars, box plots, and violin plots to represent data variability.
- CLO3:** Apply and interpret parametric and non-parametric tests appropriate for specific experimental designs in life sciences.
- CLO4:** Execute and validate regression models (simple, multiple, and logistic) for biological prediction and association studies.
- CLO5:** Effectively communicate statistical findings using professional-grade R outputs and comprehensive analysis pipelines.

Unit	Course Content	Learning Pedagogies *	CLO(s)
<b>I</b>	<p><b>Introduction to R Environment:</b>            Data Visualization in Bioscience I: scatter plots, box plots, bar graphs with error bars, aesthetics, axis labelling, legends, and theme customization.            Data Visualization in Bioscience II: Heat maps using heatmap or Complex Heatmap packages, Violin plots            t-Test: One sample, two sample, paired t-test            One-Way ANOVA: Checking Assumptions using visualization methods and tests Post-Hoc Analysis for ANOVA            Categorical Data Analysis: Test of proportion, Chi-square test Association etc.</p>	Classroom Lectures, Case Based Learning, Problem Based Learning, Micro-Projects,	<b>1,2,3</b>
<b>II</b>	<p><b>Non-Parametric Alternatives I:</b>            Wilcoxon Signed-Rank Test and Mann-Whitney U Test as Alternatives to t-Tests  <b>Non-Parametric Alternatives II:</b> Kruskal-Wallis Test and Dunn's Post-Hoc Test as Alternatives to One-Way ANOVA            Simple Linear Regression:            Multiple Regression:            Logistic Regression:            Case Study:</p>	Micro-Projects, ICT-Enable Learning, Classroom Lectures, Case Based Learning, Problem Based Learning	<b>3,4,5</b>



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**Master of Science in Biotechnology (Semester-II)**

- **Assessment Methodologies**

**(A) Internal Assessment**

**a. Internal Formative assessment (15 marks)**

- (a) **Quiz: 05 marks**
- (b) **Class Regularity: 05 marks**
- (c) **Assignment: 05 marks**

**b. Internal Summative Assessment (10 marks)**

**(B) End of Term Examination: 25 marks**

- **Weightage of Learning Efforts for External Assessment**

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	1,2,3	30	02	02	07	11
II	3,4,5	30	03	03	08	14
		<b>60</b>	<b>05</b>	<b>05</b>	<b>15</b>	<b>25</b>

- **CLOs – PLOs Matrix**

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO 1:	2	2	3	3	3	1	-	2	1	1	-	1
CLO 2:	2	1	2	2	3	1	-	1	2	3	-	2
CLO 3:	3	3	3	3	2	1	1	2	2	1	-	1
CLO 4:	3	3	3	3	2	1	1	2	3	1	-	2
CLO 5:	1	2	3	3	2	2	2	2	3	3	3	3

Values to CLO-PLO matrix are assigned by **judging the importance of the particular CLO** in relation to the PLOs.

CLO – PLO correlation	Value
<b>Strong</b>	<b>3</b>
<b>Moderate</b>	<b>2</b>
<b>Low</b>	<b>1</b>
<b>No correlation</b>	<b>-</b>

- **Assessment and Evaluation**

Sr.No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Group Learning, Written Exam	50%
2	End-Semester Examination	Written Exam	50%



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## Master of Science in Biotechnology (Semester-II)

### ● Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Dalgaard, P.	Introductory Statistics with R	2008	Springer Science & Business Media
2	Logan, M.	Biostatistical Design and Analysis Using R: A Practical Guide	2010	Wiley-Blackwell.
3	Zar, J. H.	Biostatistical Analysis	2010	Pearson Education

### ● Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Free textbook	<a href="https://learningstatisticswithr.com/">https://learningstatisticswithr.com/</a>
2	R for Data Science: Online textbook	<a href="https://r4ds.hadley.nz/">https://r4ds.hadley.nz/</a>
3	Modern Statistics with R: Online textbook	<a href="https://www.modernstatisticswithr.com/">https://www.modernstatisticswithr.com/</a>
4	simpleR – Using R for Introductory Statistics: Online textbook	<a href="https://cran.r-project.org/doc/contrib/Verzani-SimpleR.pdf">https://cran.r-project.org/doc/contrib/Verzani-SimpleR.pdf</a>
5	Swirl: Interactive R package learning resource	<a href="https://swirlstats.com/">https://swirlstats.com/</a>
6	Cloud based hands on tutorials	<a href="https://posit.cloud/learn/recipes">https://posit.cloud/learn/recipes</a>
7	Harvard University's "Statistics and R"	<a href="https://pll.harvard.edu/course/statistics-and-r">https://pll.harvard.edu/course/statistics-and-r</a>



