Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

Structure and Curriculum of Four Year Multidisciplinary Degree (Honors) Programme with Multiple Entry and Exit option

Undergraduate Programme of Science and Technology

B.Sc. (Honors) in Biotechnology

Board of Studies

in

Biotechnology

Rajarshi Shahu Mahavidyalaya, Latur

(Autonomous)

[UG III Year]

w.e.f. June, 2025

(In Accordance with NEP-2020)

Review Statement

The NEP Cell reviewed the Curriculum of **B.Sc. (Honors) in Biotechnology** Programme to be effective from the **Academic Year 2023-24.** It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 09/08/2023

Place: Latur

NEP Cell
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of B.Sc. **(Honors) in Biotechnology** Programme to be effective from the **Academic Year 2025-26.**

Date: 01/04/2025

Place: Latur

(Dr.Sachin Kulkarni)
Chairperson
Board of Studies in Biotechnology
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Members of Board of Studies in the Subject Biotechnology
Under the Faculty of Science and Technology

Sr. No.	Name	Designation	In position
1	**Dr. Sachin S. Kulkarni** Head, Department of Biotechnology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous)	Chairperson	HoD
2	**Prof. Tukaram. A. Kadam** Professor, School of Life Sciences SRTMU, Nanded.	Member	V.C. Nominee
3	**Dr. Rahul. P. Bhagat** Asst. Professor, Department of Biotechnology, Govt. Institute of Science, Aurangabad (Autonomous)	Member	Academic Council Nominee
4	**Dr. Rajesh M. Jorgewad** Asst. Professor, Department of Biotechnology and Bioengineering, KIT college, Kolhapur (Autonomous)	Member	Academic Council Nominee
5	**Dr. Gunderao. H. Kathwate** Asst. Professor, Dept. of Biotech. S. P. P. U. Pune	Member	Expert from outside for Special Course
6	**Mr. Abhay. M. Desai** Wockhardt, Aurangabad	Member	Expert from Industry
7	**Dr. Santosh Narwade** Serum Institute Pvt.Ltd. Pune	Member	P.G. Alumni
8	**Dr. Manisha. A. Dhotre**	Member	Faculty Member
9	**Mr. Udaybhanu. P. Sirdeshmukh**	Member	Faculty Member
10	**Dr. Ravindra. B. Ade**	Member	Faculty Member
11	**Dr. Sanghapal. S. Kshirsagar**	Member	Faculty Member
12	**Mr. Suraj. D. Kadam**	Member	Faculty Member
13	**Mr. Akash. J. Waghmare**	Member	Faculty Member
14	**Miss. Swati G. Swami**	Member	Faculty Member
15	**Mr. Sanket M. Bansode**	Member	Faculty Member
16	**Miss. Karuna S. Komatwar**	Member	Faculty Member
17	**Dr. Kakasaheb S. Raut**	Member	Member from same Faculty

From the Desk of the Chairperson…

Biotechnology as a subject is a highly interdisciplinary that combines biological sciences with engineering technologies to manipulate living organisms and biological systems to produce products that advances healthcare, medicine, agriculture, food, pharmaceuticals and environment. At its simplest, biotechnology is technology based on biology - which harnesses cellular and bimolecular processes to develop technologies and products that help to improve our lives and health of our planet.

Taking into consideration of the importance of Biotechnology, Rajarshi Shahu Mahavidyalaya, Latur (Autonomous), have taken an initiative to introduce a new emerging field as an undergraduate Programme in biotechnology under the faculty of science. B. Sc. Biotechnology is a Three-year graduate degree program which is started in the academic year 2004-05 followed by the postgraduate program started in academic year 2006-07.

National Education Policy (NEP) 2020 recognizes the relevance of biotechnology in the education system due to its interdisciplinary nature, potential for research and innovation, and its alignment with the development of 21st-century skills. By integrating biotechnology into the curriculum, the policy aims to prepare students for the challenges and opportunities of a rapidly advancing biotechnology driven world.

NEP-2020 has conceptualized the idea to develop well rounded competent individuals for making the nation a self-reliant and global leader. In the same spirit, we at Department of Biotechnology, have developed a curriculum framework to encompass the goals of NEP 2020. In the overall curriculum we have incorporated choice of courses of study, creating academic pathways having constructive combinations with multiple entry and exit points as well as focus on experiential learning for students by introducing multidisciplinary, skill enhancement, vocational courses along generic elective(s) and course based on Indian knowledge system and actual Hand's on training in the recent and trending areas of Biotechnology.

With reference to global changes occurring in higher education in various national and foreign universities, the newly designed syllabi of B.Sc. Biotechnology as per NEP 2020 guidelines are effectively implemented from June, 2023. The committee members of Board of Studies in Biotechnology also took the local need and employability of graduate students into consideration while framing the given curriculum, keeping in view of the guidelines given in the University Grants Commission, New Delhi.

By aligning curriculum development, pedagogy, interdisciplinary connections, research opportunities, industry collaborations, teacher training, and available infrastructure with the institute, the department of biotechnology plans to integrate students with a comprehensive understanding of biotechnology, foster critical thinking and research skills, and prepare them for future careers in the field.

(Dr. Sachin Kulkarni)
Chairperson
Board of Studies in Biotechnology

Shiv Chhatrapati Shikshan Sanstha's

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Rajarshi Shahu Mahavidyalaya, Latur

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Faculty of Science and Technology

Structure for Four Year Multidisciplinary Undergraduate Degree Programme in Biotechnology Multiple Entry and Exit (In accordance with NEP-2020)

Year & Level	Sem	Major		Minor	GE/ OE	VSC/ SEC (VSEC)	AEC/ VEC	OJT, FP, CEP, RP	Credit per Sem.	Cum./Cr. per exit
		DSC	DSE							
1	**2**	**3**		**4**	**5**	**6**	**7**	**8**	**9**	**10**
III 5.5	V	DSC IX: 04 Cr. DSC X: 04 Cr.	DSE I: 04 Cr.	Minor III:04 Cr.	NA	VSC III: 02 Cr.	VEC III: 02 Cr.	Minor IV: 02 Cr.	22	88+44 Cr. UG Degree
	VI	DSC XI: 04 Cr. DSC XII: 04 Cr.	DSE II: 04 Cr.	Minor V:04 Cr.	NA	VSC IV: 02 Cr.	NA	Academic Project/I APC/OJT /FE : 04 Cr.	22	
	Cum. Cr.	16	08	08	-	04	02	06	44	
Exit Option: Award of UG Diploma in Major with 88Credits and Additional 04 Credits Core NSQF Course/Internship or continue with Major and Minor										

Abbreviations:

1.	DSC	: Discipline Specific Core (Major)
2.	DSE	: Discipline Specific Elective (Major)
3.	DSM	: Discipline Specific Minor
4.	OE	: Open Elective
5.	VSEC	: Vocational Skill and Skill Enhancement Course
6.	VSC	: Vocational Skill Courses
7.	SEC	: Skill Enhancement Course
8.	AEC	: Ability Enhancement Course
9.	MIL	: Modern Indian Languages
10.	IKS	: Indian Knowledge System
11.	VEC	: Value Education Courses
12.	OJT	: On Job Training
13.	FP	: Field Projects
14.	CEP	: Fostering Social Responsibility & Community Engagement (FSRCE)
15.	CC	: Co-Curricular Courses
16.	RP	: Research Project/Dissertation
17.	SES	: Shahu Extension Services

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

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Faculty of Science & Technology

Programme Outcomes (POs) for B.Sc. Programme	
PO 1	
PO 2	
PO 3	
PO 4	
PO 5	
PO 6	
PO 7	

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Programme Specific Outcomes (PSOs) for B.Sc. Biotechnology (Honors)	
PSO No.	Upon completion of this programme, the students will be able to -
PSO 1	Prepare the students with the skills, ethics, aptitude and human values of practicing the science in day-to-day life
PSO 2	Promote the interdisciplinary research in biotechnology for tackling the future problems threatening the society
PSO 3	Equip the students with the abilities required to attain self-sufficiency and life sustainability by imparting entrepreneurial skills
PSO 4	Design process equipment, plants, biosensors and recombinant molecules for biotechnological and allied processes
PSO 5	Identify measures for energy, environment, health, safety and society following ethical principles and apply the knowledge of basic science and engineering to solve complex biotechnological problems
PSO 6	Isolate, purify and characterize biological samples using sophisticated analytical experimental techniques
PSO 7	Apply modern software tools including prediction and modeling methods on biological databases to identify issues in biomedical problems
PSO 8	Assess personal, product and environmental safety, intellectual property and social responsibilities related to modern biotechnological research and development

Shiv Chhatrapati Shikshan Sanstha's

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Department of Biotechnology
B.Sc. (Honors) in Biotechnology

Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
III 5.5	V	301BIO5101 (DSC-IX)	r-DNA Technology	03	45
		301BIO5103	Lab Course-IX	01	30
		301BIO5102 (DSC-X)	Ecology and Evolution	03	45
		301BIO5104	Lab Course-X	01	30
		301BIO5201 (DSE-I) (A) Or 301BIO5201 (DSE-I) (B)	Developmental Biology Or Medical Biochemistry	03	45
		301BIO5202	Lab Course-DSE-I	01	30
		301BIO5301 (Minor III)	Food Microbiology	03	45
		301BIO5302	Lab Course-Minor III	01	30
		301BIO5303 (Minor IV)	Computational Biology	02	50
		301BIO5501 (VSC-III)	Plant Cell Culture	02	50
		301RSM5801 VEC-III	Environmental Studies	02	50
	Total Credits			**22**	
	VI	301BIO6101 (DSC-XI)	Bioinformatics	03	45
		301BIO6103	Lab Course-XI	01	30
		301BIO6102 (DSC-XII)	Traditional Medicine and Modern Biopharmaceutical Technology	03	45
		301BIO6104	Lab Course-XII	01	30
		301BIO6201 (DSE-II) (A) Or 301BIO6201 (DSE-II) (B)	Environmental Biotechnology Or Nanobiotechnology	03	45
		301BIO6202	Lab Course-XIII	01	30
		301BIO6301 (Minor V)	Process Technology	03	45
		301BIO6302	Lab Course-Minor V	01	30
		301BIO6501 (VSC-IV)	Bakery & Confectionery	02	50
		AIPC/OJT-I	Academic Project	04	100
	Total Credits			**22**	
Total Credits (Semester V & VI)				**44**	

Semester - Fifth

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

Course Type: DSC IX
Course Title: r-DNA Technology
Course Code: 301BIO5101
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1 To gain a foundational understanding of gene cloning and the molecular tools used in the process.
LO 2 To learn about the functions and applications of restriction enzymes, DNA ligases, and alkaline phosphatase.
LO 3 To explore the different types of cloning vectors such as plasmids, bacteriophages, and cosmids.
LO 4 To understand various methods for inserting DNA into vectors, including transformation, conjugation, electroporation, and Agrobacterium-mediated transformation.
LO 5 To learn key techniques like PCR, blotting methods, DNA sequencing, and advanced analysis methods.
LO 6 To comprehend the construction of genomic and cDNA libraries and the various screening techniques used.
LO 7 To explore the agricultural, industrial, and pharmaceutical applications of recombinant DNA technology.
LO 8 To enhance the ability to analyze and interpret results from molecular biology experiments.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 demonstrate comprehensive knowledge of gene cloning principles and molecular tools.
CO 2 apply various gene cloning and transformation techniques in laboratory settings.
CO 3 analyze and interpret the results of dna sequencing, pcr and blotting techniques.
CO 4 successfully construct and screen genomic and cdna libraries for specific genes.
CO 5 effectively utilize r-DNA technology in solving agricultural, industrial, and pharmaceutical challenges.
CO 6 apply molecular biology techniques to solve real-world problems in biotechnology.
CO 7 communicate experimental findings effectively in both written and oral forms.
CO 8 prepare for advanced research or professional work in the fields of genetic engineering and biotechnology.

Unit No.	Title of Unit & Contents	Hrs.
I	**Fundamentals of Gene Cloning and Molecular Tools**	**10**
	1. Introduction to Gene Cloning: Overview of gene cloning principles, historical milestones, and its significance in biotechnology. 2. Molecular Tools: ➢ Restriction Enzymes: Types, mechanisms, and applications in gene cloning. ➢ DNA Ligases: Role and mechanism in DNA repair and recombinant DNA technology. ➢ Alkaline Phosphatase: Function in preventing recircularization of vectors. 3. Cloning Vectors: ➢ Plasmids: Detailed study of pBR322, pUC18. ➢ Bacteriophages: λ Phage, M13 Phage. ➢ Cosmids: Characteristics and applications.	
	Unit Outcomes: UO 1.Demonstrate comprehensive knowledge of gene cloning principles and molecular tools. UO 2.Apply various gene cloning and transformation techniques in laboratory settings.	
II	**Gene Insertion Techniques and Transformation Methods**	**11**
	1. Gene Cloning Strategies: Insertion of DNA into Vectors: Mechanisms and techniques. 2. Transformation Methods: ➢ Chemical Transformation: Mechanism of DNA uptake in bacterial cells. ➢ Conjugation: Process and its application in horizontal gene transfer. ➢ Electroporation: Principles and application in bacterial and eukaryotic systems. ➢ Agrobacterium-mediated Transformation: Mechanism and its use in plant genetic engineering.	
	Unit Outcomes: UO 1. Analyze and interpret the results of DNA sequencing, PCR, and blotting techniques. UO 2. Understand the principal and applications of various gene cloning techniques.	
III	**r-DNA Techniques, Analysis and library construction**	**12**
	1. Blotting Techniques: ➢ Southern Blotting: DNA detection. ➢ Northern Blotting: RNA detection.	

Unit No.	Title of Unit & Contents	Hrs.
	➢ Western Blotting: Protein detection. ➢ Dot Blotting: Rapid detection technique. 2. DNA Sequencing: ➢ Sanger's Method: Chain termination method. ➢ Maxam-Gilbert Method: Chemical degradation method. 3. PCR (Polymerase Chain Reaction): Mechanism, types (e.g., Real-time PCR, Multiplex PCR) and applications. 4. Advanced Techniques: ➢ DNA Microarrays (DNA Chips): Gene expression analysis. ➢ DNA-Protein Interaction Studies: Techniques like EMSA. ➢ Protein-Protein Interaction Studies: ELISA. 5. Genomic and cDNA Library Construction: ➢ Genomic Library Construction: Maniatis Strategy, use of vectors, partial digestion. ➢ cDNA Library Construction: Conventional and full-length cDNA cloning. 6. Screening Techniques: ➢ Nucleic Acid Probes: Design and application. ➢ Screening of Libraries: Probe-based direct and indirect methods.	
	Unit Outcomes: UO 1. Apply molecular biology techniques to solve real-world problems in biotechnology. UO 2. Communicate experimental findings effectively in both written and oral forms. UO 3. Successfully construct and screen genomic and cDNA libraries for specific genes.	
IV	**Applications of Recombinant DNA Technology**	**12**
	1. Agricultural Applications: ➢ BT-Cotton: Mechanism and benefits. ➢ Transgenic Maize: Nutritional enhancement and pest resistance. ➢ Golden Rice: Engineering for vitamin A production. ➢ Protein Engineering: Improving detergent enzymes. 2. Industrial Applications: ➢ Pharmaceutical Applications: ➢ Recombinant Human Insulin: Production and application. ➢ Hepatitis B Vaccine: Development using r-DNA technology.	

