SHIVAJI UNIVERSITY, KOLHAPUR - 416004,
MAHARASHTRA
PHONE:EPABX-2609000, www.unishivaji.ac.in, bos@unishivaji.ac.in
शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र
दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९४
०२३१—२६०९४८७

Estd. 1962
"A++" Accredited by
NAAC (2021)
With CGPA 3.52

Ref.No.SU/BOS/Science/146 **Date: 26/05/2026**

The Principal,
All Concerned Affiliated Colleges/Institutions
Shivaji University, Kolhapur.

Subject: Regarding revised syllabi of B.Sc. Part-III (Sem.V & VI) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0).

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the syllabi, nature of question paper B.Sc. Part-III (Sem.V & VI) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0).

B.Sc.Part-III (Sem. V & VI) as per NEP-2020 (2.0)			
1.	Animation (Entire)	6.	Food Science and Technology (Entire)
2.	Food Science (Entire)	7.	Food Technology & Management (Entire)
3.	Biotechnology (Entire)	8.	Environmental Science (Entire)
4.	Computer Science (Entire)	9.	Sugar Technology (Entire)
5.	Information Technology (Entire)		

This syllabus, nature of question and equivalence shall be implemented from the academic year 2026-2027 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website **www.unishivaji.ac.in>Syllabus>Syllabus as per NEP2020.**

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2026 & March/April 2027. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dy Registrar

Encl: as above

for information and necessary action

Copy to:

1	Dean, Faculty of Science & Technology	6	Appointment Section A & B
2	Director, Board of Examinations and Evaluation	7	I.T.Cell /Computer Centre
3	Chairman, Respective Board of Studies	8	Eligibility Section
4	B.Sc.-M.Sc. Exam Section	9	Affiliation Section (T.1) (T.2)
5	Internal Quality Assurance Cell (IQAC Cell)	10	P.G. Seminar Section

SHIVAJI UNIVERSITY, KOLHAPUR

Established: 1962

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Structure and Revised Syllabus in Accordance with

National Education Policy - 2020

With Multiple Entry and Multiple Exit

Bachelor of Science Part III Biotechnology (Entire)

Under

Faculty of Science and Technology

(To Be Implemented From Academic Year 2026-27)

SHIVAJIUNIVERSITY,KOLHAPUR

NEP-2020: Credit Framework for UG(B. Sc.) Programme under Faculty of Science and Technology

SEM (Level)	COURSES			OE	VSC/SEC	AEC/VEC/IKS	OJT/FP/CEP /CC/RP	Total Credits	Degree/Cum. Cr
	Course-1	**Course-2**	**Course-3**						
SEMI (4.5)	DSC-I(2) DSC-II (2) DSC P-I(2)	DSC-I(2) DSC-II (2) DSC P-I(2)	DSC-I(2) DSC-II (2) DSC P-I(2)	OE-1(2) (T/P)		IKS-I(2)		**22**	**UG Certificate 44**
SEMII (4.5)	DSC-III(2) DSC-IV (2) DSC P-II(2)	DSC-III(2) DSC-IV (2) DSC P-II(2)	DSC-III(2) DSC-IV (2) DSC P-II(2)	OE-2(2) (T/P)		VEC-I(2) (Democracy, Election and Constitution)		**22**	
Credits	**8(T)+4(P)=12**	**8(T)+4(P)=12**	**8(T)+4(P)=12**	**2+2=4 (T/P)**	**--**	**2+2=4**	**--**	**44**	**Exit Option:4 credits NSQF/Internship/Skill courses**
	MAJOR		**MINOR**						
SEMIII (5.0)	Major V(2) Major VI (2) Major P III (2)	--	Minor V(2) Minor VI (2) Minor P III(2)	OE-3(2) (T/P)	VSC I (2) (P) (Major specific) SEC I(2) (T/P)	AEC I(2) (English)	CC-I (2)	**22**	**UG Diploma 88**
SEMIV (5.0)	Major VII(2) Major VIII (2) Major P IV (2)	--	Minor VII(2) Minor VIII (2) Minor P IV (2)	OE-4(2) (T/P)	SEC-II(2) (T/P)	AEC-II(2) (English) VEC-II(2) (Environmental studies)	CEP-I(2)	**22**	
Credits	**8(T)+4(P)=12**		**8(T)+4(P)=12**	**2+2=4(T/P)**	**4(T/P)+2(P)=6**	**2+4=6**	**2+2=4**	**44**	**Exit Option:4 credits NSQF/Internship/Skill courses**
SEMV (5.5)	Major IX(2) Major X (2) Major P V (4)	Major I (ELEC)(2) Major P-I (ELEC) (2)	-	OE-5(2) (T/P)	VSC II (2) (Major specific)(P)	AEC III(2) (English)	**OJT (04)**	**22**	**UG Degree 132**
SEMVI (5.5)	Major XI(2) Major XII (2) Major P VI (4)	Major II (ELEC)(2) Major P-II(2) (ELEC)	-		VSC III (2) (Major specific) (P) SEC III(2) (T/P)	AEC IV(2) (English) IKS 2 (Major specific) (2)	**FP-(02)**	**22**	
Credits	**8(T)+8(P)=16**	**4(T)+4(P)=8**	**-**	**2(T/P)**	**2(T/P)+4(P)=6**	**4+2=6**	**4+2=6**	**44**	
Total Credits	**40+20=60**		**24**	**10**	**12**	**16**	**10**	**132**	**Exit Option**

SEMVII (6.0)	Major -XIII(4) Major -XIV(4) Major(P).-VII(4) Major (P) .-VIII(2)	MAJOR III (4) (ELEC)	RM-I(4)	-	-	-		22	**UG Honours Degree 176**
SEMVIII (6.0)	Major -XV(4) Major -XVI(4) Major (P)- IX(4) Major (P). - X(2)	MAJOR IV (4) (ELEC)	-	-	-	-	**OJT(04)**	22	
Credits	**16(T)+12(P)=28**	**8(T)**	**4**	**-**	**-**	**-**	**04**	**44**	
									Exit Option
Total Credits	**68+28=96**		**28**	**10**	**12**	**16**	**14**	**176**	
SEMVII (6.0)	Major -XIII (4) Major -XIV (4) Major(P).-VII (2)	MAJOR (4) (ELEC)	RM-I (4)	-		-	**RP-4**	22	**UG Honours with Research Degree 176**
SEMVIII (6.0)	Major -XV (4) Major -XVI (4) Major (P)-VIII (2)	MAJOR (4) (ELEC)		-		-	**RP-8**	22	
Credits	**16(T)+4(P)=20**	**8(T)**	**4**	**-**	**-**	**-**	**12**	**44**	
Total Credits	**60+28=88**		**28**	**10**	**12**	**16**	**22**	**176**	

Note:

- University may decide to offer maximum of three subjects (Courses) in the first year. The student may select one subject out of combination of three subjects (Courses), (which a student has chosen in the first year) as a **MAJOR** subject (Course) and one subject (Course) as **MINOR** Subject in the second year. Thereby it is inferred that the remaining third subject (Course) shall stand discontinued.
- **DSC:** Discipline Specific Course
- **MAJOR:** Mandatory/Elective
- **MINOR:** Course may be from different disciplines of same faculty of DSC Major
- **OE(Open Elective):** Elective courses/**Open Elective to be chosen compulsorily from faculty other than that of the Major.**
- **VSC/SEC: Vocational Skill Courses (MAJOR related)/Skill Enhancement Courses**
- **AEC/ VEC / IKS:** Ability Enhancement Courses (English, Modern Indian Language)/Value Education Courses/ Indian Knowledge System (Generic & Specific))
- **OJT/FP/RP/CEP/CC:** On-Job Training (Internship/Apprenticeship) / Field Project (Major related)/ Research Projects (Major related) Community Engagement **(Major related)/ Co-Curricular courses(CC)** such as Health& Wellness, Yoga Education, Sport, and Fitness, Cultural activities, NSS/NCC and Fine /applied/visual/performing Arts / Vivek Vahini etc.

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Shivaji University, Kolhapur Syllabus for Bachelor of Science (B. Sc. Part-III) Biotechnology (Entire) under the Faculty of Science

(Revised Syllabus will be implemented from June, 2026 onwards.)

Ordinance and Regulations: (As applicable to Degree Course) Shivaji University, Kolhapur Revised syllabus for Bachelor of Science (NEP)

1. YEAR OF IMPLEMENTATION:-

Revised Syllabi (As per NEP 2020) will be implemented from June 2026 onwards. Guidelines shall be as per B.Sc. Regular Program. Rules and Regulations shall be as per B.Sc. Regular Program except CBCS R. B. Sc. III Structure of Program and List of Courses.

2. Preamble:

This syllabus is so designed to give a sound basis to the undergraduate students of B.Sc. Biotechnology (Entire). It is known that Biotechnology is no doubt a youngest branch of life science but it is a very important interdisciplinary subject, where in subjects of Plant science, Animal science, Microbiology, Physics, Chemistry and other sciences are blended in such a way that the students are prepared with basic knowledge of Molecular biology, Biochemistry, Biophysics, Genetic engineering, Bioinformatics, Environmental sciences, Plant and Animal cell culture etc. and their technological applications. Such students having multidisciplinary knowledge are in tremendous demand in industries, education and fundamental research, as trainee workforce. The career opportunities of these students are very wide in different sectors dealing with life sciences.

3. Program Outcomes (POs)

1. **Domain Specific knowledge:** Apply the knowledge of Chemistry, Biochemistry, Microbiology, Plant science, Animal science, Cell biology, Genetics, Immunology, Molecular biology, Metabolic pathways, Enzymology, Plant and Animal Biotechnology, Ecology, Environmental Biotechnology, rDNA Technology, Industrial biotechnology, Medical Biotechnology, Bioinformatics, Nanotechnology, Biostatistics and Computer science to provide the solution to the Scientific and Technological and Social problems as well.

2. **Problem analysis:** Identification and formulation of the problems. Data analysis and Interpretation of the results with basic principles.

3. **Design/Development of solutions:** Design solutions for Scientific and Technological and Social problems of various disciplines that significantly realize domestic, agricultural, medical, pharmaceutical, industrial, societal, environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.

5. **Modern Tool Usage:** Making use of sophisticated tools, Sophisticated Instruments, Modern methodology, Microscopy, Chromatography, Spectroscopy, Electrophoresis, Thermal Cycler, Gel documentation, DNA Sequencer, Nanotechnology.