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**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSE	P2S02NEBIT02	Microtechniques	1-2-0	60	02

**Course Learning Outcomes (CLOs)**

On completing the course, the students will be able to:

- CLO1** Explain principles and procedures of sample preparation techniques such as maceration, squash, and clearing for microscopic analysis.
- CLO2** Describe fixation, dehydration, infiltration, embedding, and staining methods used in light microscopy and evaluate their significance in tissue preservation.
- CLO3** Apply microtomy techniques using rotary, sliding, and cryostat microtomes for sectioning biological specimens.
- CLO4** Analyse histochemical localization of cellular components such as carbohydrates, proteins, lipids, lignin, and nucleic acids in plant tissues.
- CLO5** Interpret principles and procedures involved in electron microscopy sample preparation including fixation, ultrathin sectioning, staining, and grid preparation.
- CLO6** Evaluate ultrastructural cytochemistry and enzyme localization techniques, including immunocytochemistry, for advanced cellular studies.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	<p><b>Techniques in Light Microscopy</b>  Maceration, squash and clearing techniques.  Sample preparation for light microscopy.  Classification of fixatives, formulas (Plants).  Processing samples for light microscopy: Fixation, dehydration, infiltration, embedding media, staining (Stains and staining procedures- negative and positive staining procedures).  Microtomes: Rotary, sliding, cryostat.  Histochemical localization of metabolites for light microscopy: Starch, proteins, lipids, total carbohydrates, lignins, polyphenols, nucleic acid, histones, cutin, suberin and waxes. Localization of enzymes: Peroxidase, acid phosphatase and succinic dehydrogenase.</p>	<p>Classroom  Lecture,  Seminars,  Case-Based Learning,  Experiential Learning,  ICT-Enabled Learning,  Self-Directed Learning</p>	1, 2, 3, 4



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<b>II</b>	<b>Techniques in Electron Microscopy</b> Freeze etching and freeze fracturing. Sample preparation for Electron microscope: Fixatives, double fixation, dehydration and infiltration, embedding media and embedding, sectioning (semi thin sectioning, ultrathin sectioning), grids, formvar coating, Staining for electron microscopy. Fixation and embedding of particulate samples like bacteria, virus etc. Operations of ultramicrotome and freezing ultramicrotome. Ultrastructural cytochemistry: Tannin, protein, cell wall polysaccharide, lignin and membrane. Ultrastructural cytochemistry: Enzymes: Peroxidase and phosphatase. Immunocytochemistry.	Classroom Lecture, Seminars, Case-Based Learning, Research-Oriented Learning, Experiential Learning, ICT-Enabled Learning	<b>5, 6</b>
<b>III</b>	<b>Techniques in Light Microscopy</b> Maceration, squash and clearing techniques. Sample preparation for light microscopy. Classification of fixatives, formulas (Plants). Processing samples for light microscopy: Fixation, dehydration, infiltration, embedding media, staining (Stains and staining procedures- negative and positive staining procedures). Microtomes: Rotary, sliding, cryostat. Histochemical localization of metabolites for light microscopy: Starch, proteins, lipids, total carbohydrates, lignins, polyphenols, nucleic acid, histones, cutin, suberin and waxes. Localization of enzymes: Peroxidase, acid phosphatase and succinic dehydrogenase.	Classroom Lecture, Seminars, Case-Based Learning, Experiential Learning, ICT-Enabled Learning, Self-Directed Learning	<b>1, 2, 3, 4</b>

- **Assessment Methodologies**

**(A) Internal Assessment**

**a. Internal Formative assessment (15 marks)**

(a) **Quiz: 05 marks**

(b) **Seminar: 05 marks**

(c) **Group Learning/Assignment: 05 marks**

**b. Internal Summative Assessment (10 marks)**

**(B) End of Term Examination: 25 marks**



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**Master of Science in Biotechnology (Semester-II)**

● **Weightage of Learning Efforts for External Assessment**

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/Analyse & above (A)	
I	1 to 4	20	01	01	06	08
II	5, 6	20	01	01	07	09
III	1 to 4	20	-	-	08	08
		<b>60</b>	<b>02</b>	<b>02</b>	<b>21</b>	<b>25</b>

● **CLOs – PLOs Matrix**

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO 1:	3	1	2	1	3	1	-	3	1	1	-	1
CLO 2:	3	2	2	2	3	1	-	3	1	1	-	1
CLO 3:	2	1	2	1	3	1	1	3	1	1	-	2
CLO 4:	3	2	3	2	3	1	-	3	2	1	-	2
CLO 5:	3	2	3	2	3	2	-	3	2	1	-	2
CLO 6:	3	3	3	3	3	3	2	3	3	2	1	3