Unit No.	Title of Unit & Contents	Hrs.
	➢ Monoclonal Antibodies: Production and therapeutic use. ➢ Clotting Factors: Production of Factor VIII and IX. ➢ Tissue Plasminogen Activator (tPA): Use in thrombolysis. ➢ Erythropoietin (EPO): Use in anemia treatment. ➢ Human Growth Hormone (HGH): Production and therapeutic applications.	
	Unit Outcomes: UO 1. Effectively utilize r-DNA technology in solving agricultural, industrial, and pharmaceutical challenges. UO 2. Prepare for advanced research or professional work in the fields of genetic engineering and biotechnology.	

Learning Resources:

1. Principles of Gene Manipulation and Genomics, S.B. Primrose, R.M. Twyman, Wiley-Blackwell, 2006.
2. Molecular Cloning: A Laboratory Manual, J. Sambrook, D.W. Russell , Cold Spring Harbor Laboratory Press, 2001.
3. Genomes, T.A. Brown , Garland Science, 2017.
4. Recombinant DNA: Genes and Genomes - A Short Course, J.D. Watson, A. Baker, S.P. Bell, A. Gann, M. Levine, R. Losick , W.H. Freeman, 2007.
5. Genetic Engineering: Principles and Methods, J.K. Setlow, Springer, 2002.
6. Biotechnology: DNA to Protein - A Laboratory Project, T. Brown, Chapman & Hall, 1996.
7. Gene Cloning and DNA Analysis: An Introduction, T.A. Brown, Wiley-Blackwell, 2016.
8. Molecular Biotechnology: Principles and Applications of Recombinant DNA, B.R. Glick, J.J. Pasternak, C.L. Patten, ASM Press, 2010.
9. Genetic Engineering: Principles and Practice, A. Dasgupta, Universities Press, 2017.
10. Recombinant DNA Technology, A. Dale, M. von Schantz, Wiley-Blackwell, 2007.
11. Molecular Genetics of Bacteria, L. Snyder, W. Champness, ASM Press, 2013.
12. Advanced Genetic Analysis: Finding Meaning in a Genome, R. Brooker Oxford University Press, 2008.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

Course Type: DSC IX
Course Title: Lab Course IX (Based on DSC IX)
Course Code: 301BIO5103
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1 To learn the techniques for isolating high-quality genomic DNA from bacterial cells.
LO 2 To understand the process of isolating plasmid DNA from resistant clinical isolates.
LO 3 To perform Gel Electrophoresis: Develop proficiency in using agarose gel electrophoresis to analyze DNA fragments.
LO 4 To gain practical experience in ligating DNA fragments to create recombinant molecules.
LO 5 To learn how to prepare competent bacterial cells for transformation experiments.
LO 6 To understand and perform bacterial transformation using prepared competent cells.
LO 7 To master the technique of screening recombinant colonies using blue-white selection.
LO 8 To gain hands-on experience in Southern blotting for DNA detection and Western blotting for protein analysis.
LO 9 To learn the principles and practical aspects of amplifying bacterial genomic DNA using PCR.
LO 10 To develop the skills to extract and purify amplified DNA fragments from gels for further analysis.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 successfully isolate and analyze genomic and plasmid DNA from bacterial samples.
CO 2 execute restriction digestion and analyze the resulting DNA fragments through agarose gel electrophoresis.
CO 3 perform DNA ligation and bacterial transformation with competency, leading to successful cloning experiments.
CO 4 accurately screen for and identify recombinant bacterial colonies using blue-white selection.
CO 5 demonstrate proficiency in southern and western blotting techniques for DNA and protein analysis, respectively.
CO 6 conduct PCR amplification of bacterial genomic DNA and analyze the results effectively.

CO 7 successfully extract and purify specific DNA fragments from gels, ensuring they are suitable for downstream applications.
CO 8 apply restriction fragment length polymorphism (RFLP) and random amplified polymorphic DNA (RAPD) techniques to analyze genetic variation.
CO 9 perform cloning and expression of green fluorescent protein (GFP) in bacterial cells, demonstrating understanding of gene expression systems.
CO 10 gain exposure to real-world molecular biology and genetic engineering research by visiting specialized laboratories.

Practical No.	Unit
1	Isolation of Genomic DNA from Bacterial Cells
2	Isolation of Plasmid DNA from Antibiotic-Resistant Clinical Isolates
3	Agarose Gel Electrophoresis and Restriction Enzyme Digestion of DNA
4	Ligation of DNA Fragments into Cloning Vectors
5	Preparation of Competent Bacterial Cells and Transformation
6	Screening of Recombinant Colonies by Blue-White Selection
7	Polymerase Chain Reaction (PCR) Amplification of Isolated Bacterial Genomic DNA Using Universal Primers
8	Extraction and Purification of Amplified DNA Fragments from Agarose Gel
9	Southern Blotting for DNA Detection
10	Western Blotting for Protein Detection
11	Restriction Fragment Length Polymorphism (RFLP) Analysis
12	Random Amplified Polymorphic DNA (RAPD) Analysis
13	Green Fluorescent Protein (GFP) Cloning and Expression

N.B.: Any Ten Practicals from above.

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(Autonomous)

Department of Biotechnology

Course Type: DSC-X
Course Title: Ecology and Evolution
Course Code: 301BIO6102
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1 To demonstrate a deep understanding of fundamental ecological principles, such as population dynamics, community interactions, and ecosystem processes.
LO 2 To apply ecological concepts and theories to real-world scenarios, such as analyzing the impact of human activities on ecosystems or designing conservation strategies.
LO 3 To develop critical thinking skills by evaluating and synthesizing ecological literature.
LO 4 To recognize the interdisciplinary nature of ecology and be able to integrate knowledge from other fields, such as geography, genetics, evolution, and environmental science, into their understanding of ecological theory.
LO 5 To understand the historical development of evolutionary theory, including the contributions of key figures such as Darwin, Wallace, and Mendel, and the role of evolutionary theory in shaping our understanding of biology.
LO 6 To use evidence from the fossil record, comparative anatomy, molecular biology, and other sources to support evolutionary explanations and to evaluate alternative hypotheses.
LO 7 To understand the mechanisms of evolution, including natural selection.
LO 8 To recognize the interdisciplinary nature of evolution.

Course Outcomes:

After completion of course the student will be able to-

CO 1 demonstrate a comprehensive understanding of fundamental ecological concepts, including the structure and function of ecosystems, population dynamics, and community interactions.
CO 2 apply ecological principles to analyze and solve real-world environmental problems, such as habitat loss, species extinction, and climate change
CO 3 recognize the interdisciplinary nature of ecology and be able to integrate knowledge from other fields such as geography, genetics, evolution and molecular biology.
CO 4 develop a sense of environmental stewardship and understand the importance of sustainable practices in maintaining ecological balance.
CO 5 understand the historical development of evolutionary theory, including the contributions of key figures such as Darwin, Wallace, and Mendel, and the role of evolutionary theory in shaping our understanding of biology.
CO 6 demonstrate a thorough understanding of the mechanisms of evolution, including natural selection.
CO 7 apply evolutionary concepts to explain patterns in biological diversity, such as the

complex traits.

CO 8 recognize the interdisciplinary nature of evolutionary theory and be able to integrate knowledge from other fields.

Unit No.	Title of Unit & Contents	Hrs.
I	**Ecological Fundamentals**	**10**
	1. The Environment: Physical environment, Biotic environment, Biotic and Abiotic interactions. 2. Biogeochemical cycles. 3. Concept of habitat and niche. 4. Niche width and overlap. 5. Fundamental and realized niche. 6. Population Ecology: Characteristics of a population. 7. Population dynamics -population growth curves. 8. Population regulation. 9. Life history strategies (r and K selection).	
	Unit Outcomes: UO 1 Understand Environmental Interactions and Ecological Niches. UO 2 Understand Population Ecology and Life History Strategies	
II	**Ecological dynamics**	**12**
	1. Climate patterns 2. Terrestrial and aquatic biomes 3. Environmental constraints on species distribution 4. Factors affecting population density 5. Ecosystems 6. Interactions among communities 7. Ecological remediation, species diversity, ecological succession 8. Food webs and energy flow through ecosystem.	
	Unit Outcomes: UO 1 Understand Climate Patterns, Biomes, and Species Distribution. UO 2 Explore Ecosystem Dynamics and Community Interactions.	
III	**History and Theories of Evolution**	**13**

	1. Origin and history of life on earth. 2. Abiotic synthesis of biological macromolecules. 3. Concept of Oparin and Haldane. 4. Experiment of Miller (1953), protocell. 5. Dating fossils and origin of multicellularity 6. Theories of evolution – Lamarckism, Darwinian view. 7. Natural selection, fossil record and descent with modification. 8. Species and speciation.	
	Unit Outcomes: UO 1 Understand the Origin of Life and Early Biological Processes. UO 2 Comprehend Evolutionary Theories and Mechanisms.	
IV	**Evolutionary trends**	**10**
	1. The Geological time scale. 2. Eras, periods and epoch. 3. Major events in the evolutionary time scale. 4. Adaptive radiation. 5. Isolating mechanisms. 6. Speciation. 7. Allopatric and Sympatric. 8. Convergent evolution. 9. Concepts of neutral evolution. 10. Molecular divergence and molecular clocks.	
	Unit Outcomes: UO 1 Understand Geological Time and Major Evolutionary Events. UO 2 Understand Evolutionary Mechanisms and Molecular Evolution.	

Learning Resources:

1. Fundamentals of Ecology, Eugene P. Odum and Gary W. Barrett, Brooks/Cole,5th edition,2004.
2. Ecology and Environment, P.D. Sharma, Rastogi Publications, 2nd Edition,2011
3. Ecology: Concepts and Applications, Manuel C. Molles Jr, Mac GrawHill Education, 7th Edition,2015.
4. Elements of Ecology, Thomas M. Smith and Robert L. Smith, Pearson Education India,9th Edition,2015
5. Fundamentals of Ecology, M. C. Dash and S.P. Dash, McGraw Hill Education India,3rd Edition, 2009
6. Evolution, Douglas J. Futuyma, OUP USA, 4th Edition, 2017.
7. Strickberger's Evolution, Monroe W. Strickberger. Jones & Bartlett, 4th Edition,2007
8. Ecology and Field biology, R.L. Smith and T.M. Smith, Benjamin Cummings, 6th Edition, 2000.
9. Organic Evolution, Veer Bala Rastogi, MedTech Publication, 3rd Edition, 2018.
10. Organic Evolution, N Arumugam, Saras Publication,11th Edition,2019.

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(Autonomous)

Department of Biotechnology

Course Type: Lab Course
Course Title: Lab Course –X (Based on DSC-X)
Course Code: 301BIO5104
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1 To understand and apply methods to measure key water quality parameters such as temperature, pH, dissolved oxygen, and nitrate levels.
LO 2 To apply the quadrat sampling method to estimate population sizes of plant species in regional fields. controlled conditions.
LO 3 To investigate the effects of environmental changes on plant growth under controlled conditions.
LO 4 To examine models and photographs of fossils, living fossils, and connecting links to understand evolutionary transitions.
LO 5 To conduct field visits to natural areas to observe and document ecological processes in action.
LO 6 To Comprehend the importance of various ecological interactions like competition predation, and mutualism within ecosystems
LO 7 To understand the inherent variability within a population, a crucial element for natural selection to act upon.
LO 8 To examine the population growth and its dynamics by using available research data of plants and animals.

Course outcomes

After completion of the course, the student will be able to-

CO 1 demonstrate proficiency in measuring and analyzing water quality parameters and their impact on aquatic ecosystems.
CO 2 develop a deep understanding of ecological interactions and their significance in maintaining ecosystem balance.
CO 3 apply mathematical models to predict and analyze population growth and invasion dynamics in ecosystems.
CO 4 gain hands-on experience in field sampling techniques, specifically in plant population studies using quadrat sampling.
CO 5 evaluate how environmental factors influence plant growth and development through controlled experiments .
CO 6 construct and interpret phylogenetic trees to understand evolutionary relationships among species.
CO 7 exhibit competence in observing and documenting ecological processes and species variations in natural settings.

ecological interactions, enhancing the understanding of evolutionary processes.

Practical No.	Unit
1	To measure and study various water quality parameters like Temperature, pH, dissolved oxygen, and nitrate levels etc.
2	To study the importance of ecological interactions in the ecosystem
3	To study the basic concept of pest population invasion and its impacts on the ecosystem
4	To apply the quadrat sampling Method for sampling populations of plants in the regional fields.
5	To study plant growth and responses to environmental changes under controlled conditions
6	To study the population growth and its dynamics by using available research data of plants and animals.
7	To Visit natural areas like forests, wetlands, or beaches allows for observing ecological processes in action.
8	To Study the fossils, living fossils and connecting links Archaeopteryx, Peripatus, Limulus, Nautilus, Latimeria using models, photo
9	To Examine how ecological interactions, such as competition, predation, and mutualism, drive evolutionary change
10	The study of evolutionary relationships among species, often using molecular data to reconstruct phylogenetic trees.
11	To Visit a local park or garden and closely examining a specific organism, like butterflies or birds. Students can observe and record variations in traits like wing color, beak size, or body patterns. This helps them understand the inherent variability within a population, a crucial element for natural selection to act upon.

N.B.: Any Ten Practical from above.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

Course Type: DSE I (A)
Course Title: Developmental Biology
Course Code: 301BIO5201
Credits: 03 **Max. Marks: 75** **Lectures: 45Hrs.**

Learning Objectives:

LO 1 To learn the fundamental processes of development, including cell division, differentiation, pattern formation, and morphogenesis.
LO 2 To study various model organisms used in developmental biology.
LO 3 To explore how gene expression is regulated during development.
LO 4 To become proficient in the experimental techniques used in developmental biology research.
LO 5 To explore the mechanisms by which cells acquire specific identities during development.
LO 6 To delve into the biology of stem cells and their potential applications in regenerative medicine.
LO 7 To study the formation of organs and tissues, focusing on the molecular and cellular mechanisms.
LO 8 To gain an in-depth understanding of key signaling pathways involved in development.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 demonstrate a deep understanding of the fundamental processes of development.
CO 2 effectively use model organisms such as Drosophila, X. laevis, and Chick to study developmental processes.
CO 3 explain the mechanisms of gene regulation during development.
CO 4 gain hands-on experience with key experimental techniques in developmental biology.
CO 5 describe and analyze the mechanisms of cell fate determination.
CO 6 demonstrate an understanding of stem cell biology and will critically evaluate the potential and challenges of stem cell therapies.
CO 7 describe the molecular and cellular mechanisms driving the development of specific organ systems.

CO 8 understand of key developmental signaling pathways and will be able to analyze how their dysregulation can lead to developmental disorders.

Unit No.	Title of Unit & Contents	Hrs.
I	**Fundamentals of development and Model organisms**	**14**
	1. Developmental Biology-Introduction, Present and future impact of developmental biology on biology. 2. Gametogenesis- Spermatogenesis and Oogenesis in animal. 3. Fertilization in animals. 4. Embryonic Development in Animals – Blastulation, gastrulation, Neurulation in • *Xenopus laevis* • The Chick (*Gallus gallus*) • *Drosophila melanogaster*	
	Unit Outcomes: UO 1 To understand basics of development in animal embryogenesis. UO 2 To study basics of embryogenesis processes in Model Organisms.	
II	**Molecular mechanisms in developmental biology**	**13**
	1. Gene regulation during development. 2. Signal transduction pathways in development. 3. Epigenetic regulation (DNA methylation, histone modification). 4. Pattern Formation. 5. Morphogens and gradients. 6. Segmentation genes (gap, pair-rule, and segment polarity genes). 7. Homeotic genes and Hox gene clusters. 8. Notch, Wnt, Hedgehog, and BMP signaling pathways. 9. Cell division and Growth, Cell lineage, Apoptosis and Ageing.	
	Unit Outcomes: UO 1 To understand gene regulation of animal development. UO 2 To understand pattern formation and signaling pathways in animal development.	
III	**Stem cells, Regeneration and techniques in developmental biology**	**10**
	1. Types of stem cells and their properties. 2. Molecular mechanisms of stem cell differentiation.	