6. **The Science and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, industrial, agricultural issues.

7. **Environment and sustainability:** Application of the knowledge to ensure environmental sustainability

8. **Ethics:** Apply ethical principles in scientific Practices

9. **Individual and team work:** Function effectively as an Individual and as a Member or Leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on Scientific and Technological and problems with society at large. This includes ability to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions to realize outreach to the society.

11. **Life-long learning:** Recognize the need of study and ability to engage in independent and life-long learning in the broadest context of scientific change.

12. **Project management and finance:** Demonstrate knowledge and understanding of the Scientific, Technological and management principles and apply these to the project work, as a member or leader in a team.

Program Specific Outcomes (PSOs)

After completing the programme, students will be able to:

PSO1: Core Biotechnology Knowledge

Understand the principles of molecular biology, genetic engineering, microbiology, and biochemistry in biotechnology applications.

PSO2: Biotechnological Techniques

Perform and interpret laboratory techniques such as DNA isolation, PCR, electrophoresis, fermentation technology, and enzyme assays.

PSO3: Industrial and Applied Biotechnology

Apply biotechnology principles in agriculture, medicine, pharmaceuticals, food technology, and environmental management.

PSO4: Research and Data Analysis

Design small research projects, analyze experimental data, and apply statistical and computational tools in biotechnology research.

PSO5: Bioinformatics and Modern Tools

Use bioinformatics tools and databases for sequence analysis, protein structure prediction, and genomic studies.

4. OBJECTIVES OF THE PROGRAM

- To introduce the concepts in various allied subjects.
- To enrich students' knowledge in basic and applied aspects of life sciences.
- To help the students to build interdisciplinary approach in teaching/ learning & in research.
- To inculcate the sense of scientific responsibilities and social awareness.
- To help students build-up a progressive and successful career in academia and industry.
- To make the students knowledgeable with respect to the subject and its practicable applicability.
- To promote understanding of basic and advanced concepts in Biotechnology.
- To expose the students to various emerging areas of Biotechnology.
- To prepare students for further studies, helping in their bright career in the subject.
- To expose the students to different processes used in industries and in research field.
- To prepare the students to accept the challenges in life sciences.
- To develop skills required in various industries, research labs and in the field of human health.

5. DURATION OF THE COURSE: The course shall be a fulltime course.

6. PATTERN:-

Pattern of examination will be semester.

7. FEE STRUCTURE:-

As per Government / University rules

1. Refer brochure and prospectus of concern affiliated college/institute to Shivaji University, Kolhapur.
2. Other fee will be applicable as per rules and norms of Shivaji University, Kolhapur.

8. MEDIUM OF INSTRUCTION: The medium of instruction shall be in **English**

9. ELIGIBILITY FOR ADMISSION: As per guidelines obtained from Shivaji University, Kolhapur by following rules and regarding reservations by Govt. of Maharashtra

10. STRUCTURE OF THE COURSE – B.Sc. III Biotechnology (Entire)

THIRD YEAR (SEMESTER V / VI)

SHIVAJI UNIVERSITY, KOLHAPUR

B.Sc. - III. Biotechnology (Entire)

Semester-V and VI

Semester V - (Theory + Practical)			
Paper No.	**Title of Paper**	**Theory/ Practical**	**Internal**
Major-IX(2)	Basics in Genetic Engineering	**40**	**10**
Major -X(2)	Plant Tissue Culture	**40**	**10**
Major P V (A) (2)	Techniques in Genetic Engineering	**50**	**--------**
Major P V (B) (2)	Techniques in Plant Tissue Culture	**50**	**--------**
Major Elective I A (2)	Food and Microbial Biotechnology	**40**	**10**
Major Elective I B (2)	Agricultural Biotechnology	**40**	**10**
Major Elective P-1 A(2)	Techniques in Food and Microbial Biotechnology	**50**	**------**
Major Elective P-1 B(2)	Techniques in Agricultural Biotechnology	**50**	**-----**
OE –V(2)	Alcohol Technology **(Offered to other Faculty)**	**40**	**10**
VSC -II (Major specific) (P) (2)	Techniques in Quality Assurance in Biotechnological Industries.	**50**	**-------**
AEC III(2)	English	**40**	**10**
OJT(4)	On Job Training	**80**	**20**
Semester-VI (Theory + Practical)			
Paper No.	**Title of Paper**	**Theory/ Practical**	**Internal**
Major - XI(2)	Advances in Genetic Engineering	**40**	**10**
Major - XII(2)	Animal Tissue Culture	**40**	**10**
Major P VI (A) (2)	Techniques in Advances in Genetic Engineering	**50**	**------**
Major P VI (B) (2)	Techniques in Animal Tissue Culture.	**50**	**------**
Major Elective II A (2)	Bioinformatics	**40**	**10**
Major Elective II B (2)	Medical Biotechnology	**40**	**10**
Major Elective P-1A(2)	Techniques in Bioinformatics	**50**	**-------**
Major Elective P-1 B (2)	Techniques in Medical Biotechnology	**50**	**-------**
VSC – III (Major specific) (P) (2)	Techniques in Stem Cell Biotechnology.	**50**	**------**

SEC- III (T) (2)	Stem Cell Biotechnology	**40**	**10**
AEC IV(2)	English	**40**	**10**
IKS- II (Major specific) (2)	Indian Knowledge System (IKS) in Biotechnology	**40**	**10**
FP(2)	Field Project	**50**	------

(T)- Theory, (P)- Practical

11. SCHEME OF TEACHING- As per University/BOS guidelines.

Sr. No.	**Subject/ Paper**	**Teaching Scheme (Hrs / Week)**			**Examination Scheme (Mark)**		
		T	**P**	**Total**	**Theory**	**Term Work**	**Total**
		Semester-V					
1	Major-IX	02	-	02	40	10	50
2	Major-X	02	-	02	40	10	50
3	Major P V (A)	-	05	05	50	-	50
4	Major P V (B)	-	05	05	50	-	50
5	Major Elective I A **OR** B	02	-	02	40	10	50
6	Major Elective P I A **OR** B	-	05	05	50	-	50
7	OE -V	02	-	02	40	10	50
8	VSC -II (Major specific) (P)	-	05	05	50	-	50
9	AEC III (English)	02	-	02	40	10	50
10	OJT	-	04	04	100	-	100
	Semester-VI						
1	Major - XI	02	-	02	40	10	50
2	Major - XII	02	-	02	40	10	50
3	Major P VI (A)	-	05	05	50	-	50
4	Major P VI (B)	-	05	05	50	-	50
5	Major Elective II A **OR** B	02	-	02	40	10	50
6	Major Elective P II A **OR** B	-	05	05	50	-	50
7	VSC– III(Major specific) (P)	-	05	05	50	-	50
8	SEC- III (T)	02	-	02	40	10	50
9	AEC IV	02	-	02	40	10	50

10	IKS -II (Major specific)	02	-	02	40	10	50
11	FP	-	02	02	50	-	50

12. SCHEME OF EXAMINATION

- The standard of passing Examination Ordinances and Rules will be applicable as per the existing system.
- The examination will be conducted as per the rules and regulations of Shivaji University which are applicable at that time.

 Theory:-

- There shall be 40 marks for each course (paper). For each course 40:10 pattern shall be applicable, wherein 40 marks shall be for University Assessment (UA) (Time duration: 2 hrs.) and 10 marks for internal assessment (IA).
- There shall be separate passing for theory as well as internal examinations. Minimum 14 marks out of 40 required for passing UA and minimum 4 marks out of 10 required for passing

 Internal Assessment:-

- As per UGC guidelines there shall be continuous internal assessment for B.Sc. Programme.
- Internal Examination will be compulsory for all students. If a student fails/remains absent in internal Examination then he / she will have to clear the internal Examination in subsequent attempt/s.
- The internal examination of 10 Marks shall be conducted at the mid of the each semester. The nature of questions shall be MCQ / true / false /one sentence answer type question/ short answer type questions/Home assignments (Time duration: 30 minutes).

Practical Examination: -

- Practical exam will be conducted after theory exam.
- The practical examination shall be conducted as per respective BOS guidelines.

13. STANDARD OF PASSING AND DETERMINATION OF SGPA/CGPA, GRADING AND DECLARATION OF RESULTS.

As prescribed under rules and regulation of university for each degree.

14. NATURE OF QUESTION PAPER-Theory (40 + 10)

Nature of Question Paper for all (Theory) papers U.G. Courses under Faculty of Science.
B.Sc. Part – III/Sem. – V/VI Examination – 2026 (NEP - 2020)
Biotechnology
Title of the Subject
(Subject Code)

Day & Date: **Total Marks: 40**

Time: (Duration-(1Hr., 30 Min.)

Instructions: 1) All questions are compulsory.

2) Figures to the right indicate full marks

3) Draw neat labeled diagrams wherever necessary.

Q. 1 Objective (8 Marks)

Q.2 Attempt any two of the following (out of three) (Long Answer Questions) (16 Marks)

Q.3 Attempt any four of the following (out of six) (Short Answer Questions) (16 Marks)

Nature of question paper: Practical Examination (As per guidelines of BOS)

A) Every candidate must have recorded his/her observations in the Laboratory journal and written a report on each exercise performed. Every journal is to be signed periodically by a member of the teaching staff and certified by the Head of the Department at the end of the year. Candidates are to produce their journals at the practical examination and such journals will be taken into account by the examiners in assigning marks.

Note:-At least 80% Practical's should be covered in practical examination.

B) The practical examination will be of 6 hours duration and conducted on two successive days (6 hours per day).

Distribution of Marks for Practical Examination:

1. A) Major experiment 20 marks
   B) Minor experiment 10 marks
2. Spotting 10 marks
3. A) Journal 05 marks

B) Viva-voce 05 marks Total Marks: 50 marks

Note: Experiments may be arranged as per convenience of the examiner.