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

● **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Group Learning, Written Exam	50
2	End-Semester Examination	Written Exam	50



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### Master of Science in Biotechnology (Semester-II)

#### ● Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Microscopy and Microtechnique	R. Marimuthu	2017	MJP Publishers
2	Plant Microtechnique	Johansen	1940	McGraw-Hill Inc., USA
3	Botanical Microtechnique and Cytochemistry	Berlyn	1976	Wiley-Blackwell, USA
4	Study of Plant Structure	O'Brien & McCully	1969	Termarcaphi Pty. Ltd.
5	Botanical Microtechniques: Principle and practice	S. M. Khasim	2002	Capital Publishing Company

#### ● Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Transmission Electron Microscopy	<a href="https://nptel.ac.in/courses/113106924">https://nptel.ac.in/courses/113106924</a>
2	Fundamentals of Cryo-Electron Microscopy	<a href="https://nptel.ac.in/courses/102108668">https://nptel.ac.in/courses/102108668</a>
3	Electron Microscopy-I	<a href="https://archive.nptel.ac.in/content/storage2/courses/102103047/module6/lec34/1.html">https://archive.nptel.ac.in/content/storage2/courses/102103047/module6/lec34/1.html</a>



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**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSE	P2S02NEBIT03	Developmental Biology	2-0-0	60	02

**Course Learning Outcomes (CLOs)**

On completing the course, the students will be able to:

- CLO1:** Understand key concepts of Developmental Biology including cell fate, induction, and differentiation in plants and animals.
- CLO2:** Explain gametogenesis, fertilization, and early embryonic development along with underlying molecular mechanisms.
- CLO3:** Analyze morphogenesis and organogenesis using model organisms like *Drosophila melanogaster* and *Caenorhabditis elegans*.
- CLO4:** Apply developmental principles to plant systems including embryogenesis, seed formation, and environmental regulation.

Unit	Course Content	Learning Pedagogies*	CLO(s)
<b>I</b>	Basic concepts of Development, fertilization and early development Induction, competence, induction, specification, determination, differentiation, dedifferentiation, redifferentiation; Fate maps, cell fate, cell lineages; Stem cells: potency, genomic equivalence, cytoplasmic determinants Gametogenesis: spermatogenesis and oogenesis-structure and function of gametes; Fertilization: mechanisms, sperm-egg interaction, egg activation; Molecular basis of development; development of germ layers in animals Male gametophyte development, embryo sac development and double fertilization in plants, embryogenesis, establishment of symmetry in plants, seed formation, embryo and endosperm developmental dynamics and germination	Classroom Lecture Case-Based Learning Problem-Based Learning ICT-Enabled Learning Seminars	<b>1,2</b>
<b>II</b>	Morphogenesis and organogenesis in plants and animals Organization of shoot and root apical meristem, shoot and root development, leaf development and phyllotaxy, transition to flowering, floral meristems, organogenesis and floral development Cell aggregation and differentiation in Dictyostelium, axes and pattern formation in Drosophila, amphibia and chick; organogenesis - vulva formation in <i>Caenorhabditis elegans</i> , eye lens induction, limb development and regeneration in vertebrates, differentiation of neurons, post embryonic	Classroom Lecture Case-Based Learning Seminar Problem-Based Learning Inquiry-	<b>3,4</b>



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	development - larval formation, metamorphosis; environmental regulation of normal development; sex determination	Based Learning ICT-Enabled Learning Seminars	
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● **Assessment Methodologies**

**(A) Internal Assessment**

**a. Internal Formative assessment (15 marks)**

(a) Quiz: 05 marks

(b) Seminar: 05 marks

(c) Group Learning/Assignment: 05 marks

**b. Internal Summative Assessment (10 marks)**

**(B) End of Term Examination: 25 marks**

● **Weightage of Learning Efforts for External Assessment**

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/Analyse & above (A)	
I	1,2	30	02	04	06	12
II	3,4	30	02	04	07	13
		<b>60</b>	<b>04</b>	<b>08</b>	<b>13</b>	<b>25</b>

● **CLOs – PLOs Matrix**

CLOs \ PLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO 1:	3	1	2	2	1	1	-	1	2	1	-	1
CLO 2:	3	1	2	2	1	1	-	1	1	1	-	1
CLO 3:	3	2	3	2	2	1	-	2	2	1	-	2
CLO 4:	3	2	2	1	1	2	-	1	2	1	-	1