Unit No.	Title of Unit & Contents	Hrs.
	3. Stem cell therapy and regenerative medicine. 4. In situ hybridization, immunohistochemistry, and microscopy. 5. Gene knockout and transgenic models. 6. RNA interference and CRISPR/Cas9 in developmental studies. 7. Live imaging and lineage tracing.	
	Unit Outcomes: UO 1 To understand Stem cells and their applications in future in medicine and research. UO 2 To understand technologies used in studying developmental biology.	
IV	**Plant Development**	**08**
	1. Angiosperm Plant Life Cycles. 2. Gamete Production in Angiosperms Pollination. 3. Fertilization in plant. 4. Germination, and Senescence. 5. Embryonic Development in plant Embryonic Development in Monocotyledonous plant. 6. *Arabidopsis thaliana* (A dicotyledonous plant)-Role of genes in embryogenesis, Role of genes in Organogenesis-Shoot patterning, Root patterning, Leaf Patterning, Flower patterning.	
	Unit Outcomes: UO 1 To understand the plant development by understanding basic concepts in plant development. UO 2 To understand plant embryogenesis and gene regulation in development.	

Learning Resources:

1. Developmental biology Gilbert, S. F., & Barresi, M. J. F. (12th ed.). Sinauer Associates, 2020
2. Principles of development, Wolpert, L., Tickle, C., Arias, A. M., & Wilkinson, D. G. (6th ed.). Oxford University Press,2019.
3. Essential developmental biology, Slack, J. M. W. , (3rd ed.). Wiley-Blackwell,2012.

4. Molecular biology of the cell, Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. 6th ed. Garland Science,2014.
5. Developmental biology: A very short introduction, Gilbert, S. F., Oxford University Press,2013.
6. From DNA to diversity: Molecular genetics and the evolution of animal design, Carroll, S. B., Grenier, J. K., & Weatherbee, S. D. , (2nd ed.). Blackwell Publishing,2005.
7. The principles of developmental biology, Wolpert, L., & Tickle, C. Oxford University Press,2010.
8. Principles of developmental genetics, Moody, S. A. ,2nd ed.. Academic Press,2014.
9. Essential developmental biology: A practical approach, Stern, C. D. Oxford University Press,2004.
10. Evolutionary developmental biology, Wolpert, L., & Jesell, J. Oxford University Press,2001.
11. The atlas of chick development, Bellairs, R., & Osmond, M. (3rd ed.). Academic Press,2014.
12. The regulatory genome: Gene regulatory networks in development and evolution, Davidson, E. H. Academic Press,2006.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

Course Type: DSE I (A)
Course Title: Lab Course -DSE-I (Based on DSE I (A))
Course Code: 301BIO5203
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1 To provide Hands-on frog development by using permanent mounted slides.
LO 2 To study T.S. of ovary for arrangement of ovules within ovary.
LO 3 To learn Flower development from vegetative shoot
LO 4 To study morphological and anatomical changes in plants.
LO 5 To understand basics of embryonic development by studying chick embryogenesis in-vitro.
LO 6 To study chick blastodisc for their feature from hen egg.
LO 7 To understand different types of sperms and its features by using charts.
LO 8 To study chick development up to eight days through egg incubation, candling and Egg dissection technique.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 gain hands on experience in observing and analyzing different stages of frog development using permanent mounted slides.
CO 2 develop the ability to identify and describe the arrangement of ovules within the ovary by studying transverse sections (T.S.) of plant ovaries.
CO 3 acquire practical knowledge of the developmental transition from vegetative to reproductive phases in plants by studying the stages of flower development from vegetative shoots.
CO 4 investigate and describe the morphological and anatomical changes that occur in plants during different stages of growth and development.
CO 5 demonstrate a clear understanding of the basics of embryonic development by studying chick embryogenesis through in vitro techniques.
CO 6 enhance the comprehensive skills required to evaluate oral drug delivery systems.
CO 7 adapt the techniques to extract natural molecules.
CO 8 grasp the knowledge about the types of eggs by using charts.

Practical No.	Unit
1	Introduction to developmental biology-embryo, protocols, ethics, and model Systems.
2	Study of frog development by using permanent mounted slides from zygote to Tadpole.
3	Study of chick development by using permanent slides from 18 hours to 96 hours of chick embryos.
4	Study types of egg by using charts, as well as real specimen eggs.
5	A study of chick blastodisc for their feature from hen egg.
6	A study of chick development up to eight days through egg incubation, candling and Egg dissection technique.
7	A study of different types of sperms and its features by using charts.
8	A study of pollen genesis by using T.S. of Anther preparation technique.
9	A study of T.S. of ovary for arrangement of ovules within ovary.
10	A study of Flower development from vegetative shoot of any suitable plant.
11	A study of morphological and anatomical changes in plants- (about tissue organization) during plant development from germinated seed, seedling and other stages of development.

N.B.: Any Ten Practicals from above.

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Course Type: DSE I (B)
Course Title: Medical Biochemistry
Course Code: 301BIO5202
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1 To gain a foundational understanding of preservatives and adulterants in food.
LO 2 To learn about the starvation diet therapy.
LO 3 To explore the different types of radio isotope techniques.
LO 4 To understand chemistry and properties of hemoglobin and myoglobin.
LO 5 To learn key concepts of marker enzymes in myocardium, liver and pancreas.
LO 6 To understand about the techniques used to study metabolic disorders.
LO 7 To learn oxygen dissociation curve.
LO 8 To enhance the ability to analyze biosensors in disease diagnosis.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 acquaint the starvation diet therapy knowledge.
CO 2 understand the catabolism and biosynthesis of Hb.
CO 3 acquire comprehensive knowledge of basal metabolic rate.
CO 4 analyze and learn chemistry and properties of hemoglobin and myoglobin.
CO 5 effectively grasp the concept of the development of diagnostic kit using biomaterial
CO 6 adapt the knowledge about techniques used to study metabolic disorders
CO 7 apply radio isotope techniques to solve real-world problems in biotechnology.
CO 8 understand the catabolism and biosynthesis of Hb.

Unit No.	Title of Unit & Contents	Hrs.
I	**Nutrition and Dietetics**	**12**
	1. Respiratory quotient. 2. Basal metabolic rate. 3. Specific dynamic action, nitrogen balance, protein quality, biological value, dietary fiber, balanced diet. 4. Preservatives and adulterants in food. 5. Obesity, Protein – energy malnutrition. 6. Starvation Diet therapy for DM, Atherosclerosis and hyper tension.	
	Unit Outcomes: UO 1 Acquire comprehensive knowledge of Basel metabolic rate. UO 2 Acquaint the starvation diet therapy knowledge.	
II	**Heme Metabolism**	**13**
	1. Heme metabolism- chemistry and properties of hemoglobin and myoglobin. 2. Transport of gases. 3. Oxygen dissociation curve. 4. Biosynthesis of Hb. 5. Catabolism of heme. 6. Bile pigments- bilirubin and related chromoproteins Hb derivatives, hemoglobin variants, Jaundice.	
	Unit Outcomes: UO 1 Analyze and learn chemistry and properties of hemoglobin and myoglobin. UO 2 Understand the catabolism and biosynthesis of Hb.	
III	**Metabolic disorders and Diagnostic enzymology**	**10**
	1. Disorders of metabolism: Carbohydrates, Lipids, Amino acids and Nucleic acids. 2. Diagnostic enzymes: Role of Enzymes in Clinical Practice. 3. Marker enzymes in myocardium, liver and pancreas. 4. Tumor markers. 5. Radio isotope techniques.	
	Unit Outcomes: UO 1 Apply radio isotope techniques to solve real-world problems in biotechnology. UO 2 Acquaint the knowledge about Disorders of metabolism.	
IV	**Role of metabolism in disease diagnosis**	**10**
	1. Development of diagnostic kit using biomaterial. 2. Biosensors in disease diagnosis.	

Unit No.	Title of Unit & Contents	Hrs.
	3. Metabolic disorders. 4. Techniques used to study metabolic disorders.	
	Unit Outcomes: UO 1 Effectively grasp the concept of the Development of diagnostic kit using biomaterial. UO 2 Adapt the knowledge about techniques used to study metabolic disorders.	

Learning Resources:

1. Medical Biochemistry, Dr. M. P. N. Nair, Jaypee Brothers Medical Publishers, 2018.
2. Textbook of Medical Biochemistry, Dr. S. S. Lal, Elsevier, 2020.
3. Fundamentals of Medical Biochemistry, Dr. A. K. Shukla, CBS Publishers & Distributors, 2022.
4. Essentials of Medical Biochemistry, Dr. S. K. Gupta, Ane Books Pvt Ltd, 2019.
5. Medical Biochemistry: A Comprehensive Study, Dr. Prashant Kumar, Springer India, 2021.
6. Biochemistry for Medical Students, Dr. R. R. Kumar, Academic Publishers, 2023.
7. Textbook of Biochemistry with Clinical Correlations, Dr. A. K. Ghosh, Wolters Kluwer India, 2020.
8. Basic and Clinical Biochemistry, Dr. J. K. Gupta, CBS Publishers & Distributors, 2022.
9. Biochemistry: A Short Course for Medical Students, Dr. N. R. Patel, Jaypee Brothers Medical Publishers, 2021.
10. Clinical Biochemistry: Principles and Techniques, Dr. R. C. Joshi, Elsevier, 2019.

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Course Type: DSE I (B)
Course Title: Lab Course -DSE-I (Based on DSE I B)
Course Code: 301BIO203
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1 To provide hands-on sample collection and demonstration using different types of microscopes.
LO 2 To make the student able to analyze blood glucose level.
LO 3 To teach the student how to estimation Serum electrolytes.
LO 4 To learn the method of protein estimation.
LO 5 To learn how to perform haemoglobin estimation.
LO 6 To understand and perform serum uric acid estimation.
LO 7 To master the skills in collecting samples for different biochemical investigation.
LO 8 To gain hands-on experience in estimation of vitamins.

Course Outcomes

After completion of the course, the student will be able to-

CO 1 understand the concept of biomolecules estimation.
CO 2 study estimation of serum components for various disease diagnosis.
CO 3 perform various lab investigations.
CO 4 understand collection, handling and transportation of specimens.
CO 5 demonstrate proficiency in estimation of vitamins.
CO 6 conduct methodology to learn blood glucose analysis.
CO 7 successfully learn the technique for estimation of total protein.
CO 8 acquaint the knowledge about the estimation of calcium and phosphorus.

Practical No.	Unit
1.	Demonstrates skills in collecting samples for different biochemical investigation.
2.	Blood glucose analysis.
3.	Estimation of Vitamins (A, E, C, etc.)
4.	Blood urea analysis.
5.	Estimation of Calcium and Phosphorous
6.	Serum uric acid estimation.
7.	Estimation of Haemoglobin.
8.	Estimation of total protein.
9.	Urine analysis.
10.	Estimation of Serum Electrolytes.

N.B.: Any Ten Practicals from above.

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Course Type: DSM-III
Course Title: Food Microbiology
Course Code: 301BIO5301
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1 To understand the sources of microbial contamination in foods and how they affect food quality and safety.

LO 2 To explore the intrinsic and extrinsic factors that influence microbial growth in various food substrates.

LO 3 To study the mechanisms of microbial spoilage in different food types

LO 4 To identify and evaluate methods for preventing food spoilage, including physical, chemical, and biological preservation techniques.

LO 5 To comprehend the major foodborne pathogens and their role in causing foodborne diseases, poisonings, and infections.

LO 6 To familiarize students with the principles and applications of HACCP in ensuring food safety across the food supply chain.

LO 7 To investigate methods of microbial quality control in food production.

LO 8 To analyze food safety regulations and standards and their impact on food safety and quality control.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Identify and explain the sources of contamination in food and the factors influencing microbial growth.

CO 2 Gain a deep understanding of microbial spoilage in different food categories and suggest appropriate preservation techniques.

CO 3 Evaluate the effectiveness of various physical and chemical methods used for food preservation.

CO 4 Differentiate between foodborne pathogens and their associated diseases, including bacterial, viral, fungal, and parasitic infections.

CO 5 Apply HACCP principles to develop food safety management plans in real-world food processing environments.

CO 6 Conduct microbiological testing and quality control measures in food production, including the use of rapid detection methods.

CO 7 Understand the importance of sanitation and hygiene practices in food production and processing environments.

CO 8 Analyze food safety regulations ((FSSAI, FDA, Codex) and evaluate their role in safeguarding public health and ensuring food quality.

Unit No.	Title of Unit & Contents	Hrs.
I	**Sources of Contamination and Factors Influencing Microbial Growth**	**10**
	1. Sources of contamination: Molds, yeast, bacteria 2. Food as a substrate for microorganisms: • Intrinsic factors: Nutrient content, pH, water activity, redox potential, natural antimicrobial compounds • Extrinsic factors: Temperature, humidity, gaseous atmosphere, storage conditions **3.** Factors influencing microbial growth (pH, temperature, moisture, etc.)	
	Unit Outcomes: UO 1 Identify the different sources of microbial contamination in foods, including molds, yeasts, and bacteria. UO 2 Explain the intrinsic and extrinsic factors that influence microbial growth in food products.	
II	**Food Spoilage and Preservation**	**15**
	1. Principles of food spoilage 2. Microbial spoilage of • Vegetables and Fruits • Meat and Meat Products • Milk and Milk Products • Fish and other Seafood • Egg and Poultry 3. Preservation methods: • Physical methods: Low temperature, high temperature, radiation, drying • Chemical methods: Class I and Class II preservatives • Bio-preservation, canning 4. Food packaging: Types of packaging materials, properties, and benefits.	
	Unit Outcomes: UO 1 Describe the microbial spoilage mechanisms in different food types (fruits, vegetables, meats, dairy, seafood, eggs).	

Unit No.	Title of Unit & Contents	Hrs.
	UO 2 Discuss various food preservation methods and their effectiveness in preventing spoilage.	
III	**Foodborne Pathogens and Safety**	**08**
	1. Foodborne pathogens (bacterial, viral, fungal, parasitic) 2. Foodborne poisoning, intoxications, and infections including Case Studies. 3. HACCP principles and their application in food safety management	
	Unit Outcomes: UO 1 Classify various foodborne pathogens and describe their modes of transmission and associated diseases. UO 2 Apply HACCP principles to ensure food safety in different food production environments.	
IV	**Food Safety, Quality Control, and Regulatory Aspects**	**12**
	1. Food Quality Testing and Control: • Rapid microbiological detection methods: ATP bioluminescence, immunological assays. • Methods of examination of fecal contamination. • Quality control measures in food production 2. Food Sanitation and Hygiene Practices: • Sanitation standards in food processing. • Waste treatment and disposal methods • GMP and GLP Practices 3. Food safety regulations: FSSAI, FDA, Codex Alimentarius 4. Microbial Testing in Food: • Plate count methods, rapid microbiological testing, molecular techniques (PCR, DNA-based methods) • Bacterial indicators of contamination (coliforms, enterococci) • Risk assessment and hazard identification for foodborne pathogens	
	Unit Outcomes: UO 1 Evaluate food quality control measures and the role of rapid microbiological testing in ensuring food safety. UO 2 Analyze food safety regulations and standards, including FSSAI, FDA, and Codex Alimentarius.	