15. SYLLABUS

Semester V		
Major IX: Basics in Genetic Engineering (2Cr)		
	Course Objectives-	**Bloom's Level**
	To introduce the fundamental concepts and scope of recombinant DNA technology and the role of enzymes used in genetic engineering.	Remember,
	To develop understanding of restriction enzymes, DNA modifying enzymes, and their applications in DNA manipulation and molecular cloning.	Understand
	To enable students to apply the knowledge of cloning vectors and recombinant DNA construction in gene cloning and expression studies.	Apply
	To analyze different nucleic acid hybridization techniques and probe labeling methods used for gene detection.	Analyze
	To evaluate the principles and applications of DNA sequencing and blotting techniques used in molecular biology research.	Evaluate
	To develop the ability to design strategies for gene identification and analysis using modern molecular techniques and recombinant DNA tools.	Create
Topic No.		**Lectures 30**
	Credit I	
1.	**Enzymes in r-DNA Technology** Introduction and Scope, Enzymes and its applications, Restriction enzymes- types (I, II, III), nomenclature, recognition sequences, cleavage patterns, modification of cut ends (linkers and adaptors), application – RFLP, Restriction mapping. Alkaline phosphatases, DNA ligases T4 and *E. coli* Ligases, Methylase , Reverse Transcriptases, Polymerases- Klenow enzymes, T4 DNA polymerases, Taq DNA polymerases, Polynucleotide kinase. **Cloning Vectors:** Introduction, properties of good vectors, cloning and expression vectors, types – ***E. coli*** vectors: plasmid – **pBR322** and **pUC18**. Bacteriophage vectors – phage vector, **M13 vectors** (replacement e.g. **EMBL3**, **EMBL4** and insertional e.g. **λgt10** and **λgt11**). Cosmid vector, phagemid vector e.g. **pBluescript II KS/SK**, yeast vectors – **YAC** and **BAC**, animal vectors – **retroviral vectors**, plant vectors – **Ti plasmid**, **Ri plasmid**, shuttle vector e.g. **pJBD219**, **TA cloning vector** (introductory), selection of recombinant vector.	15
	Credit II	
2.	**Nucleic Acid Hybridization:** Nucleic Acid and plasmid purification. Probe Preparation, Methods of labelling probes. Radio labelling – Nick translati on, End labeling, Primer extension, Non Radiolabelling – Biotin, dioxygenin, fluorescent dyes, Applications of probes. **DNA Sequencing and Blotting Technique:** Maxam Gilbert method, Sanger Coulson method, Automated DNA sequencing, Southern Blotting, Northern Blotting, Western blotting, Dot blotting.	15
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**

CO1	Define and recall the basic principles, scope, and enzymes involved in recombinant DNA technology.	Remember
CO2	Explain the types, nomenclature, recognition sequences, and cleavage patterns of restriction enzymes and other DNA modifying enzymes.	Understand
CO3	Apply knowledge of cloning vectors and recombinant DNA techniques for gene cloning and vector selection.	Apply
CO4	Analyze nucleic acid hybridization methods, probe labeling techniques, and their applications in gene detection.	Analyze
CO5	Evaluate different DNA sequencing methods and blotting techniques used for molecular analysis.	Evaluate
CO6	Design approaches for gene identification and molecular analysis using recombinant DNA technology and hybridization techniques.	Create

References :

1. **Glick, B. R., Pasternak, J. J., & Patten, C. L.***Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.
2. **Brown, T. A.***Gene Cloning and DNA Analysis: An Introduction*. Wiley-Blackwell.
3. **Nicholl, D. S. T.***An Introduction to Genetic Engineering*. Cambridge University Press.
4. **Old, R. W., & Primrose, S. B.***Principles of Gene Manipulation: An Introduction to Genetic Engineering*. Blackwell Scientific Publications.
5. **Lewin, B.***Genes VIII*. Pearson Education.
6. **Purohit, S. S.***Fundamentals of Biotechnology*. Agrobios (India), Jodhpur.
7. **Chawla, H. S.***Introduction to Plant Biotechnology*. Oxford & IBH Publishing.
8. **Gupta, P. K.***Elements of Biotechnology*. Rastogi Publications.
9. **Wilson, K., & Walker, J.***Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
10. **Gupta, P. K.***Plant Biotechnology*. Rastogi Publications.
11. **Jogdand, S. N.***Gene Biotechnology*. Himalaya Publishing House.
12. **Philipse, M.***Protein Biotechnology*. Springer / Academic Press.
13. **Channarayappa.***Molecular Biotechnology: Principles and Practices*. Universities Press.
14. **Dubey, R. C.***A Textbook of Biotechnology*. S. Chand Publishing.
15. **Sambrook, J., & Russell, D. W.***Molecular Cloning: A Laboratory Manual* (Vol. I, II, III). Cold Spring Harbor Laboratory Press.

Major X: Plant Tissue Culture (2Cr)		
	Course Objectives-	**Bloom's Level**
	To introduce the fundamental concepts of plant tissue culture including cellular totipotency, developmental plasticity, and different in vitro culture systems.	Remember
	To develop understanding of laboratory organization, aseptic techniques, sterilization methods, and culture media composition used in plant tissue culture laboratories.	Understand
	To enable students to apply the principles of plant tissue culture techniques such as callus culture, somatic embryogenesis, organogenesis, and ovary/ovule culture.	Apply
	To analyze the different pathways of micropropagation and the role of somaclonal variation, suspension culture, and anther or pollen culture in plant biotechnology.	Analyze
	To evaluate the applications and limitations of plant tissue culture techniques in crop improvement, germplasm conservation, and large-scale plant propagation.	Evaluate
	To develop the ability to design strategies for plant improvement using advanced techniques such as protoplast culture and micropropagation systems.	Create
Topic No.		**Lectures 30**
	Credit- I	
1.	**Introduction to plant tissue culture**- Definition, scope, history, cellular totipotency, developmental plasticity, overview of in vitro systems. **Laboratory Design & Organization**- different work areas, equipments and instruments required and other requirements. **Aseptic Techniques-** Washing and preparation of glassware's, packing and sterilization, media sterilization, surface sterilization, aseptic workstation and precautions to maintain aseptic conditions. **Culture Medium-** Composition of basal M.S. medium macro/micronutrients, vitamins, carbon sources, plant growth regulators, media preparationand preparation of media. **Callus Culture Techniques-** Introduction, principle, protocol, morphology and internal structure, genetic variations and applications. **Somatic Embryogenesis-** Introduction, principle, protocol, factors affecting, applications and limitations. **Organogenesis-** Introduction, principle, protocol, applications. **Ovary and ovule Culture Technique-** Introduction, principle, protocol, and applications.	**15**
	Credit-II	
2.	**Anther & Pollen Culture Technique-** Introduction, principle, protocol, factors affecting and applications. **Micropropagation-** Introduction, stages of Micropropagation, factors affecting, advantages and applications. **Different Pathways of Micropropagation**- Axillary bud proliferation, somatic embryogenesis, organogenesis and meristem culture. **Somaclonal Variation-** Introduction, terminology, origin, selection at plant level, selection at cell level, mechanism, assessment, applications and limitations.	**15**

	Suspension Culture Technique- Introduction, principle, protocol, types, growth measurement, synchronization and applications. **Plant Protoplast Culture:**-History, Principle, protocol for isolation-Mechanical and Enzymatic, protoplast culture and importance.	
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Define and recall the principles of plant tissue culture, cellular totipotency, and in vitro culture systems.	Remember
CO2	Explain laboratory design, aseptic techniques, sterilization procedures, and composition of plant tissue culture media.	Understand
CO3	Apply plant tissue culture methods such as callus culture, somatic embryogenesis, organogenesis, and ovary or ovule culture in plant regeneration studies.	Apply
CO4	Analyze the mechanisms and pathways involved in micropropagation, somaclonal variation, suspension culture, and anther or pollen culture.	Analyze
CO5	Evaluate the advantages and limitations of plant tissue culture techniques in agriculture and plant biotechnology.	Evaluate
CO6	Design approaches for plant improvement using advanced techniques like protoplast culture and different micropropagation pathways.	Create

References:-

1. **Razdan, M. K.***Introduction to Plant Tissue Culture*. Oxford & IBH Publishing Co., New Delhi.
2. **Bhojwani, S. S., &Razdan, M. K.***Plant Tissue Culture: Theory and Practice*. Elsevier / Elsevier Science.
3. **Dey, Kalyan Kumar***Plant Tissue Culture*. New Central Book Agency, Kolkata.
4. **Singh, B. D.***Biotechnology: Expanding Horizons*. Kalyani Publishers, New Delhi.
5. **Dubey, R. C.***A Textbook of Biotechnology*. S. Chand Publishing.
6. **Kumar, U.***Plant Tissue Culture*. Agrobios (India), Jodhpur.
7. **Bhojwani, S. S., &Bhatnagar, S. P.***Plant Tissue Culture and Micropropagation*. Oxford & IBH Publishing.
8. **Borg, G., & Phillips, G. C.***Plant Cell, Tissue and Organ Culture: Fundamental Methods*. Springer / Academic Press.
9. **Purohit, S. S.***Fundamentals of Biotechnology*. Agrobios (India).
10. **Chawla, H. S.***Biotechnology in Crop Improvement*. Oxford & IBH Publishing.
11. **Chawla, H. S.***Introduction to Plant Biotechnology*. Oxford & IBH Publishing

Major P V (A) Techniques in Genetic Engineering (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the basic principles of DNA isolation and manipulation techniques used in recombinant DNA technology.	Remember
	To explain the principles and procedures of restriction mapping, Southern blotting, Western blotting, bacteriophage transduction and DNA ligation.	Understand
	To apply molecular biology techniques for calculation of molecular size of DNA fragments and construction of restriction maps.	Apply
	To analyze DNA and protein detection methods using Southern and Western blotting techniques.	Analyze
	To evaluate the role of bacteriophage transduction and DNA ligation in gene transfer and recombinant DNA construction.	Evaluate
	To develop experimental approaches for molecular cloning and genetic analysis using recombinant DNA techniques.	Create
Sr. No.	**Name of the Practical**	
1.	Isolation of DNA from fungal cell.	Major
2.	Isolation of DNA from animal cell (Blood, Hair etc.)	Major
3.	Calculation of Molecular size of Digested DNA	Minor
4.	Construction of Restriction Map of Plasmid DNA	Minor
5.	Study of Western Blotting Technique	Major
6.	Study of Southern Blotting Technique	Major
7.	Study of Northern Blotting Technique	Major
8.	Study of Bacteriophage Transduction	Major
9.	DNA Ligation using DNA Ligase Enzyme	Minor
CO	**Course outcome-** After completion of this course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of DNA isolation, restriction digestion, DNA ligation, blotting techniques, and bacteriophage transduction.	Remember
CO2	Explain the procedures involved in restriction mapping, Southern blotting, Western blotting and bacteriophage-mediated gene transfer.	Understand
CO3	Perform calculation of molecular size of DNA fragments and construct restriction maps of plasmid DNA.	Apply
CO4	Analyze DNA and protein samples using Southern blotting and Western blotting techniques.	Analyze
CO5	Evaluate the efficiency of DNA ligation and bacteriophage transduction in recombinant DNA experiments.	Evaluate
CO6	Develop strategies for recombinant DNA construction and molecular analysis using genetic engineering techniques.	Create

References

1. **Sambrook, J. and Russell, D. W.***Molecular Cloning: A Laboratory Manual.* Cold Spring Harbor Laboratory Press.
2. **Glick, B. R., Pasternak, J. J. and Patten, C. L.***Molecular Biotechnology: Principles and Applications of Recombinant DNA.* ASM Press.
3. **Old, R. W. and Primrose, S. B.***Principles of Gene Manipulation: An Introduction to Genetic Engineering.* Blackwell Scientific Publications.
4. **Nicholl, D. S. T.***An Introduction to Genetic Engineering.* Cambridge University Press.
5. **Brown, T. A.***Gene Cloning and DNA Analysis: An Introduction.* Wiley-Blackwell.
6. **Purohit, S. S.***Fundamentals of Biotechnology.*Agrobios India.