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-



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Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

## Master of Science in Biotechnology (Semester-II)

### ● Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Group Learning, Written Exam	50
2	End-Semester Examination	Written Exam	50

### ● Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Developmental Biology	Scott F. Gilbert & Michael J.F. Barresi	13th Ed. (2023)	Oxford University Press
2	Principles of Development	Lewis Wolpert et al.	6th Ed. (2019/20)	Oxford University Press
3	Essential Developmental Biology	Jonathan Slack	4th Ed. (2021)	Wiley-Blackwell
4	Langman's Medical Embryology	T.W. Sadler	15th Ed. (2023)	Wolters Kluwer
5	Analysis of Biological Development	Klaus Kalthoff	2nd Ed. (2000)	McGraw-Hill

### ● Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Introduction to Developmental Biology	<a href="https://nptel.ac.in/courses/102106084">https://nptel.ac.in/courses/102106084</a>



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**Master of Science in Biotechnology (Semester-II)**

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSE	P2S02NEBIT04	Molecular Endocrinology	2-0-0	60	02

**Course Learning Outcomes (CLOs)**

On completing the course, the students will be able to:

- CLO1:** Demonstrate understanding of endocrine glands and hormone classification
- CLO2:** Analyse hormone synthesis secretion and regulation mechanisms
- CLO3:** Evaluate certain endocrine diseases with reference to etymology symptoms treatment modalities

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	<b>Introduction to Endocrine System and hormones:</b> Hormones: Classification, Synthesis & Functions: Classes of hormones: peptide, steroid, thyroid, eicosanoids, pheromones, Hormone synthesis, storage, transport, metabolism; Endocrinology of pregnancy, parturition and lactation; Synthetic hormones: Insulin analogues, Steroid drugs; Industrial applications: Fertility regulation, Growth promoters, Endocrine disruptors (EDCs), Pharmaceutical hormone production	Classroom Lecture Research-Oriented Learning Inquiry-Based Learning ICT-Enabled Learning	1,2
II	<b>Pathophysiology of Endocrine Glands:</b> Overview of methods to study Hormone-receptor interactions, Disorders of endocrine glands: Pituitary, thyroid, adrenal, pancreas, gonads; Hormone imbalance and diseases, Hormone replacement therapy Clinical case studies: Diabetes mellitus, Hypo/hyperthyroidism, Cushing's syndrome, PCOS, Diagnostic interpretation (laboratory reports and imaging interpretation), Personalized endocrine therapy	Classroom Lecture Case-Based Learning Problem-Based Learning Seminars	2,3

- **Assessment Methodologies**

- (A) **Internal Assessment**

- a. **Internal Formative assessment (15 marks)**
  - (a) **Quiz: 05 marks**
  - (b) **Seminar: 05 marks**
  - (c) **Group Learning/Assignment: 05 marks**
- b. **Internal Summative Assessment (10 marks)**

- (B) **End of Term Examination: 25 marks**



**Master of Science in Biotechnology (Semester-II)**

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CLO 2:	3	2	3	2	1	1	-	2	2	1	-	1
CLO 3:	3	3	3	2	1	2	2	2	3	2	2	2

Values to CLO-PLO matrix are assigned by **judging the importance of the particular CLO** in relation to the PLOs.

CLO – PLO correlation	Value
<b>Strong</b>	<b>3</b>
<b>Moderate</b>	<b>2</b>
<b>Low</b>	<b>1</b>
<b>No correlation</b>	<b>-</b>

● **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
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### Master of Science in Biotechnology (Semester-II)

#### ● Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/ Year	Publisher
1	Principles and Techniques of Biochemistry and Molecular Biology	Keith Wilson & John Walker	8th Ed. (2018)	Cambridge Univ. Press
2	Vertebrate Endocrinology	David O. Norris & James A. Carr	6th Ed. (2021)	Academic Press Elsevier)
3	Greenspan's Basic and Clinical Endocrinology	David G. Gardner & Dolores Shoback	10th Ed. (2017/20)	McGraw Hill
4	Endocrinology: An Integrated Approach	Stephen Nussey & Saffron Whitehead	1st Ed. (2022)	BIOS Scientific Publishers
5	Imaging in Endocrine Disorders	Sahdev, A. & Reznik, R.	1st Ed. (2023)	Springer

#### ● Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Endocrinology	<a href="https://onlinecourses.swayam2.ac.in/e-learning/preview/cec20_bt21">https://onlinecourses.swayam2.ac.in/e-learning/preview/cec20_bt21</a>