Learning Resources:

1. Food Microbiology, M. R. Adams and M. O. Moss, Royal Society of Chemistry, 2008.
2. Modern Food Microbiology, James M. Jay, Springer, 7th Edition, 2005.

3. Principles of Food Sanitation, Norman G. Marriott and Robert B. Gravani, Springer, 5th Edition, 2006.
4. Foodborne Microorganisms of Public Health Significance, Ailsa D. Hocking (Ed.), Australian Institute of Food Science and Technology (AIFST), 2003.
5. Fundamental Food Microbiology, Bibek Ray and Arun Bhunia, CRC Press, 5th Edition, 2013.
6. Essentials of Food Microbiology, John Garbutt, Arnold Publishers, 1997.
7. Food Safety Management: A Practical Guide for the Food Industry, Yasmine Motarjemi and Huub Lelieveld (Eds.), Academic Press, 2013.
8. Microbial Hazard Identification in Fresh Fruits and Vegetables, Jennylynd James (Ed.), John Wiley & Sons, 2016.
9. Food Microbiology: Fundamentals and Frontiers, Michael P. Doyle and Robert L. Buchanan (Eds.), ASM Press, 4th Edition, 2013.
10. HACCP: A Practical Approach, Sara Mortimore and Carol Wallace, Springer, 3rd Edition, 2013.
11. Food Safety: Theory and Practice, Paul L. Knechtges, Jones & Bartlett Learning, 2012.
12. Foodborne Diseases, Christine Dodd, Tim Aldsworth, and Richard Stein, Academic Press, 2017.
13. Foodborne Pathogens: Microbiology and Molecular Biology, Pina M. Fratamico, ASM Press, 2005.
14. Food Spoilage Microorganisms, Clive de W. Blackburn (Ed.), Woodhead Publishing, 2006.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

Course Type: DSM III
Course Title: Lab Course DSM III (Based on DSM III)
Course Code: 301BIO5302
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1 To identify and quantify microbial loads in various food samples using plate count methods.
LO 2 To isolate and characterize pathogenic microorganisms from food samples through microbiological techniques.
LO 3 To determine the pH, water activity, and redox potential in food products and analyze their implications for microbial growth.
LO 4 To investigate microbial spoilage mechanisms in fruits and vegetables and identify contributing factors.
LO 5 To evaluate the effect of temperature on microbial growth in food products and its significance for food preservation.
LO 6 To apply Good Manufacturing Practices (GMP) in food production and assess their impact on food safety and quality.
LO 7 To assess fecal contamination levels in food and water samples using the Most Probable Number (MPN) method.
LO 8 To evaluate the role of lactic acid bacteria in bio-preservation methods for fermented foods and their impact on food safety.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 perform the enumeration of microbial load in various food samples using plate count methods and interpret the results for food safety assessments.
CO 2 isolate and accurately identify pathogenic microorganisms from food samples, understanding their implications for public health.
CO 3 determine and analyze the pH, water activity, and redox potential in foods, explaining their roles in microbial growth and food preservation.
CO 4 evaluate the microbial spoilage mechanisms in fruits and vegetables and recommend effective preservation methods to mitigate spoilage.
CO 5 assess the effect of temperature on microbial growth in foods and apply this knowledge to improve food storage and handling practices.

CO 6 analyze Good Manufacturing Practices (GMP) in food production and apply them to enhance food safety and quality in various food industries.

CO 7 assess fecal contamination in water and food samples using the most probable number (MPN) method and discuss its implications for food safety and public health.

CO 8 develop and execute a Hazard Analysis and Critical Control Points (HACCP) plan for a selected food product, identifying and controlling critical contamination points effectively.

Practical No.	Unit
1	Enumeration of Microbial Load in Various Food Samples Using Plate Count Methods
2	Isolation and Identification of Pathogenic Microorganisms from Food Samples
3	Determination of pH, Water Activity, and Redox Potential in Foods
4	Study of Microbial Spoilage in Fruits and Vegetables
5	Effect of Temperature on Microbial Growth in Foods
6	Study of Good Manufacturing Practices (GMP) in Food Production
7	Assessment of Fecal Contamination in Water and Food Using MPN Method
8	Microbial Quality Testing of Food Samples Using Plate Count Methods
9	Evaluation of Lactic Acid Bacteria for Bio-Preservation in Fermented Foods
10	Rapid Detection of Microbial Contamination in Food Products Using ATP Bioluminescence Assay
11	Antibiotic Susceptibility Testing of Foodborne Pathogens Using Disk Diffusion
12	Detection and Analysis of Bacterial Toxins in Contaminated Food Samples
13	Develop and execute a HACCP plan for a selected food product, identifying and controlling critical contamination points.
14	Effect of Food Packaging on Microbial Growth in Packaged Foods

N.B.: Any Ten Practicals from above.

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Course Type: Minor IV

Course Title: Computational Biology

Course Code: 301BIO5303

Credits: 02 **Max. Marks: 50** **Lectures: 15T**

Learning Objectives:

LO 1 To understand the principles of bioinformatics and its significance in molecular biology.

LO 2 To explore the various tools, databases, and software used in bioinformatics.

LO 3 To gain knowledge of data generation techniques in molecular biology.

LO 4 To learn the types and sources of biological data, and how to manage them.

LO 5 To master the concepts of sequence alignment and the algorithms used.

LO 6 To develop skills in using bioinformatics tools for data visualization.

LO 7 To understand the basic concepts of genomics and proteomics.

LO 8 To apply bioinformatics tools and techniques in real-world research and applications.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Demonstrate a clear understanding of bioinformatics and its role in molecular biology.

CO 2 Efficiently use bioinformatics tools and databases for research purposes.

CO 3 Generate and manage large-scale molecular biology data.

CO 4 Classify and present biological data using appropriate methods.

CO 5 Perform sequence alignments using various algorithms.

CO 6 Visualize complex biological data with advanced software tools.

CO 7 Apply knowledge of genomics and proteomics in analyzing biological data.

CO 8 Design and conduct bioinformatics research, utilizing appropriate tools and techniques.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to Bioinformatics and Data Generation**	**04**
	1. Introduction to bioinformatics and its relationship with computational and molecular biology. 2. Applications of bioinformatics in biology and health sciences. 3. Data generation methods: • DNA sequencing • Protein sequencing • Gel electrophoresis	
	Unit Outcomes: UO 1. Understand the principles of bioinformatics and its significance in molecular biology. UO 2. Explore the various data generation methods used in bioinformatics.	
II	**Biological Databases and Data Repositories**	**04**
	1. Public and private biological databases: • GENBANK • PubMed • Protein Data Bank (PDB) 2. Nucleic acid sequence databases: • NCBI • DDBJ • EMBL	
	Unit Outcomes: UO 1. Gain knowledge of data sources in molecular biology. UO 2. Learn the types and sources of biological data, and how to manage them.	
III	**Sequence Alignments and Comparative Analysis**	**03**
	1. Sequence types and alignment approaches: • Local vs. global alignment 2. Pairwise sequence alignment techniques: • Basic Local Alignment Search Tool (BLAST) • Applications of pairwise alignment 3. Multiple sequence alignment: • ClustalW algorithm and its usage	

	Unit Outcomes: UO 1. Master the concepts of sequence alignment and the algorithms used. UO 2. Develop skills in using bioinformatics tools for comparative analysis of data.	
IV	**Visualization of Molecular Structures**	**04**
	1. Visualization tools for structural bioinformatics: • Overview of 3D molecular structure visualization • RasMol • Cn3D	
	Unit Outcomes: UO 1. Understand the basic concepts of Visualization tools for structural bioinformatics . UO 2. Apply bioinformatics tools and techniques in real-world research and applications.	
V	**Practicals (Included in above 04 units)**	**30**
	1. Exploration of Bioinformatics Database: NCBI 2. Retrieval of Nucleotide and Protein Sequences from Public Databases 3. Pairwise Sequence Alignment Using BLAST 4. Multiple Sequence Alignment Using ClustalW 5. Understanding Sequence File Formats: FASTA 6. 3D Protein Structure Visualization Using RASMOL 7. Molecular Visualization and Analysis Using Cn3D 8. Analysis of Protein Structures from the Protein Data Bank (PDB).	

Learning Resources:

1. Introduction to Bioinformatics, Teresa Attwood, David Parry-Smith , Prentice Hall, 1999.
2. Bioinformatics: The Machine Learning Approach, Pierre Baldi, Søren Brunak MIT Press, 2001.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Andreas D. Baxevanis, B.F. Francis Ouellette, J. Wiley, 1998.
4. Structural Bioinformatics, Philip E. Bourne, Helge Weissig , Wiley, 2003.
5. Bioinformatics for Dummies, Jean-Michel Claverie, Cedric Notredame , Wiley, 2002.
6. Computational Molecular Biology: An Introduction, Peter Clote, Rolf Backofen Wiley, 2000.
7. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison, Cambridge University Press, 1998.
8. Statistical Methods in Bioinformatics: An Introduction, Warren J. Ewens, Gregory R. Grant, Springer, 2001.
9. Algorithms on Strings, Trees, and Sequences, Dan Gusfield, Cambridge University Press, 1997.
10. Bioinformatics: Sequence, Structure, and Databanks: A Practical Approach, D. Higgins, W. Taylor, Oxford University Press, 2000.
11. Models for Bioinformatics: Hidden Markov Models, Timo Koski, Kluwer Academic Publishers, 2001.
12. Introduction to Bioinformatics: A Theoretical and Practical Approach, Stephen A. Krawetz, David D. Womble, Humana Press, 2002.
13. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press, 2002.
14. Bioinformatics: Sequence and Genome Analysis, David W. Mount , Cold Spring Harbor Laboratory Press, 2001.
15. Computational Molecular Biology: An Algorithmic Approach, Pavel A. Pevzner, MIT Press, 2000.
16. Introduction to Computational Molecular Biology, João Carlos Setubal, João Meidanis, PWS Pub., 1997.
17. Introduction to Computational Biology: Maps, Sequences, and Genomes: Interdisciplinary Statistics , Michael S. Waterman, Chapman & Hall/CRC, 1995.

Rajarshi Shahu Mahavidyalaya, Latur
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Course Type: VSC III

Course Title: Plant Cell Culture

Course Code:

Credits: 02 **Max. Marks: 50** **Lectures: 15Hrs.**

Learning Objectives:

LO 1 To explore the historical milestones and scope of plant tissue culture.

LO 2 To understand the design and organization of a plant tissue culture laboratory.

LO 3 To learn about the various sterilization techniques used in plant tissue culture.

LO 4 To comprehend the components and significance of media preparation in plant tissue culture.

LO 5 To analyze the role of plant growth regulators and other components in the culture media.

LO 6 To understand the principles and applications of key techniques such as micropropagation, somatic embryogenesis, and anther/pollen culture.

LO 7 To study the process of protoplast isolation, its culture, and its applications in plant biotechnology.

LO 8 To gain hands-on experience with practical applications, including explant preparation, media preparation, callus induction, and micropropagation of economically important plants.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 describe the laboratory design and equipment used in plant tissue culture setups, understanding their role in successful culture experiments.

CO 2 explain the significance of various historical contributions to the development of plant tissue culture and its scope in biotechnology.

CO 3 demonstrate the preparation and composition of plant tissue culture media, including basal media (like Murashige and Skoog) and growth regulators.

CO 4 discuss different sterilization techniques crucial for maintaining aseptic conditions in plant tissue culture experiments.

CO 5 apply micropropagation techniques, including different stages of micropropagation, to produce pathogen-free plantlets.

CO 6 explain the steps involved in somatic embryogenesis, synthetic seed production, and anther/pollen culture, with a focus on haploid production.

CO 7 analyze the methods for protoplast isolation, regeneration, and their applications in plant biotechnology.

CO 8 perform practical experiments related to explant sterilization, media preparation, callus induction, protoplast isolation, and micropropagation of economically and ornamentally important plants.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction to Plant Tissue Culture**	**04**
	1. History and scope of Plant Tissue culture. 2. Milestones in plant Tissue culture. 3. Laboratory organization of plant tissue culture: Various equipment and instruments in plant tissue culture. 4. Design and construction of plant tissue culture. 5. Sterilization techniques in plant Tissue culture.	
	Unit Outcomes: UO 1 Describe the designs of Plant tissue culture laboratory. UO 2 Explain various concepts and contributors in plant Tissue culture.	
II	**Media preparation for Plant Tissue Culture**	**04**
	1. Importance of Media for growth of tissue. 2. Established medium for plant tissue culture. 3. Murashige and Skoog basal media. 4. Growth regulators and other complexes for plant tissue culture media.	
	Unit Outcomes: UO 1 Explain the basic media component used in plant tissue culture. UO 2 Plant Growth regulators and other component in Plant tissue culture.	
III	**Techniques in Plant Tissue Culture**	**04**

Unit No.	Title of Unit & Contents	Hrs.
	1. Micropropagation technique. 2. Stages of Micropropagation. 3. Somatic embryogenesis and synthetic seed. 4. Anther and pollen culture.	
	Unit Outcomes: UO 1 Understand the major important techniques in Plant tissue culture. UO 2 Explain the concept of pathogen free plantlets.	
IV	**Protoplast culture and Applications of Plant Tissue culture**	**03**
	1. Protoplast culture historical perspective. 2. Protoplast Isolation. 3. Media and reagent for protoplast isolation. 4. Applications of plant tissue Culture.	
	Unit Outcomes: UO 1 Explain the process of Protoplast isolation and regeneration. UO 2 Understand the various applications of Plant Tissue Culture.	
V	**Practicals (Included in above 04 units)**	**30**
	1. Laboratory organization of Plant tissue culture laboratory 2. Washing of glassware and sterilization 3. Explant collection, selection and surface sterilization 4. Media preparation, stock solution of media and hormone solutions 5. Study of callus induction. 6. Zygotic Embryo culture technique. 7. Somatic embryogenesis 8. Anther and pollen culture for haploid production. 9. Protoplast isolation 10. Preparation of Synthetic seed. 11. Micropropagation of horticulturally important plants viz. Banana and Sugarcane. 12. Micropropagation of ornamental plants viz. Gladiolus, Gerbera and Rose etc.	

Learning Resources:

1. Plant tissue culture theory and practice, Bhojwani S.S. and Razdan M.K., Elsevier Publication, New holland, 1996.
2. Plant Tissue Culture, Jayarama Reddy, 1st edition, CRC, 2024.
3. Advances in plant Tissue culture: Current development and future trends, Avinash Chandra Roy, Science direct, 2022.
4. Introduction to plant tissue cultur,e M. K. Razdan, Oxford & IBH, 1996.
5. Plant Tissue culture: Techniques and experiment, Sunghun Park, Academic Press, 2021.
6. Plant tissue culture, Kalyan Kumar Day, Kalyani Publications, 2008.
7. Plant tissue culture: An introductory text, S. S. Bhojwani and Prem Kumar Dantu, Springer, 2013.
8. Advances in Plant tissue culture: Current development and future trends, Avinash Chandra Roy, Academic press, 2022.
9. Plant Cell and Tissue Culture: A Tool for Genetic Engineering, Michael R. Davey and Paul Anthony, Springer, 2018.
10. Plant Tissue Culture: A Practical Approach, John P. Bentley, Oxford University Press, 2019.
11. Plant Cell Culture Protocols, Robert P. Adams, Humana Press, 2015.
12. Plant Biotechnology: Principles and Applications, P. S. Srivastava, Springer, 2021.
13. Plant Tissue Culture: Methods and Applications, S. K. Gupta and S. K. Jain, Wiley, 2017.
14. Plant Cell Culture: Essential Methods, Sarah Robinson and Karen A. Michael., Wiley- Blackwell, 2018.
15. Handbook of Plant Cell Culture, S. M. Jain, P. K. Gupta and R. L. J. A. S. S., Springer, 2014.