Major P V (B) Techniques in Plant Tissue culture (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce laboratory organization, general techniques, and basic principles of plant tissue culture.	Remember
	To explain preparation of Murashige and Skoog (M.S.) medium, stock solutions, and aseptic techniques used in plant tissue culture.	Understand
	To apply techniques such as micropropagation, callus culture, suspension culture, embryo culture, and Anther culture.	Apply
	To analyze growth and morphological changes in plant tissues during callus formation and micropropagation.	Analyze
	To evaluate different stages of plant micropropagation including initiation, multiplication, rooting, and acclimatization.	Evaluate
	To design protocols for plant tissue culture and micropropagation for plant improvement and mass propagation.	Create
Sr. No.	**Name of the Practical**	
1.	Laboratory Organizations and general techniques.	Major
2.	Preparation of M.S. Stock Solutions and Medium.	Major
3.	Micropropagation Stage I – Initiation from Shoot Tip/Axillary Bud .	Major
4.	Callus Culture Technique - Initiation of Culture and Study of Callus Morphology.	Major
5.	Suspension Culture Technique -Initiation of Culture.	Minor
6.	Aseptic *in vitro*Seed Germination.	Minor
7.	Embryo Culture Technique.	Minor
8.	Anther Culture Technique	Minor
9.	Micropropagation stage II- Multiplication of Culture.	Minor
10.	Micropropagation stage III-Rooting- *in vitro.*	Minor
11.	Micropropagation stage IV-Acclimatization and Hardening.	Minor
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of plant tissue culture, laboratory organization, and aseptic techniques.	Remember
CO2	Explain the preparation of MS medium and procedures used for plant tissue culture experiments.	Understand
CO3	Perform plant tissue culture techniques such as micropropagation, callus culture, suspension culture, embryo culture, and Anther culture.	Apply
CO4	Analyze growth patterns and morphological characteristics of cultured plant	Analyze

	tissues.	
CO5	Evaluate different stages of micropropagation including initiation, multiplication, rooting, and acclimatization of plantlets.	Evaluate
CO6	Develop protocols for plant tissue culture and plant propagation for research and agricultural applications.	Create

References :

1. **Bhojwani, S. S., &Razdan, M. K.***Plant Tissue Culture: Theory and Practice*. Elsevier Science, Amsterdam.
2. **Razdan, M. K.***Introduction to Plant Tissue Culture*. Oxford & IBH Publishing Co., New Delhi.
3. **Freshney, R. Ian.***Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*. Wiley-Blackwell.
4. **Masters, J. R. W.***Animal Cell Culture: A Practical Approach*. Oxford University Press.
5. **George, E. F., Hall, M. A., & De Klerk, G. J.***Plant Propagation by Tissue Culture*. Springer.
6. **Bhojwani, S. S., &Bhatnagar, S. P.***Plant Tissue Culture and Micropropagation*. Oxford & IBH Publishing.
7. **Purohit, S. S.***Plant Biotechnology: Fundamentals and Applications*. Agrobios (India).
8. **Singh, B. D.***Biotechnology: Expanding Horizons*. Kalyani Publishers.
9. **Ranga, M. M.***Animal Biotechnology*. Agrobios (India).
10. **Butler, M.***Animal Cell Culture and Technology*. Taylor & Francis.

Major Elective I (A)-Food and Microbial Biotechnology (2Cr)		
	Course Objectives-	**Bloom's Level**
	Define the concepts of pure and mixed cultures and microbial growth kinetics in fermentation processes.	Remember
	Explain microbial production of industrially important products such as enzymes, antibiotics, vitamins, amino acids, organic acids, edible mushrooms, and single cell protein.	Understand
	Apply the principles of microbial fermentation in the production of fermented foods and beverages such as cheese, yoghurt, bread, beer, and wine.	Apply
	Analyze the different types of food spoilage (physical, chemical, and biological) and their causes.	Analyze
	Evaluate the effectiveness of various food preservation methods and the impact of food toxins and food-borne diseases on public health.	Evaluate
	Design strategies for safe food production and food supply considering food safety, sustainability, nutritional adequacy, and accessibility.	Create
Topic No.	**Credit I**	**Lectures 30**
1	**Microbial Cultures and Production** Concept of pure and mixed culture., Microbial growth kinetics basic concept (Batch, Continuous and Fed Batch). Microbial Production of - Enzymes (amylase – koji fermentation), Antibiotics (Penicillin), Vitamins (B12), Amino acids (Lysine), Organic acid (Citric acid). Edible mushroom, Single Cell Protein- (Spirulina). **Fermented Foods and Beverages** Dairy Products – Cheese, Dahi, Yoghurt, Indian Foods – Idli, Bakery Products – Bread , Fermented Pickles – Sauerkraut, Beverages – Beer, Wine (Red and white table) .	**15**
	Credit II	
2	**Food Spoilage, Preservation and Toxicity** Types of spoilage- Physical, Chemical and Biological (auto and microbial), Preservation methods- High and Low temperatures, Controlled atmosphere and Anaerobiosis, Radiations and Asepsis. Chemical preservatives (Salt, sugar, organic acids, SO_2, NO2). Food Toxicity – Mycotoxin (Aflatoxin), Exotoxin (*Staphylococcal*), Neurotoxin (Botulinum), Food borne illness- Shigellosis, Amoebiosis, Aspergillosis. **Impact of GM Food on Human Health** Principle, Risk analysis and Regulations, Multidisciplinary perspectives of GM foods and impact, Public health principles Characteristics of food supply for public health, Food Safety, Capacity to supply nutritional adequacy, Sustainability, Capacity for Consumer choice, Accessibly and affordability to all.	**15**
CO	**Course Outcomes-**After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the basic concepts of microbial cultures, growth kinetics, and fermentation processes.	Remember
CO2	Explain the role of microorganisms in the production of industrial products and fermented foods.	Understand

CO3	Apply microbial fermentation principles in the preparation and processing of different fermented foods and beverages.	Apply
CO4	Analyze the causes and types of food spoilage and methods used to prevent them.	Analyze
CO5	Evaluate the risks associated with food toxicity, food-borne diseases, and genetically modified foods.	Evaluate
CO6	Develop approaches for maintaining food safety, public health, and sustainable food supply systems.	Create

References :

1. **H. K. Das**, *Text Book of Biotechnology*, Wiley India.
2. **Arnold L. Demain and Julian E. Davies**, *Industrial Microbiology & Biotechnology*, ASM Press.
3. **Jayant Acharekar**, *Fermentation Technology*, Himalaya Publishing House.
4. **Colin Ratledge and Björn Kristiansen**, *Basic Biotechnology*, Cambridge University Press.
5. **P. S. Bisen**, *Frontiers in Microbial Biotechnology*, CBS Publishers & Distributors.
6. **C. Prescott and C. G. Dunn**, *Industrial Microbiology*, McGraw Hill.
7. **P. F. Stanbury, A. Whitaker and S. J. Hall**, *Principles of Fermentation Technology*, Butterworth-Heinemann.
8. **Jens Nielsen and John Villadsen**, *Bioprocess Engineering: Principles*, Springer.
9. **L. E. Casida**, *Industrial Microbiology*, New Age International Publishers.
10. **H. A. Modi**, *Fermentation Biotechnology*, Akta Prakashan.
11. **A. H. Patel**, *Industrial Microbiology*, Macmillan Publishers India.
12. **Varun Mehta**, *Food Biotechnology*, Daya Publishing House

Major Elective I (B)- Agricultural Biotechnology (2Cr)		
	Course Objectives-	**Bloom's Level**
	To introduce the principles of crop improvement, plant tissue culture, transgenic plants, and biofertilizers.	**Remember**
	To explain breeding methods, somatic hybridization, artificial seed technology, germplasm conservation, and transgenic approaches in plants.	**Understand**
	To apply plant biotechnology techniques such as micropropagation, somatic embryogenesis, cryopreservation, and production of biofertilizers and biopesticides.	**Apply**
	To analyze strategies for development of disease-resistant, insect-resistant, herbicide-resistant, and nutritionally improved transgenic plants.	**Analyze**
	To evaluate the environmental, ethical, socio-economic, and legal issues related to GM foods, IPR, and plant biotechnology applications.	**Evaluate**
	To develop biotechnological approaches for sustainable agriculture, crop improvement, germplasm conservation, and plant protection.	**Create**
Topic No.	**Credit I**	**Lectures 30**
1	**Methods for crop Improvement** Introduction and Acclimatization, Breeding for self and cross pollinated plants and vegetatively reproducing plants, selection (clonal pure line and mass), Hybridization and Mutation breeding. **Somatic hybridization-** Definition, protoplast, fusion technique, selection of hybrids, symmetric and asymmetric hybrids, cybrid production. **Artificial Seed-** Definition, Techniques, factors affecting, applications limitations. **Germplasm Conservation-** Introduction, *In-situ* conservation, *Ex- situ* conservation, cryopreservation, Techniques of Cryopreservation, applications, limitations.	**15**
	Credit II	
2	**Transgenic Plants** Herbicide resistant – Glyphosate resistance, Pho sphinothricin resistance, Fungal and Bacterial disease resistance approaches- PR proteins, Chitinase, Glucanase, RIPs protein, Virus resistance –Virus coat proteins, Movement proteins ,Trasmission proteins ,Satellite RNAs, Antisense RNAs, Ribozymes, Insect resistance approaches – Bt protein (Bt Cotton, Bt-Brijal) , Non Bt protein, Transgenic plant with improved nutrition - Golden Rice, Molecular farming. GM Foods, ethical & socio-economic, legal and environmental issues. Forms of protection -IPR and IPP- Patents, copyright, trademark ,trade secret and PBR **Biofertilizers –** Definition ,Principle , Mass production and field application – *Rhizobium,Azotobacter,Azospirillum,Acetobacter,Azolla, Cyanobacteria*, PSB, VAM. **Biopesticide –** Definition, production and applications of Bacterial, fungal, viral and Plant origin Biopesticides.	**15**

CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of crop improvement, plant tissue culture, transgenic plants, biofertilizers, and biopesticides.	**Remember**
CO2	Explain breeding techniques, somatic hybridization, artificial seed production, and germplasm conservation methods.	**Understand**
CO3	Apply plant biotechnology techniques such as micropropagation, somatic embryogenesis, cryopreservation, and production of biofertilizers and biopesticides.	**Apply**
CO4	Analyze different strategies for developing herbicide-resistant, disease-resistant, insect-resistant, and nutritionally enhanced transgenic plants.	**Analyze**
CO5	Evaluate the ethical, environmental, socio-economic, and legal implications of GM foods and intellectual property rights in biotechnology.	**Evaluate**
CO6	Develop sustainable biotechnological strategies for crop improvement, plant protection, and agricultural productivity enhancement.	**Create**

References :

1. **Satyanarayana, U.** *Biotechnology*. Books and Allied (P) Ltd., Kolkata.
2. **Singh, B. D.** *A Textbook of Plant Breeding*. Kalyani Publishers, New Delhi.
3. **Jogdand, S. N.** *Medical Biotechnology*. Himalaya Publishing House, Mumbai.
4. **Chaudhary, R. C**. *Introduction to Plant Breeding*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
5. **Dubey, R. C**. *A Textbook of Biotechnology*. S. Chand and Company Ltd., New Delhi.
6. **Vyas, S. P. and Dixit, V. K**. *Pharmaceutical Biotechnology*. CBS Publishers and Distributors, New Delhi.
7. **Purohit, S. S.** *Fundamentals of Agricultural Biotechnology*. Agrobios (India), Jodhpur.
8. **Freshney, R. I.** *Animal Cell Biotechnology*. Wiley-Liss Publications, New York.
9. **Butler, M.** *Animal Cell Biotechnology*. BIOS Scientific Publishers, Oxford.
10. **Prescott, D. M.** *Methods in Cell Biology, Volume 57*. Academic Press, New York.
11. **Deshkar, R. N.** *Cell and Developmental Biotechnology*. Everest Publishing House, Pune.
12. **Rajvaidya, N.** *Agricultural Applications of Microbiology*. Pointer Publishers, Jaipur.

Major Elective P I: (A) Techniques in Food and Microbial Biotechnology (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the basic principles of microbial fermentation and the role of microorganisms in food and industrial product formation.	Remember
	To explain fermentation processes involved in the production of products such as vinegar, bread, curd, lactic acid, antibiotics, and single cell protein.	Understand
	To develop practical skills in performing microbial fermentation and production of industrial products using microorganisms.	Apply
	To analyze microbial activity in fermented foods and identify spoilage-causing microorganisms.	Analyze
	To evaluate microbial enzyme production, antibiotic recovery, and microbial quality of food samples.	Evaluate
	To design experimental approaches for microbial production and quality analysis of fermented food and industrial products.	Create
Sr. No.	**Name of the Practical**	
1.	Vinegar production by using *Acetobacter* spp.	Minor
2.	Bread fermentation by using baker's yeast	Minor
3.	Preparation of curd using lactic acid bacterial starter culture	Minor
4.	Production and analysis of Single cell protein (SCP)	Major
5.	Microbial production of lactic acid	Minor
6.	Production and recovery of antibiotic like penicillin/streptomycin	Major
7.	Extracellular production, characterization of cellulose enzyme and its application	Major
8.	Isolation and identification of spoilage causing bacteria from spoiled food sample	Major
9.	Isolation of halophilic bacteria from food sample	Major
10	Microbial analysis of fermented food products (curd, pickle, bread etc.).	Major
11	Determination of microbial load in food samples using standard plate count method.	Minor
CO	**Course Outcomes-**After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of microbial fermentation and microbial techniques used in food and industrial microbiology.	Remember
CO2	Explain the microbial processes involved in the production of vinegar, bread, curd, lactic acid, antibiotics, and single cell protein.	Understand

CO3	Perform microbial fermentation experiments such as bread fermentation, curd preparation, SCP production, and lactic acid production.	Apply
CO4	Analyze microbial contamination and identify spoilage-causing bacteria and halophilic bacteria in food samples.	Analyze
CO5	Evaluate enzyme production, antibiotic recovery, and microbial quality of fermented food products using laboratory techniques.	Evaluate
CO6	Develop laboratory protocols for microbial production and microbial analysis of food samples using standard microbiological methods.	Create

References

1. **Frazier, W. C. and Westhoff, D. C.***Food Microbiology.* McGraw-Hill, New York.
2. **Adams, M. R. and Moss, M. O.***Food Microbiology.* Royal Society of Chemistry, Cambridge.
3. **Patel, A. H.***Industrial Microbiology.* Macmillan India Ltd., New Delhi.
4. **Stanbury, P. F., Whitaker, A. and Hall, S. J.***Principles of Fermentation Technology.* Butterworth-Heinemann.
5. **Casida, L. E.***Industrial Microbiology.* Wiley Eastern Ltd.
6. **Singh, B. D.***Biotechnology: Expanding Horizons.*Kalyani Publishers.

Major Elective P I: (B) Techniques in Agricultural Biotechnology (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the role of beneficial microorganisms in agriculture and their importance in soil fertility and plant growth.	Remember
	To understand the characteristics and functions of agriculturally important microorganisms such as *Azotobacter*, *Rhizobium*, PSB, *Trichoderma*, and *Bacillus thuringiensis*.	Understand
	To develop practical skills in isolation, identification, and cultivation of beneficial microorganisms from soil and plant samples.	Apply
	To analyze the role of microbial inoculants in biofertilizer and biopesticide production for sustainable agriculture.	Analyze
	To evaluate the effectiveness of microbial products such as biofertilizers, biopesticides, artificial seeds, and compost inoculum.	Evaluate
	To design methods for production and application of microbial biofertilizers, biopesticides, and compost inoculum for agricultural use.	Create
Sr. No.	**Name of the Practical**	
1.	Isolation of *Azotobacter*	Major
2.	Isolation of *Rhizobium* from root nodules	Major
3.	Isolation of PSB from soil.	Major
4.	Production of Biofertilizer- *Azotobacter* /PSB	Major
5.	Isolation of *Trichoderma*	Major
6.	Isolation of *Bacillus thuringenisis*	Major
7.	Production of Biopesticide – *Trichoderma*	Minor
8.	Production of Biopesticide – *Bacillus thuringenisis*	Minor
9.	Production of Artificial seed	Minor
10	Isolation and Preparation of Microbial Compost Inoculum	Minor
CO	**Course outcome** :After successful completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the importance of beneficial microorganisms used in agriculture and soil fertility management.	Remember
CO2	Explain the characteristics and functions of microorganisms such as *Azotobacter*, *Rhizobium*, PSB, *Trichoderma*, and *Bacillus thuringiensis.*	Understand
CO3	Perform laboratory techniques for isolation and cultivation of agriculturally important microorganisms from soil and plant samples.	Apply
CO4	Analyze microbial processes involved in the production of biofertilizers, biopesticides, and compost inoculum.	Analyze
CO5	Evaluate the role and effectiveness of microbial biofertilizers and	Evaluate

	biopesticides in sustainable agriculture.	
CO6	Develop protocols for production and application of microbial products such as artificial seeds, biofertilizers, and biopesticides.	Create

Reference Books

1. **Dubey, R. C.***A Textbook of Biotechnology*. S. Chand & Company Ltd., New Delhi.
2. **Pelczar, M. J., Chan, E. C. S., and Krieg, N. R.***Microbiology*. McGraw Hill Education.
3. **Subba Rao, N. S.***Soil Microbiology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
4. **Agrios, G. N.***Plant Pathology*. Academic Press, Elsevier.
5. **Singh, B. D.***Biotechnology: Expanding Horizons*. Kalyani Publishers, New Delhi.
6. **Smith, J. E.***Biotechnology*. Cambridge University Press.

OE-V(2Cr)
Student can Choose one Open Elective course from Basket available from arts, commerce i.e. other than science faculty.