Semester - Sixth

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Biotechnology

Course Type: DSC XI
Course Title: Bioinformatics
Course Code: 301BIO6101
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives

LO 1. To understand the nature, organization and biological significance of DNA, RNA and protein sequences.
LO 2. To retrieve and interpret biological sequences from public bioinformatics databases.
LO 3. To understand sequence similarity and perform similarity search using BLAST tools.
LO 4. To analyze multiple sequence alignments and identify conserved regions.
LO 5. To understand evolutionary relationships through phylogenetic analysis.
LO 6. To visualize and interpret three-dimensional protein structures.
LO 7. To identify genomic regulatory elements using bioinformatics tools.
LO 8. To apply basic proteomics tools for protein structure prediction and analysis.

Course Outcomes

After completion of the course, the student will be able to-

CO 1. Retrieve nucleotide and protein sequences from standard biological databases and explain their biological relevance.
CO 2. Perform BLAST-based similarity searches and interpret output parameters for gene and protein annotation.
CO 3. Generate and analyze multiple sequence alignments to identify conserved regions among homologous sequences.
CO 4. Construct and interpret phylogenetic trees to understand evolutionary relationships.
CO 5. Retrieve protein structures from Protein Data Bank and visualize them using bioinformatics tools.
CO 6. Analyze protein structural features such as secondary structures and functional sites.
CO 7. Identify transcription factor binding sites and regulatory elements using genomic databases.
CO 8. Apply introductory proteomics tools to predict protein secondary structure and relate structure to function.

Unit No.	Title of Unit & Contents	Hrs.
I	**Sequence Alignment and Similarity Search**	**11**
	1. Introduction to biological sequences: DNA, RNA and proteins 2. Biological sequence databases: NCBI and UniProt 3. Sequence formats: FASTA, GenBank and PDB	

Unit No.	Title of Unit & Contents	Hrs.
	4. Concept of sequence similarity and identity 5. Introduction to BLAST (BLASTn and BLASTp) 6. Interpretation of BLAST results 7. Applications of BLAST in gene and protein function prediction	
	Unit Outcomes: UO 1. Retrieve and interpret biological sequences from public databases. UO 2. Perform BLAST searches and interpret results for biological function prediction.	
II	**Multiple Sequence Alignment and Phylogenetics**	**12**
	1. Concept and significance of multiple sequence alignment 2. Tools for multiple sequence alignment (ClustalX) 3. Introduction to molecular phylogeny 4. Construction of phylogenetic trees 5. Visualization and interpretation of phylogenetic trees using TreeView	
	Unit Outcomes: UO 1. Generate multiple sequence alignments and identify conserved regions. UO 2. Construct and interpret phylogenetic trees to infer evolutionary relationships.	
III	**Protein Structure Visualization and Analysis**	**10**
	1. Levels of protein structure: primary, secondary, tertiary and quaternary 2. Protein Data Bank (PDB): structure retrieval and interpretation 3. Protein structure visualization tools: RasMol, Cn3D and SPDBV	
	Unit Outcomes: UO1. Visualize protein structures using bioinformatics tools. UO 2. Analyze structural features related to protein function.	
IV	**Genomics and Proteomics**	**13**
	1. Overview of genomics and proteomics 2. Gene expression in prokaryotes and eukaryotes 3. Protein secondary structure prediction 4. Introduction to homology-based protein modeling	
	Unit Outcomes:	

Unit No.	Title of Unit & Contents	Hrs.
	UO 1. Identify genomic regulatory elements using bioinformatics tools. UO 2. Apply basic proteomics tools for protein structure prediction and analysis.	

Learning Resources:

1. Introduction to Bioinformatics, Lesk A., 2nd Edition, Oxford University Press, Oxford, 2019.
2. Bioinformatics: Sequence and Genome Analysis, Mount D. W., 2nd Edition, Cold Spring Harbor Laboratory Press, New York, 2004.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Baxevanis A. D. and Ouellette B. F. F., 3rd Edition, Wiley-Liss, New York, 2005.
4. Bioinformatics and Functional Genomics, Pevsner J., 3rd Edition, Wiley-Blackwell, Hoboken, 2015.
5. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Durbin R., Eddy S., Krogh A., Mitchison G., 1st Edition, Cambridge University Press, Cambridge, 1998.
6. Fundamentals of Bioinformatics and Computational Biology, Xiong J., 1st Edition, Cambridge University Press, Cambridge, 2006.
7. Introduction to Computational Genomics, Setubal J. C. and Meidanis J., 1st Edition, PWS Publishing, Boston, 1997.
8. Structural Bioinformatics, Bourne P. E. and Weissig H., 1st Edition, Wiley-Liss, New York, 2003.
9. Protein Structure and Function, Petsko G. A. and Ringe D., 1st Edition, Oxford University Press, Oxford, 2004.
10. Bioinformatics: Principles and Applications, Rastogi S. C., Mendiratta N., Rastogi P., 3rd Edition, PHI Learning Pvt. Ltd., New Delhi, 2010.
11. Introduction to Protein Structure, Branden C. and Tooze J., 2nd Edition, Garland Science, New York, 1999.
12. Genomics and Proteomics: Functional and Computational Aspects, Xiong J., 1st Edition, Cambridge University Press, Cambridge, 2006.
13. Phylogenetic Trees Made Easy: A How-To Manual, Hall B. G., 5th Edition, Sinauer Associates, Sunderland, 2018.
14. Proteomics: From Protein Sequence to Function, Pennington S. R. and Dunn M. J., 1st Edition, Springer-Verlag, Berlin, 2001.
15. Discovering Genomics, Proteomics and Bioinformatics, Campbell A. M. and Heyer L. J., 2nd Edition, Benjamin Cummings, San Francisco, 2007.

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Biotechnology

Course Type: DSC XI
Course Title: Lab Course XI (Based on DSC XI)
Course Code: 301BIO6103
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives

LO 1. To provide hands-on training in retrieval and handling of biological sequence data.
LO 2. To perform sequence similarity searches and interpret BLAST results.
LO 3. To generate and analyze pairwise and multiple sequence alignments.
LO 4. To construct and interpret phylogenetic trees using bioinformatics tools.
LO 5. To visualize protein three-dimensional structures using standard software.
LO 6. To predict secondary protein structure using online tools.
LO 7. To analyze protein secondary structure.
LO 8. To apply basic proteomics tools for structure prediction and comparative analysis.

Course Outcomes

After completion of the course, the student will be able to-

CO 1. Retrieve nucleotide and protein sequences from public biological databases.
CO 2. Perform BLAST-based similarity searches and interpret output parameters.
CO 3. Generate multiple sequence alignments and identify conserved regions.
CO 4. Construct and interpret phylogenetic trees to infer evolutionary relationships.
CO 5. Retrieve and visualize protein structures from Protein Data Bank.
CO 6. Analyze secondary structure elements and functional regions of proteins.
CO 7. Identify genomic regulatory elements such as transcription factor binding sites.
CO 8. Compare predicted and experimentally determined protein structural features.

Practical No.	Unit
1.	Retrieval of nucleotide sequences from NCBI database and interpretation of sequence records.
2.	Retrieval of protein sequences from NCBI database and understanding FASTA format.
3.	Pairwise sequence alignment of nucleotide sequences using online alignment tools.
4.	Pairwise sequence alignment of protein sequences and interpretation of alignment results.
5.	BLASTn analysis for nucleotide sequence similarity search and functional inference.
6.	BLASTp analysis for protein sequence similarity search and

7.	Multiple sequence alignment (MSA) of homologous protein sequences using ClustalX.
8.	Analysis of conserved regions and motifs from multiple sequence alignment output.
9.	Construction of phylogenetic tree using aligned sequences.
10.	Visualization and interpretation of phylogenetic trees using TreeView.
11.	Retrieval of protein structures from Protein Data Bank (PDB).
12.	Visualization of protein 3D structures using RasMol and Cn3D.
13.	Analysis of protein secondary structure elements using structure visualization tools.
14.	Identification of active sites and ligand binding regions in protein structures.
15.	Prediction of protein secondary structure from amino acid sequence and comparison with PDB structure.

N.B.: Any Ten Practicals from above.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

Course Type: DSC XII

Course Title: Traditional Medicine and Modern Biopharmaceutical Technology

Course Code: 301BIO6102

Credits: 03 **Max. Marks: 75** **Lectures: 45Hrs.**

Learning Objectives:

LO 1 Understand the historical background, importance, and future prospects of medicinal plants.
LO 2 Acquire knowledge of medicinal plant diversity, systematics, classification, and geographical distribution.
LO 3 Learn conservation strategies and sustainable utilization of medicinal plant resources.
LO 4 Understand the principles and philosophies of Indian traditional systems of medicine including Ayurveda, Siddha, Unani, Homeopathy, and Naturopathy.
LO 5 Gain insight into ethnomedicine, phytomedicines, and herbal raw materials used in healthcare.
LO 6 Understand modern biopharmaceutical processes involving genetically engineered cells for drug production.
LO 7 Learn principles of recombinant DNA technology, microbial transformation, and production of recombinant hormones and antibiotics.
LO 8 Understand advanced biopharmaceutical technologies including monoclonal antibodies, gene therapy, and modern vaccine development.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Identify, classify, and describe important medicinal plants of India along with their therapeutic uses.
CO 2 Explain medicinal plant diversity, conservation issues, and sustainable management practices.
CO 3 Interpret the concepts and applications of traditional systems of medicine practiced in India.
CO 4 Analyze the role of ethnomedicine and phytotherapeutics in primary healthcare systems.
CO 5 Describe drug development processes using genetically engineered microbial systems.

CO 6 Explain the production and applications of recombinant hormones, interferons, steroids, and semi-synthetic antibiotics.

CO 7 Evaluate emerging biopharmaceutical approaches such as phage therapy and discovery of novel antibiotic targets.

CO 8 Understand and compare modern therapeutic technologies including monoclonal antibodies, gene therapy (*ex vivo* and *in vivo*), and advanced vaccine platforms.

Unit No.	Title of Unit & Contents	Hrs.
I	**Medicinal Plants – Diversity, Conservation and Applications**	**12**
	1. Medicinal plants: history, importance, and future prospects 2. Status of medicinal plants in India – past and present 3. Medicinal plant diversity and local healthcare systems 4. Conservation of medicinal plants: issues, challenges, and strategies 5. Important medicinal plants of India 6. Systematics and classification of medicinal plants 7. Geographical distribution and therapeutic uses. *8.* Detailed study of: *Acorus calamus, Adhatoda vasica Abrus precatorius, Aloe vera, Stevia rebaudiana etc*	
	Unit Outcomes: UO 1 Identify and classify important medicinal plants of India. UO 2 Evaluate therapeutic applications of medicinal plants in healthcare systems.	
II	**Traditional Systems of Medicine and Herbal Biotechnology**	**11**
	1. Overview of Traditional Systems of Medicine (TSM) in India 2. Concept and principles of Ayurveda 3. Siddha system of medicine 4. Unani system of medicine 5. Homeopathy – principles and applications 6. Naturopathy – concept and therapeutic approaches 7. Introduction to phytomedicines and herbal raw materials 8. Ethnomedicine and indigenous healthcare knowledge	

Unit No.	Title of Unit & Contents	Hrs.
	9. Scope and importance of herbal drugs in the modern pharmaceutical industry	
	Unit Outcomes: UO 1 Understand principles of Indian traditional systems of medicine. UO 2 Analyze the role of ethnomedicine and phytomedicines in modern healthcare.	
III	**Biotechnology of Recombinant Therapeutic Molecules**	**11**
	1. Drug development in pharmaceutical processes 2. Production of pharmaceuticals by genetically engineered cells 3. Recombinant hormones 4. Interferons 5. Microbial transformation for production of important pharmaceuticals 6. Steroids 7. Semi-synthetic antibiotics 8. Discovery of novel antibiotic targets 9. Phage therapy and bacteriophage engineering.	
	Unit Outcomes: UO 1 Demonstrate proficiency in recombinant DNA technology systems used for pharmaceutical production. UO 2 Explain production processes of recombinant hormones and therapeutic proteins.	
IV	**Contemporary Biopharmaceutical Applications**	**11**
	1. Antibodies in research, diagnostics, and therapeutics 2. Production of monoclonal antibodies: Hybridoma technology 3. Techniques for clinical application of monoclonal antibodies 4. Gene therapy: Background and principles,Types: ex vivo and in vivo gene therapy and Case study 5. Vaccines: Vaccine vectors, Nucleic acid vaccines (DNA and mRNA vaccines), Immune-enhancing technologies and adjuvants	
	Unit Outcomes:	

Unit No.	Title of Unit & Contents	Hrs.
	UO 1 Understand principles and applications of monoclonal antibody production. UO 2 Compare *ex vivo* and *in vivo* gene therapy approaches and modern vaccine technologies.	

Learning Resources:

1. Traditional Medicine in India: An Overview, Government of India, Ministry of AYUSH, New Delhi, 2016.
2. Textbook of Pharmacognosy, Trease, G. E. and Evans, W. C., Elsevier, Amsterdam, 16th Edition, 2021.
3. Herbal Drug Technology, Subrahmanyam, C. V. S., Vallabh Prakashan, New Delhi, 2nd Edition, 2016.
4. Ethnobotany and Medicinal Plants of India, Jain, S. K., Scientific Publishers, Jodhpur, 2nd Edition, 2019.
5. Pharmaceutical Biotechnology: Fundamentals and Applications, Gunter, C. M., Wiley, Hoboken, NJ, 2nd Edition, 2020.
6. Biopharmaceuticals: Biochemistry and Biotechnology, Walsh, G., Wiley-Blackwell, Hoboken, NJ, 3rd Edition, 2018.
7. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Glick, B. R., Pasternak, J. J. and Patten, C. L., ASM Press, Washington DC, 4th Edition, 2019.
8. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R. M., Wiley-Blackwell, Oxford, 7th Edition, 2016.
9. Monoclonal Antibodies: Methods and Protocols, Schook, L. B., Springer, New York, 3rd Edition, 2018.
10. Vaccines, Plotkin, S. A., Orenstein, W. A. and Offit, P. A., Elsevier, Philadelphia, 7th Edition, 2018.