OE-V(2Cr) (Offered to other Faculty Students) Alcohol Technology (T)		
	Course Objectives	**Bloom's Level**
	Introduce students to the basic concepts of alcohol technology including types of alcohol, history, and uses in different industries.	Remember & Understand
	Explain raw materials, microorganisms, and fermentation processes involved in alcohol production.	Understand
	Develop understanding of alcohol production processes such as fermentation, distillation, and beverage preparation.	Apply
	Familiarize students with quality control, hygiene, and safety practices in breweries and distilleries.	Analyze
	Create awareness about environmental, legal, and social aspects associated with alcohol production and consumption.	Evaluate
	Develop the ability to propose basic strategies for sustainable alcohol production**,** including improved fermentation practices, waste management, and environmentally responsible use of resources in alcohol industries.	Create
Topic No.	**Credit I**	**Lectures 30**
1	**Introduction to Alcohol Technology-**Definition and classification of alcohol.Types of alcohol: **ethanol and methanol** (basic concept and differences).History and development of alcohol production.Uses of alcohol:Beverage industry, Medicinal and pharmaceutical uses, Industrial solvent, Biofuel.Basic concept of fermentation. **Raw Materials and Fermentation-** Raw materials used for alcohol production:Sugary materials (molasses, fruits, sugarcane juice), Starchy materials (cereals, grains – basic idea), Microorganisms used in alcohol fermentation.Role of yeast (*Saccharomyces cerevisiae*).Basic fermentation process and steps.Factors affecting fermentation: temperature, pH, sugar concentration, oxygen.	**15**
	Credit II	
2	**Alcohol Production Process-** Principle of distillation (basic concept).Alcohol recovery and purification.Types of alcoholic beverages:Beer, Wine, Spirits (whisky, rum, vodka – basic idea).Introduction to breweries and distilleries.By-products of alcohol industry. **Quality Control and Safety** -Concept of alcohol percentage and proof spirit.Basic quality testing methods in alcohol production.Hygiene and sanitation in alcohol production units.Safety measures in breweries and distilleries.Storage and packaging of	**15**

	alcoholic beverages. **Legal, Environmental and Social Aspects-**Government regulations and licensing in alcohol production (basic overview).Environmental impact of distilleries.Waste management in alcohol industries.Social and health impacts of alcohol consumption.Responsible consumption and public health awareness.	
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Define alcohol technology, classify different types of alcohol, and recall the historical development of alcohol production.	Remember
CO2	Explain raw materials used for alcohol production, the role of microorganisms such as *Saccharomyces cerevisiae*, and the basic concept of fermentation.	Understand
CO3	Describe the steps involved in alcohol production including fermentation, distillation, and alcohol purification.	Apply
CO4	Analyze factors affecting fermentation such as temperature, pH, sugar concentration, and oxygen availability.	Analyze
CO5	Evaluate quality control measures, safety practices, and hygiene standards in alcohol production industries.	Evaluate
CO6	Develop awareness about legal regulations, environmental impacts, waste management, and responsible alcohol consumption in society.	Create

References :

1. **Stanbury, P. F., Whitaker, A., & Hall, S.***Principles of Fermentation Technology.* Elsevier.
2. **Prescott, L. M., Harley, J. P., & Klein, D. A.***Microbiology.* McGraw Hill.
3. **Briggs, D. E.***Brewing: Science and Practice.*Woodhead Publishing.
4. **Lea, A. G. H., & Piggott, J. R.***Fermented Beverage Production.* Springer.
5. **Boulton, C., &Quain, D.***Brewing Yeast and Fermentation.* Wiley.

VSC-II (Major Specific) (P)-Techniques in Quality Assurance in Biotechnological Industries. (2Cr)		
	Course objectives	**Bloom's Level**
	To introduce the principles of Good Laboratory Practices (GLP), Good Documentation Practices (GDP), and laboratory safety guidelines used in biotechnology laboratories.	Remember
	To explain laboratory documentation systems, calibration of instruments, and microbiological testing methods used in quality control laboratories.	Understand
	To develop practical skills in microbiological techniques such as media preparation, environmental monitoring, microbial testing of water, food, and dairy products.	Apply
	To analyze microbiological contamination, spoilage microorganisms, and quality parameters of food and dairy products.	Analyze
	To evaluate laboratory quality control systems including calibration, BET testing, and microbial load determination in industrial and laboratory samples.	Evaluate
	To develop professional and employability skills including preparation of CV, job applications, and interview techniques for biotechnology careers.	Create
Sr. No.	**Name of the Practical**	
1	Study of Good Laboratory Practices (GLP) and laboratory safety guidelines.	Minor
2	Preparation of standard laboratory records and documentation based on Good Documentation Practices (GDP) and ALCOA principles.	Minor
3	MLT analysis of product	Major
4	Microbiological examination of water using standard plate count or coliform detection methods.	Major
5	Media preparation and its preservation	Major
6	Environmental monitoring of laboratory air by settle plate technique.	Major
7	Calibration of pH meter, weighing balance, Autoclave	Minor
8	GPT of media	Minor
9	Demonstration **of** Bacterial Endotoxin Test (BET)	Minor
10	Isolation and observation of Plant Growth Promoting Rhizobacteria (PGPR) from soil samples	Major
11	Microbiological testing of food products (e.g., milk) for microbial load.	Major
12	Study of spoilage microorganisms in milk and milk products	Major
13	Platform tests in dairy industry: COB, alcohol precipitation, titratable acidity	Minor
14	Chemical analysis of foods: pH, benzoate, and sorbate	Minor
15	Chemical examination of milk: pH, fat, protein, sugar and ash	Minor

16	Preparation of Curriculum Vitae (CV) and job application for biotechnology industries	Minor
17	Mock interview and interview skills practice for biotechnology jobs	Minor
CO	**Course outcome-** After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of GLP, GDP, ALCOA, laboratory safety guidelines, and quality systems in biotechnology laboratories.	Remember
CO2	Explain laboratory documentation, instrument calibration, and microbiological quality control procedures used in laboratories.	Understand
CO3	Perform laboratory techniques such as media preparation, environmental monitoring and microbial testing of water and food samples.	Apply
CO4	Analyze microbial contamination and spoilage microorganisms in milk, dairy products, and environmental samples.	Analyze
CO5	Evaluate laboratory testing procedures including BET, microbial load determination, and chemical analysis of food products.	Evaluate
CO6	Develop professional documents such as CV and job applications and demonstrate interview skills for biotechnology industries.	Create

References:

1. **Hugo, W. B. and Russell, A. D.***Pharmaceutical Microbiology.* Blackwell Scientific Publications, Oxford.
2. **Sandle, T.***Pharmaceutical Microbiology.*Woodhead Publishing.
3. **World Health Organization (WHO).***Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials.* WHO Press, Geneva.
4. **Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH).***Biosafety in Microbiological and Biomedical Laboratories.* U.S. Department of Health and Human Services.
5. **Frazier, W. C. and Westhoff, D. C.***Food Microbiology.* McGraw-Hill.
6. **Adams, M. R. and Moss, M. O.***Food Microbiology.* Royal Society of Chemistry.
7. **Tortora, G. J., Funke, B. R. and Case, C. L.***Microbiology: An Introduction.* Pearson Education.
8. **Patel, A. H.***Industrial Microbiology.* Macmillan India.
9. **Glick, B. R., Patten, C. L., Holguin, G. and Penrose, D. M.***Plant Growth Promoting Rhizobacteria and Sustainable Agriculture.* Springer.
10. **Ratledge, C. and Kristiansen, B.***Basic Biotechnology.* Cambridge University Press.

AEC-III English(2Cr)		
	As per Syllabus of plane B. Sc. III programme	

OJT (4Cr)		
	Guidelines and procedures regarding OJT Internship/apprenticeship) issued by Government of Maharashtra and University. संदर्भ क्र. : शिवाजी वि./अ.म./240 दिनांक : 22/04/2024	
	Course Objectives	**Bloom's Level**
	Provide students with an opportunity to recall and identify basic biotechnology concepts, laboratory practices, and industrial procedures in a real work environment.	Remember
	Enable students to understand the functioning of biotechnology laboratories and industries**,** including workflow, instrumentation, and standard operating procedures.	Understand
	Develop the ability to apply theoretical knowledge of biotechnology in practical situations such as laboratory experiments, fermentation processes, quality control, and biotechnological production systems.	Apply
	Train students to analyze experimental data, laboratory results, and operational processes used in biotechnology industries or research laboratories.	Analyze
	Encourage students to evaluate laboratory practices, quality control procedures, biosafety guidelines, and ethical standards followed in biotechnology organizations.	Evaluate
	Motivate students to develop innovative ideas, propose improvements, or design small project reports based on industrial or laboratory training experiences**.**	Create
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall fundamental biotechnology concepts, laboratory instruments, and standard procedures observed during industrial or laboratory training.	Remember
CO2	Explain the operational processes, workflow, and organizational structure of biotechnology laboratories or industries.	Understand
CO3	Apply biotechnology techniques and laboratory skills acquired during academic study in real-life industrial or research environments.	Apply
CO4	Analyze experimental observations, technical procedures, and production processes encountered during training.	Analyze
CO5	Assess the effectiveness of quality control systems, biosafety measures, and ethical practices followed in biotechnology workplaces.	Evaluate
CO6	Prepare a comprehensive training report or project, suggesting improvements, innovations, or applications based on the training experience.	Create

Semester VI		
Major XI: Advances in Genetic Engineering (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the concepts of gene isolation, artificial gene synthesis, and gene libraries used in molecular biotechnology.	Remember
	To explain the principles and components of PCR, molecular identification techniques, and DNA barcoding used in modern biology.	Understand
	To apply knowledge of recombinant DNA technology for gene cloning, plasmid construction and insertion of foreign DNA into host cells.	Apply
	To analyze different gene transfer methods, screening techniques of recombinant clones, and molecular marker technologies.	Analyze
	To evaluate applications of recombinant DNA technology including transgenic organisms, recombinant products, and gene silencing techniques.	Evaluate
	To design molecular strategies for gene identification, cloning, genetic mapping, and marker-assisted selection in biotechnology research.	Create
Topic No.		**Lectures 30**
	Credit I	
1	**Isolation of Genes-**Concept and importance of gene isolation, Isolation of desired gene from genomic DNA,Isolation of specific gene using Polymerase Chain Reaction (PCR). **Chemical Synthesis of Genes-**Principle of artificial gene synthesis Phosphotriester approach, Phosphite triester (phosphoramidite) approach, Advantages and limitations of chemical gene synthesis. **Gene Libraries-**Concept and types of gene libraries, Genomic library, cDNA library, Construction and applications of gene libraries. **Screening of Gene Libraries** - Screening Techniques, Importance of screening recombinant clones, **Methods of Library Screening-** Immunological screening, Colony hybridization, Plaque hybridization, Applications-Identification of desired genes, Detection of recombinant clones. **Polymerase Chain Reaction (PCR)-,** Basic principle of PCR, Components of PCR reaction: template DNA, primers, dNTPs, buffer, thermostable DNA polymerase, Steps in PCR Reaction- Denaturation, Annealing, Extension, Primer Designing, Characteristics of ideal primers, GC content, melting temperature, primer length, Thermostable DNA Polymerases Examples (Taq polymerase etc.), Fidelity of thermostable enzymes and its significance. Types of PCR-RT-PCR (Reverse Transcription PCR), Real Time PCR (qPCR), Touchdown PCR, Hot Start PCR, Colony PCR. Applications of PCR-Site-directed mutagenesis, Molecular diagnostics, Detection of viral and bacterial pathogens, Gene expression analysis,Forensic and medical applications. **Molecular Identification-** Introduction to Molecular Identification, Need and significance in taxonomy and biodiversity studies, Molecular Markers-16S rRNA gene in bacteria,18S rRNA gene in eukaryotes, DNA Barcoding-Concept and principle of DNA barcoding, Common	15

	barcode regions used in plants, animals and microbes, Applications in species identification and biodiversity studies.	
	Credit II	
2.	**Introduction to Gene Cloning -** Concept and importance of gene cloning, Vectors used in cloning Construction of Recombinant Plasmids, Steps in plasmid construction, Example: cloning of somatostatin gene, cloning of insulin gene. Insertion of Foreign DNA into Host Cells, Concept of host–vector system, Transformation and transfection, Applications in plant genetic engineering. **Methods of Gene Transfer -** Chemical Methods,-Calcium chloride ($CaCl_2$) mediated transformation Co-precipitation method, Polycation mediated gene transfer. Physical Methods- Liposome mediated gene transfer (Lipofection), Microinjection, Electroporation, Biolistic (Gene gun) method. Agrobacterium Mediated Gene Transfer, Mechanism of gene transfer, Role of Ti plasmid. **Screening of Recombinant Clones**- Importance of Screening Recombinants, Selection Methods-Direct selection, Insertional inactivation selection, Blue–white screening. Expression Based Screening-HART (Hybrid Arrested Translation Technology), Fluorescence Activated Cell Sorter (FACS), South-Western screening **Applications of Recombinant DNA Technology** - Production of Transgenic Organisms, Concept of transgenics, Knockout mice and their applications. Recombinant Products in Medicine -Production of recombinant insulin, Gene Silencing- Introduction to gene silencing. **Molecular Markers**- Introduction to Genetic Markers, Importance in genetics and breeding, **Types of Markers**- Morphological markers, Biochemical markers, Molecular Markers. **Molecular Markers**- RFLP (Restriction Fragment Length Polymorphism), RAPD (Random Amplified Polymorphic DNA), AFLP (Amplified Fragment Length Polymorphism), STRs (Short Tandem Repeats), SSR (Simple Sequence Repeats / Microsatellites), QTL (Quantitative Trait Loci). **Applications**- Genetic mapping, Plant breeding, Population genetics, Marker assisted selection.	**15**
CO	**Course Outcomes**-After completion of the course, students will be able to:	
CO1	Recall the concepts of gene isolation, gene synthesis, gene libraries, and molecular markers used in biotechnology.	Remember
CO2	Explain the principles of PCR, molecular identification methods, and DNA barcoding used for species identification and genetic studies.	Understand
CO3	Apply recombinant DNA technology for gene cloning, plasmid construction, and gene transfer into host cells.	Apply
CO4	Analyze different screening methods for recombinant clones and techniques used for gene library screening and molecular marker analysis.	Analyze
CO5	Evaluate the applications of recombinant DNA technology in medicine, agriculture, and genetic research including transgenic organisms and gene silencing.	Evaluate
CO6	Develop strategies for molecular identification, genetic mapping, and marker-assisted selection using modern molecular tools.	Create
References :		

1. **Glick, B. R., Pasternak, J. J., & Patten, C. L.***Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.
2. **Brown, T. A.***Gene Cloning and DNA Analysis: An Introduction*. Wiley-Blackwell.
3. **Nicholl, D. S. T.***An Introduction to Genetic Engineering*. Cambridge University Press.
4. **Old, R. W., & Primrose, S. B.***Principles of Gene Manipulation: An Introduction to Genetic Engineering*. Blackwell Scientific Publications.
5. **Lewin, B.***Genes* (e.g., **Genes VIII**). Pearson Education.
6. **Purohit, S. S.***Fundamentals of Biotechnology*. Agrobios (India), Jodhpur.
7. **Chawla, H. S.***Introduction to Plant Biotechnology*. Oxford & IBH Publishing.
8. **Gupta, P. K.***Elements of Biotechnology*. Rastogi Publications.
9. **Wilson, K., & Walker, J.***Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
10. **Gupta, P. K.***Plant Biotechnology*. Rastogi Publications.
11. **Jogdand, S. N.***Gene Biotechnology*. Himalaya Publishing House.
12. **Philipse, M.***Protein Biotechnology*. Springer / Academic Press.
13. **Channarayappa***Molecular Biotechnology: Principles and Practices*. Universities Press.
14. **Dubey, R. C.***A Textbook of Biotechnology*. S. Chand Publishing.
15. **Sambrook, J., & Russell, D. W.***Molecular Cloning: A Laboratory Manual* (Vol. I, II, III). Cold Spring Harbor Laboratory Press.

Major XII: Animal Tissue Culture (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the history, basic concepts, and requirements of animal cell culture technology.	Remember
	To explain culture media composition, laboratory design, and equipment required for animal cell culture.	Understand
	To apply techniques for initiation, maintenance, and characterization of cultured animal cells and cell lines.	Apply
	To analyze growth characteristics of cultured cells including cell cycle, cell synchronization, senescence, and apoptosis.	Analyze
	To evaluate scale-up techniques of animal cell culture and methods to control contamination in cell culture laboratories.	Evaluate
	To design applications of animal cell culture in biotechnology including tissue engineering, vaccine production, monoclonal antibodies, and recombinant products.	Create
Topic No.		**Lectures 30**
	Credit I	
1	History and Introduction of Animal Cell culture- History of animal cell culture **Requirements of Animal cell culture-** Characteristics of animal cell in culture, substrate for cell growth, Equipment's required for animal cell culture (Laminar air flow, CO_2 incubator, Centrifuge, Inverted microscope) **Culture media-** Natural media, synthetic media (serum containing media, serum free media, balanced salt solution, media constituent, complete culture media, physicochemical properties of media). **Laboratory design and layout**-Construction and services, layout of aspetic room (sterile handling area, laminar air flow, service bench), incubation (incubators, hot room), preparation area (mediapreparation, washing area, storage). **Cultured cells-** Biology and Characterization- Characteristics ofcultured cells, cell adhesion, cell proliferation, cell differentiation,and metabolism of cultured cells, Initiation of cell culture, Evolution anddevelopment of cell lines. **Characterization of cultured cells-** Morphology of cells, species oforigin of cells, Identification of tissue of origin, transformed cells,Identification of specific cell lines. **Measurement of growth parameters of cultured cells-** Growthcycle of cultured cells, plating efficiency of cultured cellsCell synchronization- Cell separation by physical means, cellseparation by chemical blockade. **Senescence and apoptosis-** Cellular senescence, Measurement ofsenescence, Apoptosis, Measurement of apoptosis.	**15**
	Credit II	
2.	**Basic technique of mammalian cell culture-** Isolation of tissue,disaggregation of tissue, measurement of viability, primary cellculture, Cell lines, Maintainance of cell culture, Subculture, Stem cell cultures	**15**

	Scale up of Animal cell culture-Scale up in suspension-stirrerculture, continuous flow culture, Airlift fermenter culture, Scale up in monolayer- Roller bottle culture, multisurface culture, multiarray disks and tubes, Microcarrier culture, Perfused monolayer culture. **Contamination-** Concept and Sources of contamination, types ofmicrobial contamination, eradication of contamination. **Applications of cell culture-**tissue transplantation, and tissue engineering, monoclonal antibodies, culture based vaccine, valuable recombinant product, cloning, ethics and morality.	
CO	**Course Outcomes-**After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the basic principles, history, and requirements of animal cell culture and laboratory setup.	Remember
CO2	Explain the composition of culture media, equipment used, and characteristics of cultured animal cells.	Understand
CO3	Apply techniques for tissue isolation, cell culture initiation, subculturing, and maintenance of cell lines.	Apply
CO4	Analyze growth parameters of cultured cells including cell cycle, plating efficiency, senescence, and apoptosis.	Analyze
CO5	Evaluate scale-up methods and identify sources of contamination and methods for their control in animal cell culture.	Evaluate
CO6	Develop applications of animal cell culture for biotechnology such as monoclonal antibody production, vaccine development, tissue engineering, and recombinant protein production.	Create

References :

1. **Paul, J.** (1975). *Animal Tissue Culture*. Academic Press, London.
2. **Freshney, R. Ian** (2010). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6th Ed.). Wiley-Blackwell.
3. **Masters, J. R. W.** (2000). *Animal Cell Culture: A Practical Approach*. Oxford University Press.
4. **Ranga, M. M.** (2006). *Animal Biotechnology*. Agrobios (India), Jodhpur.
5. **Sasidhara, R.** (2005). *Animal Biotechnology*. MJP Publishers, Chennai.
6. **Butler, M.** (2004). *Animal Cell Culture and Technology*. Taylor & Francis Group.
7. **Davis, J. M.** (2011). *Animal Cell Culture: Essential Methods*. Wiley-Blackwell.
8. **Portner, R.** (2007). *Animal Cell Biotechnology: Methods and Protocols*. Humana Press.
9. **Kumar, S.** (2012). *Animal Biotechnology*. Oxford University Press, New Delhi.
10. **Glick, B. R., Pasternak, J. J., & Patten, C. L.** (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.
11. **Brown, T. A.** (2016). *Gene Cloning and DNA Analysis: An Introduction* (7th Ed.). Wiley-Blackwell.
12. **Primrose, S. B., &Twyman, R. M.** (2006). *Principles of Gene Manipulation and Genomics* (7th Ed.). Blackwell Publishing.