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Biotechnology

Course Type: DSC XII
Course Title: Lab Course XII (Based on DSC XII)
Course Code: 301BIO6104
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1 Acquire hands-on skills in identification and documentation of locally available medicinal plants.
LO 2 Understand the medicinal importance of different plant parts used in traditional healthcare systems.
LO 3 Learn preparation methods of herbal formulations such as kadha, powders, juices, and Ayurvedic products.
LO 4 Develop practical knowledge of cultivation, conservation, storage, and packaging of medicinal plants.
LO 5 Gain experience in extraction and preliminary analysis of natural bioactive molecules.
LO 6 Understand basic pharmaceutical and microbiological laboratory techniques.
LO 7 Learn antimicrobial testing methods including antibiotic assay, MIC determination, and disinfectant evaluation.
LO 8 Understand quality control parameters of pharmaceuticals including sterility testing, stability studies, and shelf-life determination.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Identify, classify, and document commonly available medicinal plants and their therapeutic uses.
CO 2 Prepare and evaluate various herbal formulations following traditional and scientific procedures.
CO 3 Demonstrate skills in cultivation, maintenance, storage, and packaging of medicinal plants.
CO 4 Perform extraction of natural bioactive compounds from plant sources.
CO 5 Conduct antimicrobial activity assays of antibiotics using standard microbiological techniques.

CO 6 Determine minimum inhibitory concentration (MIC) and evaluate the effectiveness of antimicrobial agents.

CO 7 Perform pharmaceutical quality control tests including sterility testing as per Indian Pharmacopoeia guidelines.

CO 8 Analyze drug stability, shelf life, and the effect of chemical disinfectants on microbial growth.

Practical No.	Unit
1.	Identification of locally available common medicinal plants.
2.	Study of different parts of medicinal plants and their therapeutic uses.
3.	Preparation of herbal *kadha* using selected medicinal plants.
4.	Preparation of herbal powders (Neem leaf, Moringa leaf, Tulsi leaf, Giloy, Arandana).
5.	Preparation of herbal juices (Amla and Aloe vera).
6.	Preparation of Ayurvedic products such as Chyavanprash, herbal tea and similar formulations.
7.	Preparation of Amla candy.
8.	Study of basic tools, instruments and apparatus used in herbal medicine preparation.
9.	Study and documentation of commercial production of at least five medicinal plants (using official websites / YouTube educational resources).
10.	Submission of a digital photo album of at least ten medicinal plants with brief botanical and medicinal description.
11.	Cultivation, maintenance and reporting of at least five medicinal plants within the college campus.
12.	Study of storage methods and packaging techniques of herbal medicines.
13.	Assay of antimicrobial activity of antibiotics (Penicillin, Chloramphenicol, Streptomycin and Quinolones) by agar diffusion method.
14.	Determination of Minimum Inhibitory Concentration (MIC) of selected antibiotics.
15	Sterility testing of commercial pharmaceutical preparations (including injectables as per Indian Pharmacopoeia –demonstration).
16.	Extraction of natural bioactive molecules from plant sources.
17.	Stability analysis of drugs using UV–Visible spectrophotometry.
18.	Determination of shelf life of antibiotics (including expired drug samples).
19.	Assay of antimicrobial activity of antibiotics (Penicillin, Chloramphenicol, Streptomycin and Quinolones) by agar diffusion method.

20.	Sterility testing of commercial pharmaceuticals.
21.	Sterility testing of injectable as per IP. 7
22.	Effect of chemical disinfectants on growth of bacteria

N. B.: Any Ten Practicals from above.

Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)
Department of Biotechnology

Course Type: DSE II

Course Title: Environmental Biotechnology

Course Code: 301BIO6201

Credits: 03 **Max. Marks: 75** **Lectures: 45Hrs.**

Learning Objectives:

LO 1 To understand the processes involved in wastewater treatment plants.

LO 2 To understand the principles behind various treatment processes and their applications.

LO 3 To describe different types of microbial bioremediation techniques.

LO 4 To evaluate the role of plants in bioremediation.

LO 5 To identify and explain the causes and associated hazards of global environmental issues such as the Greenhouse effect and ozone layer depletion.

LO 6 To analyze regional environmental issues including forest and wildlife management, desertification, and the reclamation of degraded land.

LO 7 To identify practical applications of remote sensing in environmental monitoring and management.

LO 8 To outline the need for Environmental Impact Assessment (EIA) and explain the guidelines.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Describe biotechnological solutions to address environmental issues of pollution.

CO 2 Develop and implement effective solid waste management strategies.

CO 3 Explain emerging microbial bioremediation technologies that are important in environmental biotechnology.

CO 4 Apply knowledge of various phytoremediation techniques.

CO 5 Critically assess environmental issues and propose informed strategies for mitigation and sustainable development.

CO 6 Analyze the consequences of human intervention in wetlands and propose effective reclamation and conservation methods to address siltation, eutrophication, and the environmental impacts of mining.

CO 7 Effectively utilize various remote sensing techniques and energy sources for environmental and geographical studies.

CO 8 Conduct comprehensive eia and provide informed critiques and recommendations for improving eia practices, supported by case study analysis.

Unit No.	Title of Unit & Contents	Hrs.
I	**Waste Management Technology**	**12**
	1. Methods of monitoring Pollution; 2. Biological methods. 3. Detection methods for DO, BOD. 4. Chemical methods- Detection methods for COD, alkalinity, TSS, TDS. 5. Sewage and waste water treatments systems. 6. Primary, secondary and tertiary treatments. 7. Biological treatments. 8. Aerobic versus anaerobic treatments. 9. Biomedical waste management. 10. Solid Waste management.	
	Unit Outcomes: UO 1. Describe biotechnological solutions to address environmental issues of pollution. UO 2. Explain emerging technologies that are important in the area of environmental biotechnology.	
II	**Bioremediation Technology**	**10**

Unit No.	Title of Unit & Contents	Hrs.
	1. Introduction to bioremediation. 2. Bioremediation Strategies. 3. Microbial In situ Bioremediation Techniques. 4. Bioventing, Biosparging, Bioaugmentation. 5. Microbial Ex-situ Bioremediation Techniques. 6. Landfarming, Biopiles, Bioreactors. 7. Composting. 8. Phytoremediation Strategies. 9. Phytosequestration, Rhizodegradation, Phytohydraulics, Phytoextraction, Phytovolatilization, Phytodegradation.	
	Unit Outcomes: UO 1. Apply knowledge of microbial bioremediation techniques to design effective bioremediation strategies. UO 2. Explain the fundamental concepts of phytoremediation by which plants absorb, accumulate, and detoxify contaminants in soil and water.	
III	**Environmental Issues**	**13**
	Global Environmental Issues: 1. Green House effect – causes and associated hazards. 2. Ozone layer depletion – causes and associated hazards, Human Population Growth. 3. Environmental problems associated with urbanization, industrialization. 4. Modernization of agriculture, Regional Environmental Issues. 5. Forest and Wildlife management. 6. Desertification. 7. Reclamation of degraded land. 8. Human intervention on wetlands. 9. Siltation and eutrophication. 10. Reclamation of wetlands. 11. Mining and Environment.	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcomes: UO 1 Assessment of the environmental impacts of urbanization, industrialization, and modernization of agriculture, proposing sustainable solutions to mitigate these issues. UO 2 Examine the human impacts on wetlands, including siltation and eutrophication, and propose strategies for effective reclamation and sustainable mining practices.	
IV	**Remote sensing and EIA**	**10**
	Remote sensing 1. Principal, terminologies and objectives. 2. Energy sources for remote sensing. 3. Types of remote sensing. 4. Applications of Remote Sensing. **EIA** 1. The Need for EIA. 2. EIA guidelines 1994. 3. EIA Cycle and its Procedures. 4. Components of EIA. 5. Drawbacks and Recommendations of EIA. 6. Case Study: EIA.	
	Unit Outcomes: UO 1 Understanding of the principles, terminologies, and objectives of Remote Sensing and GIS. UO 2 Explain the need for Environmental Impact Assessment (EIA), understand the EIA guidelines of 1994, and describe the EIA cycle.	

Learning Resources:

1. Environmental Biotechnology, Allan Scragg, 2nd edition, OUP Oxford publication, 2005.
2. Environmental Biotechnology, Prof. Jogdand, Himalayan publication, 2010.
3. Environmental Biotechnology, Foster C.F., John Ware D.A., Ellis Horwood Ltd., 1987.
4. Biotechnology and Biodegradation, Karrely D., Chakrabarty K., Omen G.S., Portfolio Publishing Co Inc., U.S., 1990.
5. Bioremediation engineering; design and application, John. T. cookson,Jr. Mc Graw Hill, Inc., 1994.
6. Environmental Biotechnology, A.K. Chatterjee, 3rd edition, Prentice Hall India Learning Private Limited, 2011.
7. Environmental Biotechnology, Bimal Bhattachraya and Ritu Banerjee, Oxford university press, 2007.
8. Environmental pollution control engineering, C. S. Rao, 4th edition, New age international Publishers,2021.
9. Environmental Biotechnology theory and application, Gareth Evans and Judith Furlong. John Wiley and Sons Ltd., 2002.
10. Environmental Biotechnology Concept and application, Hans-Joachim Jördening and Josef Winter, 1st edition, Wiley VCH Verlag GmbH & Co. KGaA, 2004.
11. Environmental Biotechnology and Applications, Pavan Kumar, Discovery Publishing House, 2013.

Rajarshi Shahu Mahavidyalaya, Latur
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Department of Biotechnology

Course Type: DSE II
Course Title: Lab Course II (Based on DSE II)
Course Code: 301BIO6202
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1 To undertake a range of practical approaches relevant to sample testing for the presence of pollutants.
LO 2 To design experiments for qualitative analysis of water samples.
LO 3 To accurately measure and analyze various parameters of water quality.
LO 4 To accurately measure and analyze hardness of water.
LO 5 To isolate and identify bacteria and fungi from different polluted environments such as soil, water and air.
LO 6 To design and monitor composting experiments, evaluate compost quality, and apply composting principles to organic waste management.
LO 1 To study and analyze the role of symbiotic relationships between plants and microorganisms.
LO 2 To investigate various composting parameters.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Determine acidity, alkalinity, salinity of water sample.
CO 2 Determine the do and bod of water samples.
CO 3 Detect pathogens from various polluted ecological regions.
CO 4 Isolate and identify bacteria and fungi from polluted environments using appropriate microbiological techniques.
CO 5 Execute composting experiments, adjust and monitor key parameters.
CO 6 Evaluate the effectiveness of composting processes for producing high-quality compost suitable for soil amendment.
CO 7 Analyze and interpret the impact of symbiotic relationships between plants and microorganisms on plant health and soil fertility.

CO 8 Apply the knowledge gained from plant-microbe interactions to develop and recommend practical solutions for environmental management and sustainability challenges.

Practical No.	Unit
1.	Determination of total solids.
2.	Determination of alkalinity
3.	Determination of COD
4.	Determination of DO
5.	Determination of BOD
6.	Determination of hardness of water
7.	MPN Test.
8.	Isolation of bacteria from polluted soil.
9.	Isolation of bacteria from polluted water.
10.	Isolation of bacteria from polluted air.
11.	Isolation of fungi from polluted soil.
12.	Isolation of fungi from polluted water.
13.	Isolation of fungi from polluted air.
14.	Identification of Bioremediation microorganisms.
15	Characterization of Bioremediation microorganisms.
16.	Production of biofertilizers using waste.
17.	Composting of organic waste materials to produce nutrient-rich compost for soil amendment.
18.	Investigation of composting parameters such as temperature, moisture content, carbon-to-nitrogen ratio.
19.	Investigation of composting microbial activity.
20.	Study of symbiotic relationships between plants and beneficial microorganisms (e.g., mycorrhizal fungi, nitrogen-fixing bacteria) for enhancing plant growth and environmental sustainability.
21.	Case Study: EIA
22.	GIS-Remote Sensing (software demo) of local area. (e.g. college campus, water bodies etc.)

N. B.: Any Ten Practicals from above.

Rajarshi Shahu Mahavidyalaya, Latur
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Course Type: DSE II (B)

Course Title: Nano Biotechnology

Course Code: 301BIO6202

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1 To make students aware about role of nanotechnology in biological science.
LO 2 To create foundation of research and development in Nanobiotechnology.
LO 3 To train the students with industry requirement as per the field of nano biotechnology.
LO 4 To guide the students to build up career in the field of nano biotechnology.
LO 5 To describe the historical development and significance of nanotechnology.
LO 6 To identify and describe various biological nanoparticles.
LO 7 To learn the structure and function of biological nanomachines.
LO 8 To learn purification and separation of carbon nanotubes.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Understand the method of analysis of nanoparticles with biological material.
CO 2 Understand the nanoscale properties and its utilization in various field.
CO 3 Understand various carbon-based nanomaterials.
CO 4 Understand the importance and applications of nanoscience in today's era.
CO 5 Explain how the nanoscale modification of materials can lead to enhanced or unique properties.
CO 6 Understand the role of nanoparticles in biological systems and their potential applications in nanotechnology.
CO 7 Discuss how these biological nanomachines operate and their significance.
CO 8 Understand the structural characteristics and applications of each type of nanostructure.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction To Nanotechnology**	**12**
	1. Importance of Nanotechnology-History of Nanotechnology. 2. Opportunity at the nano scale length and time scale in structures-energy landscapes. 3. Inter dynamic aspects of inter molecular forces. 4. Classification based on the dimensionality. 5. Nanoparticles nanoclusters nanotubes. 6. Nanowires and nanodots. 7. Semiconductor nanocrystals carbon nanotubes. 8. Influence of Nano structuring on Mechanical, optical, electronic, magnetic and chemical properties.	
	Unit Outcomes: UO 1. Analyze the unique opportunities and phenomena that arise at the nanoscale. UO 2. Describe the structural characteristics and applications of each type of nanostructure.	
II	**Biological nanomaterial**	**13**
	1. What is nanotechnology and Development of nanobiotechnology – timelines and progress. 2. Overview Biological nanoparticles and its applications. 3. Introduction to biological nanoparticles, Exosolipoproteins, Ferritin, Biological nanometers and machines. 4. Biological nanomachines: protein assemblies, muscle myosin, ATPase, Hemoglobin, Biological nanometers. 5. Bacterial Flagella, cilia: Structure and function Biological nanopores: Ion channels. 6. Bacteriorhodopsin, Bioinspired nanomaterial and its applications. 7. DNA and protein-based nanomaterial.	
	Unit Outcomes: UO 1. Explain the structure and function of biological nanomachines, such as protein assemblies, muscle myosin, ATPase, and hemoglobin. UO 2. Examine bioinspired nanomaterials and their applications.	
III	**Carbon based nanomaterials**	**12**
	1. Production of carbon nanotubes (Single walled and multi walled).	

Unit No.	Title of Unit & Contents	Hrs.
	2. Arc discharge method, Laser ablation. 3. Chemical vapor deposition, Pyrolatic technique. 4. Purification and separation of carbon nanotubes. 5. Diamond synthesis routes. 6. Preparation of nanodiamond.	
	Unit Outcomes: UO 1. Explain purification and separation methods used for production of nanomaterials. UO 2. Design and implement processes for the effective production of different nanotubes.	
IV	**Applications of Nano biotechnology**	**13**
	1. Semiconductor (metal) nanoparticles and nucleic acid. 2. Protein based recognition groups– Application in optical detection methods. 3. Nanoparticles as carrier for genetic material. 4. Nanotechnology in agriculture. 5. Fertilizer and pesticides. 6. Designer proteins, Peptide nucleic acids, Nanomedicine. 7. Drug delivery, DNA computing. 8. Molecular design using biological selection. 9. Harnessing molecular motors, Artificial life, Hybrid materials. 10. Biosensors - Future directions.	
	Unit Outcomes: UO 1. Understand the principles and importance of semiconductor nanoparticles and their applications. UO 2. Understand uses of different nanoparticles for the drug delivery.	

Learning Resources:

1. Principles of Biochemistry, Leininger, Nelson, Cox, CBS publishers and distributors, New Delhi, 2004.
2. Fundamentals of Biochemistry, Donald Voet, Akif Uzman, Judith G. Voet, CharlotteWPratt, John Wiley and Sons, New York, 2008.
3. Biochemistry, Geoffrey L. Zubay , WCB publishers, 1998.
4. Biochemistry – Lubert Stryer, 1995. _
5. C. M. Niemeyer, C. A. Mirkin,Nanobiotechnology: Concepts, Applications and Perspectives||, Wiley – VCH, 2004.
6. Nanoscience: Nanobiotechnology and Nanobiology, P. Boisseau, P. Houdy and M. Lahmani, Springer, 2007.
7. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology, Hari Singh Nalwa, American Scientific Publishers, 2005.
8. Nanobiotechnology, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004.
9. Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer," Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact", Wiley – VCH, 2005.
10. Nicholas A. Kotov, "Nanoparticle Assemblies and Superstructures", CRC, 2006.
11. T. Pradeep, —Nano: The Essentials||, McGraw – Hill education, 2007.
12. David S Goodsell, "Bio nanotechnology ||, John Wiley & Sons, 2004.
13. Molecular Biology of the Gene, 6th Edition, James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA 2008.

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Department of Biotechnology

Course Type: DSE II
Course Title: Lab Course DSE II (Based on DSE II)
Course Code: 301BIO6203
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1 To make student aware about nanotechnology technique in biological science.
LO 2 To make the students aware about the methods in Nanotechnology.
LO 3 To learn various methods in Nano-biotechnology research.
LO 4 To learn the principles and methodologies of biosynthesis for silver nanoparticles.
LO 5 To analyze and interpret data to evaluate the structural, optical, and chemical properties of materials.
LO 6 To apply knowledge of synthesis methods to design and implement nanomaterials.
LO 7 To learn different methods for the synthesis of nanoparticles.
LO 8 To demonstrate proficiency in synthesizing nanoparticles and thin films using various methods.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Understand the method of analysis of nanoparticles with biological material.
CO 2 Understand the nanoscale properties and its utilization in various field and will be able to understand the techniques.
CO 3 Understand production of silver nanoparticle.
CO 4 Understand electrodeposition of different metals.
CO 5 Compare and contrast different synthesis methods for nanoparticles.
CO 6 Synthesize nano particles from different sources like plants, fungi and bacteria.
CO 7 Evaluate how different biological agents influence the size, shape, and properties of the nanoparticles.
CO 8 Identify the advantages, limitations, and suitability of each method for specific applications.

Practical No.	Unit
1	Biosynthesis of silver nanoparticle from plants
2	Biosynthesis of silver nanoparticle from Fungi
3	Biosynthesis of silver nanoparticle by Bacteria
4	Synthesis of silver nanoparticles by using biological method
5	Synthesis of ZnO by hydrothermal method
6	Synthesis of Polyaniline nanofibers by CBD method
7	Synthesis of Fe2O3 by Sol-gel method
8	Preparation of CdS by chemical bath deposition
9	Electrodeposition of Cobalt thin films
10	Preparation of CdSe by Successive Ionic Layer, Adsorption and Reaction (SILAR) method

N.B.: Any Ten Practicals from above.

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Course Type: DSM V
Course Title: Process Technology
Course Code: 301BIO6301
Credits: 03 **Max. Marks: 75** **Lectures: 45**

Learning Objectives

LO 1 To understand the basic construction, design, and operational principles of fermenters.

LO 2 To learn the principles and methods of air and media sterilization.

LO 3 To master media design, optimization, and estimation for cost-effective fermentation.

LO 4 To explore microbial culture development and understand strain improvement techniques.

LO 5 To analyze growth kinetics in batch, continuous, and fed-batch fermentation systems.

LO 6 To acquire skills in bioprocess monitoring and control of parameters such as cell growth, pH, temperature, and substrate consumption.

LO 7 To understand the challenges and techniques associated with scaling up bioprocesses.

LO 8 To gain insights into process economics, regulatory standards, and emerging innovations in bioprocess technology.

Course Outcomes

After completion of the course, the student will be able to-

CO 1 Gain comprehensive knowledge of fermenter design, components, and sterilization techniques.

CO 2 Develop proficiency in the principles of media sterilization and optimization for fermentation processes.

CO 3 Understand the kinetics of microbial growth and strategies for culture preservation and strain improvement.

CO 4 Learn techniques for the monitoring and control of key bioprocess parameters.

CO 5 Achieve proficiency in managing bioprocess scale-up and optimizing operational efficiency.

CO 6 Evaluate process economics and industrial case studies in bioprocess optimization.

CO 7 Understand regulatory, environmental, and waste management aspects in fermentation.

CO 8 Stay informed on future trends in bioprocess technology, including innovations and emerging technologies.

Unit No.	Title of Unit & Contents	Hrs.
I	**Fermentation Technology: Design, Components, and Sterilization**	**11**
	1. Basic Construction of fermenter, types of fermenters and their operational principles. 2. Materials of Constructions, welding, surface treatment. 3. Components of the fermenters & their specifications. 4. Air Sterilization: Principles, Methods of air sterilization. 5. Principles of Media Sterilization and its Kinetics. 6. Constituents of media, Media Optimization their estimation & quantification. 7. Design of media. Costing of media.	
	Unit Outcomes: UO 1. Understanding Fermenter Design and Operation. UO 2. Mastering Sterilization Techniques and Media Design.	
II	**Microbial Culture Development and Strain Improvement**	**12**

Unit No.	Title of Unit & Contents	Hrs.
	1. Development of Inoculum. 2. Growth Kinetics: Batch, Continuous, Fed Batch Kinetics. 3. Screening: Primary and Secondary Screening. 4. Preservation and Maintenance methods for Microbial culture. 5. Strain Improvement: a. Feedback Mechanism b. Isolation of mutants which do not produce feedback inhibitors or repressors. c. Isolation of mutants which do not recognize presence of inhibitors or repressors. d. Modification of Permeability.	
	Unit Outcomes: UO 1. Mastery of Inoculum Development and Growth Kinetics. UO 2. Proficiency in Screening, Preservation, and Strain Improvement Techniques.	
III	**Bioprocess Monitoring, Control, and Scale-Up**	**11**
	1. Measurement & Control of Bioprocesses Parameters: Cell growth. pH, temperature, Substrate consumption, product formation. 2. Measurement of O2/CO2 uptake, evolution. 3. Specific rates of consumption substrate & formation of product. 4. Strategies for fermentation control. Foam & its control. 5. Computer controlled fermentations. 6. Scale-Up in Bioprocess Fermentations • Factors affecting scale-up: mixing, aeration, agitation, heat transfer. • Impact on efficiency, yield, and operational costs.	
	Unit Outcomes: UO 1 Expertise in Monitoring and Controlling Bioprocess Parameters.	

Unit No.	Title of Unit & Contents	Hrs.
	UO 2 Proficiency in Advanced Fermentation Control and Scale-Up Techniques.	
IV	**Process Economics, and Emerging Innovations in Bioprocess Technology**	**11**
	1. Process Economics and Optimization: Costing, process optimization, and Economic feasibility: industrial case studies. 2. Regulatory and Environmental Aspects: Regulatory standards (GMP, FDA, ISO) , Environmental impact assessment of fermentations. Waste management and sustainability 3. Future Trends in Process Technology: Innovations in bioprocess engineering, synthetic biology applications Emerging technologies: biorefineries, bioeconomy, precision fermentation	
	Unit Outcomes: UO 1. Master the factors influencing scale-up and understand their impact on efficiency, yield, and operational costs in industrial fermentation processes. UO 2. Develop knowledge of process economics, regulatory standards, environmental sustainability, and emerging trends .	

Learning Resources:

1. Principles of Fermentation Technology, P. F. Stanbury, A. Whitaker, & S. J. Hall, 3rd ed., Pergamon Press, 2016.
2. Bioprocess Engineering: Basic Concepts, M. L. Shuler & F. Kargi, 2nd ed., Prentice Hall, 2017.
3. Bioprocess Engineering Principles, P. M. Doran, 2nd ed., Academic Press, 2013.
4. Biotechnology: A Textbook of Industrial Microbiology, W. Crueger & A. Crueger, 2nd ed., Sinauer Associates, 1990.

5. Fermentation Microbiology and Biotechnology, R. Patel, 2nd ed., CRC Press, 2004.
6. Biochemical Engineering Fundamentals, J. E. Bailey & D. F. Ollis, 2nd ed., McGraw-Hill, 1986.
7. Comprehensive Biotechnology, M. Moo-Young, 2nd ed., Elsevier, 2013.
8. Microbial Technology: Fermentation Technology, H. J. Peppler & D. Perlman, 2nd ed., Academic Press, 1979.
9. Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis, and Bioseparation, M. C. Flickinger & S. W. Drew, Wiley, 1999.
10. Bioprocess Engineering: Systems, Equipment, and Facilities, B. K. Lydersen, N. A. D'Elia, & K. L. Nelson, Wiley-Interscience, 1994.
11. Recent Advances in Fermentation Technology, V. K. Gupta, Elsevier, 2020.
12. Fermentation Technology: Current Developments and Future Trends, S. Singh, Springer, 2018.

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Course Type: DSM V
Course Title: Lab Course Minor V
Course Code: 301BIO6302
Credits: 01 **Max. Marks: 50** **Hours: 30**

Learning Objectives:

LO 1 To explain the principles of fermentation and its significance in biotechnology.
LO 2 To demonstrate the ability to design and set up a small-scale fermenter for various fermentation processes.
LO 3 To perform primary and secondary screenings of microbial strains to identify high-yield producers of acids, antibiotics, and enzymes.
LO 4 To induce mutations in microbial strains and assess their potential for strain improvement.
LO 5 To identify and apply appropriate sterilization techniques for fermentation equipment and media.
LO 6 To prepare and optimize fermentation media to enhance microbial growth and product yield.
LO 7 To utilize techniques for monitoring growth kinetics and product formation in batch and continuous fermentation.
LO 8 To analyze the economic aspects of fermentation processes and evaluate their feasibility in an industrial context.

Course Outcomes:

After completion of the course, the student will be able to-

CO 1 Apply theoretical knowledge of fermentation principles to practical scenarios.
CO 2 Demonstrate proficiency in setting up and operating small-scale fermenters.
CO 3 Effectively conduct screenings of microbial strains and select high-yield producers for specific fermentation processes.
CO 4 Successfully induce mutations in microbial strains and evaluate their performance in fermentation.

CO 5 Employ sterilization techniques to ensure the integrity of fermentation media and equipment.

CO 6 Prepare optimized fermentation media tailored for different microbial strains and products.

CO 7 Proficiently monitor and analyze growth kinetics and product formation during fermentation processes.

CO 8 Conduct an economic assessment of fermentation processes and develop recommendations for cost-effective production strategies.

Practical No.	Unit
1.	Design and Setup of a Small-Scale Fermenter: A Hands-On Approach
2.	Primary and secondary screenings of microbial strains to identify high-yield producers for fermentation processes (Acid, Antibiotics, Enzymes)
3.	Inducing Mutations for Strain Improvement: A Laboratory Study
4.	Sterilization Techniques for Fermentation Equipment and Media
5.	Preparation and Optimization of Fermentation Media for Microbial Growth
6.	Inoculum Development: Techniques for Cultivating Microbial Strains
7.	Batch Fermentation: Monitoring Growth Kinetics and Product Formation
8.	Continuous Fermentation: Assessing Stability and Yield
9.	Sterilizer Design- TDP, TDT
10.	Use of Computer Software for Monitoring and Controlling Fermentation
11.	Economic Analysis of Fermentation Processes: A Practical Assessment
12.	Visit to Fermentation Industry

N.B.: Any Ten Practicals from above.

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Course Type: VSC IV
Course Title: Bakery and confectionery
Course Code: 301BIO6501
Credits: 02 (01+01) **Max. Marks: 50** **Lectures: 45 Hrs.(15Th + 30P)**

Learning Objectives:

LO 1. To gain insight into the overall scope of bakery and confectionery industries.
LO 2. To learn about the structure of wheat grain and its components.
LO 3. To understand the different types of flours and their constituents.
LO 4. To identify the role of each ingredient in bread making.
LO 5. To learn the quality of bread based on external and internal characteristics.
LO 6. To understand the principles of cake and pastry production.
LO 7. To analyze cake characteristics and formula balancing.
LO 8. To recognize confectionery products and Ice Cream types.

Course Outcomes:

After completion of course the student will be able to-

CO 1. detailed knowledge of bakery & confectionery.
CO 2. expertise in wheat grain structure.
CO 3. acquaint the knowledge of proficiency in flour characteristics.
CO 4. adapt the manufacturing method of bread making skills.
CO 5. evaluate bread quality based on its characteristics and effectively troubleshoot.
CO 6. apply principles of cake and pastry production to create various types of cakes and pastries.
CO 7. effectively balance cake formulas to achieve desired results.
CO 8. identify different types of confectionery products and ice creams.

Unit No.	Title of Unit & Contents	Hrs.
I	**Fundamentals of Bakery & Confectionery**	**03**
	1. Introduction & scope of Bakery & Confectionery, Bakery terms. Organization chart of Bakery. 2. Structure of wheat grain. 3. Milling of wheat and role of bran and germ. 4. Flours: Different types of flours available, constituents of flours, PH Value of flour, water absorption power of flour, gluten, diastatic capacity of flour, grade of flour.	

	Unit Outcomes: UO 1. Understand the Scope of Bakery & Confectionery. UO 2. Identify Types and Properties of Flour.	
II	**Bread Making: Ingredients, Methods, and Quality Control**	**04**
	1. Raw material required for bread making: - Role of flour, water, yeast, salt, Sugar, milk and fats. 2. Methods of bread making. 3. Characteristics of good bread. 4. Bread faults and their remedies.	
	Unit Outcome: UO1. Recognize Good Bread Characteristics. UO 2. Learn Bread Making Methods.	
III	**Principles and Practices of Cake and Pastry Production**	**04**
	1. Principle involved in cake and pastries production. 2. Different types of cakes and their uses. 3. Cake making ingredients and Cake making methods. 4. Characteristics of cakes: External; Internal. 5. Balancing of cake formula. 6. Different types of biscuits and cookies and Ingredients used in biscuits and cookies production.	
	Unit Outcomes: UO 1. Acquaint the knowledge of different types of cakes and their uses. UO 2. Adapt the manufacturing method of different types of biscuits and cookies.	
IV`	**Confectionery Production and Storage**	**04**
	1. Characteristics of confectionary products. 2. Types of confectionary products. 3. Ingredients used in confectionary products. 4. Making of any confectionary products. 5. Storage of confectionery product. 6. Various types ice creams and bombs.	
	Unit Outcomes: UO 1. Acquaint the knowledge of Characteristics of Confectionery Products. UO 2. Describe the storage of confectionery products.	
V	**Practicals (Included in above 04 units)**	**30**
	1. Introduction to Bakery Equipments and Confectionery Equipments. 2. Estimation of Gluten.	

	3. Preparation of different types of bread. a. Plain bread b. Fermented bread c. Protein Rich bread / Milk bread d. Special bread 4. Quality evaluation of bread. 5. Preparation of Biscuits & Cookies. 6. Preparation of Flaky/Puff pastry. 7. Preparation of Choux pastry. 8. Preparation of Short crust pastry. 9. Preparation of Ice Cream and bombs. 10. Preparation of Cakes & Gauteaux. 11. Preparation of Pudding.	

Learning Resources:

1. Fundamentals of Baking, The Culinary Institute of America. Wiley, New York, 2011.
2. Modernist Bread: The Art and Science, Myhrvold N, Migoya F, and the Modernist Cuisine Team. The Cooking Lab, Bellevue, 2017.
3. The Professional Pastry Chef: Fundamentals of Baking and Pastry, Friberg B. Wiley, New York, 2002.
4. Understanding Baking: The Art and Science of Baking, Amendola J. Wiley, New York, 2009.
5. The Science of Good Cooking: Master 50 Simple Concepts to Enjoy a Lifetime of Success in the Kitchen, Cook's Illustrated. America's Test Kitchen, Boston, 2012.
6. On Food and Cooking: The Science and Lore of the Kitchen, McGee H. Scribner, New York, 2004.
7. The Art of French Pastry, Pfeiffer J, Shulman MR. Ten Speed Press, Berkeley, 2013.
8. Confectionery Science and Technology, Matthews BRW. Wiley-Blackwell, Oxford, 2005.
9. The Complete Book of Pastry, Sweet, and Savory, Dufresne W, O'Brien J. Sterling Publishing, New York, 2015.
10. Ice Creams, Water Ices, Frozen Desserts: A Cookbook, Beckerman C. McGraw-Hill, New York, 1998.

Shiv Chhatrapati Shikshan Sanstha's

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UG Second Year

Extra Credit Activities

Sr. No.	Course Title	Credits	Hours T/P
1	MOOCs	Min. of 02 credits	Min. of 30 Hrs.
2	Certificate Courses	Min. of 02 credits	Min. of 30 Hrs.
3	IIT Spoken English Courses	Min. of 02 credits	Min. of 30 Hrs.

Guidelines:

Extra -academic activities

1. All extra credits claimed under this heading will require sufficient academic input/ contribution from the students concerned.
2. Maximum 04 extra credits in each academic year will be allotted.
3. These extra academic activity credits will not be considered for calculation of SGPA/CGPA but will be indicated on the grade card.

Additional Credits for Online Courses:

1. Courses only from SWAYAM and NPTEL platform are eligible for claiming credits.
2. Students should get the consent from the concerned subject Teacher/Mentor/Vice Principal and Principal prior to starting of the course.
3. Students who complete such online courses for additional credits will be examined/verified by the concerned mentor/internal faculty member before awarding credits.
4. Credit allotted to the course by SWAYAM and NPTEL platform will be considered as it is.

Additional Credits for Other Academic Activities:

1. One credit for presentation and publication of paper in International/National/State level seminars/workshops.
2. One credit for measurable research work undertaken and field trips amounting to 30 hours of recorded work.
3. One credit for creating models in sponsored exhibitions/other exhibits, which are approved by the concerned department.
4. One credit for any voluntary social service/Nation building exercise which is in collaboration with the outreach center, equivalent to 30 hours
5. All these credits must be approved by the College Committee.

Additional Credits for Certificate Courses:

1. Students can get additional credits (number of credits will depend on the course duration) from certificate courses offered by the college.
2. The student must successfully complete the course. These credits must be approved by the Course Coordinators.
3. Students who undertake summer projects/ internships/ training in institutions of repute through a national selection process, will get 2 credits for each such activity. This must be done under the supervision of the concerned faculty/mentor.

1. The respective documents should be submitted within 10 days after completion of Semester End Examination.
2. No credits can be granted for organizing or for serving as office bearers/ volunteers for Inter-Class / Associations / Sports / Social Service activities.
3. The office bearers and volunteers may be given a letter of appreciation by the respective staff coordinators. Besides, no credits can be claimed for any services/activities conducted or attended within the college.
4. All claims for the credits by the students should be made and approved by the mentor in the same academic year of completing the activity.
5. Any grievances of denial/rejection of credits should be addressed to Additional Credits Coordinator in the same academic year.
6. Students having a shortage of additional credits at the end of the third year can meet the Additional Credits Coordinator, who will provide the right advice on the activities that can help them earn credits required for graduation.

Shiv Chhatrapati Shikshan Sanstha's

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Examination Framework

Theory:

40% Continuous Assessment Tests (CATs) and 60% Semester End Examination (SEE)

Practical:

50% Continuous Assessment Tests (CATs) and 50% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT & Mid Term	SEE	Total
1	2	3				4		5	6	5 + 6
		Att.	CAT I	Mid Term	CAT II	Att.	CAT			
DSC/DSE/Minor	75	05	10	15	10	-	-	30	45	75
Lab Course/AIPC/ OJT/FP	50	-	-	-	-	05	20	-	25	50
Minor/VSC/ VEC	50	05	05	10	05	-	-	20	30	50

Note:

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. Mid Term Exam will be conducted by the Exam Section
4. Mid Term Exam is of Objective nature (MCQ)
5. Semester End Exam is of descriptive in nature (Long & Short Answer)
6. CAT Practical (20 Marks): Lab Journal (Record Book) 10 Marks, Overall Performance 10 Marks.

Summary of cross cutting issues:

Biotechnology encompasses a diverse array of technologies that manipulate biological systems and processes to develop valuable products. These technologies range from traditional practices such as brewing and bread-making to cutting-edge genetic modifications in plants, animals, and humans. The curriculum is designed to address several critical cross-cutting issues essential for student development, including Professional Ethics, Gender, Environment and Sustainability, and Human Values. These elements are integrated throughout various courses to ensure that students cultivate both technical expertise and ethical responsibility.

Cross-cutting issues relevant to Professional Ethics, Gender, Environment and Sustainability, and Human Values into the curriculum:

Sr. No.	Course Name	Code	Relevant to Professional Ethics	Description
1	r-DNA Technology	DSC IX	Professional Ethics	Explores the ethical implications of gene editing and the responsibilities of scientists in ensuring the safe and ethical use of recombinant DNA technologies.
2	Ecology and Evolution	DSC X	Environmental Ethics	Examines the ethical considerations in conservation efforts, biodiversity preservation, and the societal implications of ecological research.
3	Bioinformatics	DSC XI	Covers ethical data usage and privacy concerns.	Addresses the importance of data integrity, confidentiality, and ethical considerations in the management and analysis o f biological data.
4	Traditional Medicine and Modern Biopharmaceutical Technology	DSC XII	Covers ethical practice in research, production and use of traditional and biopharmaceutical medicines.	Addresses the importance of traditional medicine and emphasize patient safety, scientific integrity and sustainable development of medicines.

5	Developmental Biology	DSE I (A)	Explores ethical issues in developmental research.	Investigates the ethical challenges associated with stem cell research and developmental processes, emphasizing informed consent and the welfare of model organisms.
6	Medical Biochemistry	DSE I (B)	Discusses ethical implications in medical research.	Covers the ethical considerations in the development and testing of pharmaceuticals, including issues related to human and animal trials.
7	Environmental Biotechnology	DSE II (A)	Environmental Sustainability	Discusses the ethical aspects of bioremediation, waste management, and the sustainability of biotechnological solutions to environmental challenges.
8	Nanobiotechnology	DSE II (B)	Investigates ethical concerns in nanotechnology applications.	Explores the potential risks and ethical dilemmas posed by nanomaterials in health and environmental contexts, stressing the need for responsible innovation.
9	Food Microbiology	Minor III	Highlights food safety and ethical sourcing issues.	Emphasizes the ethical considerations in food production, safety, and the importance of sustainable practices in food microbiology.
10	Computational Biology	Minor IV	Maintaining integrity, transparency, and data privacy in the responsible use of biological data and computational methods.	Addresses ethical principles for responsible data use, research integrity, privacy, and fair application of computational methods in biological research.

11	Process Technology	Minor V	Discusses the ethical implications of bioprocessing.	Examines the ethical concerns related to large-scale production processes, environmental impacts, and sustainability in bioprocess technology.
12	Plant Cell Culture	VSC-III	Focuses on ethical practices in plant biotechnology.	Investigates the ethical implications of genetic modification in plants, including biodiversity concerns and the use of traditional knowledge in biotechnological applications.
13	Bakery & Confectionery	VSC-IV	Addresses food safety and quality control ethics.	Discusses ethical sourcing of ingredients, food safety regulations, and the implications of production practices on consumer health.
14	Academic Project	AP	Research Integrity	Promotes an understanding of ethical research practices, including issues of plagiarism, data falsification, and the importance of integrity in academic work.

This table now provides a comprehensive view of how each course incorporates cross-cutting issues, focusing on the relevance to professional ethics and the specific descriptions of their ethical implications.

Curricula developed and implemented have relevance to the local, national, regional and global developmental needs

Sr. No.	Course code	Course Name	Linkage with Local/National/Regional/Global development
1	DSC IX	r-DNA Technology	Supports advancements in agriculture and healthcare through genetic engineering, addressing global food security and disease management.
2	DSC X	Ecology and Evolution	Enhances understanding of ecological balance and conservation efforts, vital for national environmental policies and global biodiversity initiatives.
3	DSC XI	Bioinformatics	Fosters global collaboration in data analysis and research, essential for personalized medicine and genomics, impacting national healthcare systems.
4	DSC XII	Traditional Medicine and Modern Biopharmaceutical Technology	Supports local to global development by promoting public health, preserving indigenous knowledge, boosting biotechnology industries and contributing to sustainable and accessible healthcare systems worldwide.
5	DSE I (A)	Developmental Biology	Advances research in regenerative medicine and developmental processes, crucial for both local healthcare innovation and global health solutions.
6	DSE I (B)	Medical Biochemistry	Supports national healthcare initiatives through the development of diagnostic tools and therapeutics, addressing both local and global health challenges.
7	DSE II (A)	Environmental Biotechnology	Contributes to local and national waste management strategies, promoting sustainable practices and remediation technologies that address global environmental challenges.
8	DSE II (B)	Nanobiotechnology	Promotes innovative solutions in drug delivery and diagnostics, addressing local health needs while contributing to global advancements in nanomedicine.
9	Minor III	Food Microbiology	Ensures food safety and quality control, directly impacting local and national food security and public health initiatives.
10	Minor IV	Computational Biology	Supports local to global development by enabling data-driven healthcare, disease surveillance, biotechnology innovation, and sustainable solutions through biological data analysis.

11	Minor V	Process Technology	Supports industrial biotechnology practices that enhance productivity and sustainability in local and regional industries, contributing to economic growth.
12	VSC-III	Plant Cell Culture	Advances agricultural biotechnology, promoting local food production and sustainable practices to meet regional and global food demands.
13	VSC-IV	Bakery & Confectionery	Addresses local food industry needs and contributes to national food security through improved production methods and quality control in baked goods.
14	AP	Academic Project	Encourages student-driven research that aligns with local and global developmental priorities, promoting innovation and community engagement.

Courses having focus on employability/ entrepreneurship/ skill development

Sr. No.	**Name of the Course**	**Course Code**	**Activities/Content with a direct bearing on Employability/ Entrepreneurship/ Skill development**			**Year of introduction**
			Employability	**Entrepreneurship**	**Skill development**	
1	r-DNA Technology	DSC IX	Prepares students for careers in genetic research, biotechnology firms, and pharmaceutical industries.	Encourages entrepreneurial ventures in biotech startups focusing on gene editing and synthetic biology.	Develops laboratory skills in DNA manipulation, cloning techniques, and genetic analysis.	2019-20
2	Ecology and Evolution	DSC X	Provides insights for careers in environmental consulting, conservation biology, and research institutions.	Encourages initiatives in sustainable development and conservation projects.	Enhances skills in ecological assessment, data collection, and fieldwork methodologies.	2024-25

3	Bioinformatics	DSC XI	Equips students for careers in data analysis, computational biology, and health informatics.	Encourages startups in health tech and personalized medicine through data-driven solutions.	Develops skills in using bioinformatics software, data mining, and statistical analysis of biological data.	2024-25
4	Traditional Medicine and Modern Biopharmaceutical Technology	DSC XII	Equips students for careers opportunities in pharmaceutical and biotech industries, research laboratories, and healthcare innovations.	Supports entrepreneurship by enabling ventures in herbal drug development, biopharmaceutical startups and sustainable healthcare products.	Develop skills in drug formulation, laboratory techniques and integration of traditional knowledge with modern biotechnology.	2025-26
5	Developmental Biology	DSE I (A)	Provides foundational knowledge for careers in developmental research, genetic counseling, and educational fields.	Encourages entrepreneurial projects related to regenerative medicine and developmental technologies.	Enhances skills in experimental design, data collection, and analysis in developmental studies.	2019-20
6	Medical Biochemistry	DSE I (B)	Prepares students for careers in clinical research, healthcare, and pharmaceuti	Encourages the development of medical diagnostic tools and therapeutics	Develops laboratory techniques in clinical biochemistry, analytical methods, and	2019-20

			cal industries.	in biotech startups.	diagnostic procedures.	
7	Environmental Biotechnology	DSE II (A)	Prepares students for roles in environmental firms, NGOs, and government agencies focused on sustainability.	Fosters entrepreneurial opportunities in green technologies and eco-friendly product development.	Develops practical skills in bioremediation techniques, waste management, and environmental monitoring.	2019-20
8	Nanobiotechnology	DSE II (B)	Prepares students for careers in nanotechnology firms, biomedical research, and advanced material sciences.	Prepares students for careers in nanotechnology firms, biomedical research, and advanced material sciences.	Prepares students for careers in nanotechnology firms, biomedical research, and advanced material sciences.	2019-20
9	Food Microbiology	Minor III	Provides career opportunities in food safety, quality control, and research in the food industry.	Encourages entrepreneurial projects in food startups focusing on safe and sustainable food production.	Develops practical skills in microbial analysis, food safety assessments, and quality control procedures.	2025-26

10	Computational Biology	Minor IV	Prepares graduates for data-driven careers in bioinformatics, genomics, drug discovery, and biomedical research by integrating biology with programming, statistics, and AI.	Applies data-driven algorithms and bioinformatics tools to develop innovative solutions such as predictive diagnostics, drug discovery platforms, and personalized medicine services.	Develops proficiency in bioinformatics tools, data analysis, and computational modeling to interpret large-scale biological datasets.	2025-26
11	Process Technology	Minor V	Equips students for careers in process engineering, biotech industries, and manufacturing.	Encourages the development of scalable biotech processes and startup ventures in biomanufacturing.	Develops skills in process design, optimization, and troubleshooting in biotechnological applications.	2025-26
12	Plant Cell Culture	VSC-III	Prepares students for careers in agriculture, horticulture, and biotechnology sectors focusing on plant sciences.	Encourages entrepreneurial opportunities in agriculture and biotechnological innovation through plant breeding.	Develops practical skills in tissue culture techniques, plant propagation, and genetic engineering of plants.	2025-26
13	Bakery & Confectionery	VSC-IV	Provides career opportunities in food production, quality control, and product	Encourages startups focused on innovative bakery products and sustainable food	Develops skills in food production techniques, quality assurance, and product developmen	2025-26

			development in the food industry.	practices.	t in the bakery sector.	
14	Academic Project	AP	Enhances research and analytical skills applicable in various professional settings.	Promotes innovation and entrepreneurial projects based on research findings and practical applications.	Develops skills in research design, data analysis, and project presentation.	2019-20

This restructured content focuses on enhancing employability through practical expertise, fostering entrepreneurship with industry-relevant knowledge, and developing essential skills to meet the demands of contemporary biotechnology fields.