Major P VI (A) Techniques in Advances in Genetic Engineering (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the principles of PCR, gene cloning, gene expression and molecular marker analysis.	Remember
	To explain the procedures involved in RT-PCR, SNP detection, RAPD, RFLP and Agrobacterium-mediated transformation.	Understand
	To apply molecular biology techniques such as PCR amplification, cDNA cloning, gene editing and recombinant gene expression in *E. coli*.	Apply
	To analyze genetic variations and polymorphisms using PCR-based molecular marker techniques.	Analyze
	To evaluate the efficiency of gene amplification, transformation and recombinant protein expression systems.	Evaluate
	To develop experimental approaches for molecular diagnostics, genetic analysis and recombinant DNA applications.	Create
Sr. No.	**Name of the Practical**	
1.	DNA Amplification by PCR	Minor
2.	cDNA cloning by Reverse Transcription PCR	Major
3.	Detection of Single Nucleotide Polymorphism by PCR	Major
4.	*Agrobacterium* transformation in plants (demonstration).	Minor
5.	Expression of gene in *E. Coli* (GST)	Major
6.	Random Amplified Polymorphic DNA (RAPD) analysis**.**	Major
7.	Restriction Fragment Length Polymorphism (RFLP) analysis**.**	Major
8.	CRISPR based gene editing.	Major
CO	**Course outcome-** After completion of this course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of PCR, RT-PCR, gene editing, gene expression and molecular marker techniques.	Remember
CO2	Explain the procedures involved in DNA amplification, cDNA cloning, SNP detection, RAPD, RFLP and Agrobacterium-mediated transformation.	Understand
CO3	Perform PCR amplification, RT-PCR-based cDNA cloning, recombinant gene expression in *E. coli* and molecular marker analysis.	Apply
CO4	Analyze genetic polymorphisms and molecular variations using RAPD, RFLP and SNP detection techniques.	Analyze
CO5	Evaluate the outcomes of gene transformation and recombinant protein expression experiments.	Evaluate
CO6	Develop molecular biology strategies for gene cloning, genetic analysis and biotechnological applications.	Create

References

1. **Sambrook, J. and Russell, D. W.***Molecular Cloning: A Laboratory Manual.* Cold Spring Harbor Laboratory Press.
2. **Glick, B. R., Pasternak, J. J. and Patten, C. L.***Molecular Biotechnology: Principles and Applications of Recombinant DNA.* ASM Press.
3. **Old, R. W. and Primrose, S. B.***Principles of Gene Manipulation: An Introduction to Genetic Engineering.* Blackwell Scientific Publications.
4. **Nicholl, D. S. T.***An Introduction to Genetic Engineering.* Cambridge University Press.
5. **Brown, T. A.***Gene Cloning and DNA Analysis: An Introduction.* Wiley-Blackwell.
6. **Purohit, S. S.***Fundamentals of Biotechnology.*Agrobios India.

Major P VI (B) Techniques in Animal Tissue Culture (2Cr)

	Course Objectives	**Bloom's Level**
	To introduce laboratory safety practices and the basic principles of animal tissue culture techniques.	Remember
	To explain aseptic techniques, sterilization methods and preparation of animal cell culture media used in tissue culture laboratories.	Understand
	To apply laboratory techniques such as cell counting, viability testing, sub culturing, cryopreservation and preparation of primary animal cell cultures.	Apply
	To analyze cell morphology, growth characteristics, and viability of cultured animal cells using microscopy and biochemical assays.	Analyze
	To evaluate cryopreservation, revival methods and cytotoxicity assays for maintaining animal cell lines.	Evaluate
	To develop experimental protocols for animal tissue culture techniques for research and biomedical applications.	Create
Sr. No.	**Name of the Practical**	
1.	Introduction to Animal Tissue Culture Laboratory and Safety Practices.	Minor
2.	Aseptic techniques for animal tissue culture (Laminar airflow cabinet, Autoclaving and Filter Sterilization)	Minor
3.	Preparation and Sterilization of Animal Cell Culture Media	Major
4.	Identification of Animal Cell Lines and Study of Cell Morphology Using Inverted Microscope	Minor
5.	Cell Counting and Viability Test Using Haemocytometer and Trypan Blue Exclusion Method	Minor
6.	Sub culturing (Passaging) of Adherent Animal Cells	Major
7.	Cryopreservation and Revival of Animal Cell Lines	Major
8	Cytotoxicity Assay Using MTT Method	Major
9	Preparation of Primary Animal Cell Culture- Isolation of animal tissue (e.g., embryonic chick tissue), mincing and washing with physiological saline for preparation of primary cell culture.	Major
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of animal tissue culture and laboratory safety practices.	Remember
CO2	Explain aseptic techniques, sterilization procedures, and preparation of animal cell culture media.	Understand
CO3	Perform laboratory techniques including cell counting, viability testing, sub culturing, cryopreservation, and preparation of primary animal cell cultures.	Apply
CO4	Analyze cell morphology, viability, and cytotoxic effects using inverted microscopy and MTT assay.	Analyze
CO5	Evaluate the effectiveness of cryopreservation, revival procedures and maintenance of animal cell lines.	Evaluate
CO6	Develop protocols for culturing and handling animal cells for research and biomedical applications.	Create
	References	

	1. **Peterson, S., Loring, J. F., Wesselschmidt, R. L. and Schwartz, P. H.** Human Stem Cell Manual: A Laboratory Guide. Academic Press / Elsevier. 2. **Subbiah, S. K., Higuchi, A. and Mok, P. L.** Stem Cell Laboratory Techniques: A Guide for Researchers and Students. Elsevier. 3. **Stein, G. S., Lian, J. B. and van Wijnen, A. J.** Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual. Wiley-Blackwell. 4. **Ulrich, H. and Negraes, P. D.** Working with Stem Cells. Springer. 5. **Kannan, N. and Beer, P.** Stem Cell Assays: Methods and Protocols. Humana Press / Springer. 6. **Rameshwar, P.** Stepwise Culture of Human Adult Stem Cells. River Publishers. 7. **Freshney, R. I.** Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell. 8. **Masters, J. R. W.** Animal Cell Culture: A Practical Approach. Oxford University Press.	

Major Elective II(A)-Bioinformatics (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the history, concepts, databases and multidisciplinary applications of bioinformatics in biology and medicine.	Remember
	To explain biological databases, sequence retrieval systems, genomics, sequence alignment, phylogenetic analysis and drug designing approaches.	Understand
	To apply bioinformatics tools and computational methods for sequence analysis, phylogenetic tree construction and drug target identification.	Apply
	To analyze nucleic acid and protein sequences using alignment algorithms, phylogenetic tools and computational biology techniques.	Analyze
	To evaluate structure-based and ligand-based drug designing strategies, including QSAR, docking and ADME analysis.	Evaluate
	To develop computational approaches for genomics research, molecular evolution studies and rational drug design.	Create
Topic No.	**Credit I**	**Lectures 30**
1	**Introduction to Bioinformatics History of bioinformatics:** Multidisciplinary approach of bioinformatics, Computers in Biology and Medicines, Internet, and related programs; Networking HTTP, HTML, WAN, LAN, MAN, applications in communication. **Information Resources**: Introduction, aim and objectives, National Centre for Biotechnology Information(NCBI), National Library of Medicine (NLM), and National Institute of Health (NIH), EBI, Sequence retrieval system(SRS): Entrez, DBGet. **Introduction to Genomics and Genome databases**: Introduction, Databases, Data, Nucleic acid sequence database, Gene Bank, EMBL, DDBJ. **Genomics:** Human Genome Project (HGP), Goal and applications, final draft of HGP (complete information resources covered).	**15**
	Credit II	
2	**Sequence Alignment and Phylogenetic analysis Sequence Alignment**: Introduction, Protein sequence, Nucleic acid sequence, Pair wise sequence alignment, Multiple sequence alignment, Local and Global sequence alignment. **Algorithm used in sequence alignment**: Matrices- Dot matrix, PAM, BLOSSOM. **Phylogenetic analysis**: Introduction: Evolution, definition of phylogenetic tree, nodes, internodes, root, tree, styles; cladogram, phenogram, curvogram, Steps involved in construction of phylogenetic tree **Phylogenetic analysis tools:** Phylip, ClustalW. **Drug designing Structure-based drug designing:** Introduction; Structure-based drug designing approaches, Target Identification and Validation, homology modeling and protein folding, receptor mapping, active site analysis and pharmacophore mapping, Grid maps. **Ligand-based drug designing and Docking:** Introduction; Ligand-based drug designing approaches, Lead Designing, combinatorial chemistry, High Throughput Screening (HTS), QSAR, Database generation and Chemical libraries, ADME property.	**15**
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**

CO1	Recall the concepts, history, databases and applications of bioinformatics in biology and medicine.	Remember
CO2	Explain genomics databases, sequence retrieval systems, sequence alignment methods, phylogenetic analysis and drug designing concepts.	Understand
CO3	Apply bioinformatics tools such as Entrez, ClustalW, and Phylip for sequence retrieval, alignment and phylogenetic analysis.	Apply
CO4	Analyze protein and nucleic acid sequences using alignment algorithms, substitution matrices and phylogenetic tree construction methods.	Analyze
CO5	Evaluate computational approaches used in structure-based and ligand-based drug designing including QSAR, docking and ADME studies.	Evaluate
CO6	Develop bioinformatics and computational drug design strategies for biological research and pharmaceutical applications.	Create

References :

1. **Rastogi, S. C., Mendiratta, N. and Rastogi, P.** *Bioinformatics: Methods and Applications*. PHI Learning Pvt. Ltd., New Delhi.
2. **Shanmughavel, P.** *Principles of Bioinformatics*. MJP Publishers, Chennai.
3. **Young, D. C.** *Computational Drug Designing*. John Wiley and Sons, New York.
4. **Young, D. C.** *Computational Drug Design: A Guide for Computational and Medicinal Chemists*. Wiley-Interscience Publications, New Jersey.
5. **Attwood, T. K. and Parry-Smith, D. J.** *An Introduction to Bioinformatics*. Pearson Education, Singapore.
6. **Sharma, V., Munjal, A. and Shankar, A.** *A Textbook of Bioinformatics*. Rastogi Publications, Meerut.

Major Elective II(B)-Medical Biotechnology (2Cr)		
	Course Objectives-	**Bloom's Level**
	To introduce important human diseases, chemotherapy, monoclonal antibodies, biosensors, gene therapy and vaccines.	Remember
	To explain the morphology, transmission, pathogenesis, diagnosis, prevention, and control of bacterial, viral, protozoal and fungal diseases.	Understand
	To apply the principles of chemotherapy, hybridoma technology, biosensors and vaccine development in medical biotechnology.	Apply
	To analyze mechanisms of antimicrobial agents, gene therapy approaches, and diagnostic applications of monoclonal antibodies and biosensors.	Analyze
	To evaluate therapeutic and diagnostic applications of vaccines, antisense therapy, monoclonal antibodies and gene therapy strategies.	Evaluate
	To develop biotechnological approaches for disease diagnosis, prevention and treatment using modern immunological and molecular techniques.	Create
Topic No.	**Credit I**	**Lectures 30**
1	**Human diseases** - Study of important human diseases with respect to morphology, cultural and biochemical characteristics, antigenic structure, mode of transmission, pathogenesis, symptoms, laboratory diagnosis, prevention and control. i) Bacterial: *Mycobacterium tuberculosis, Staphylococcus aureus* ii) Viruses: Hepatitis A & B virus iii) Protozoa :*Plasmodium falciparum* iv) Fungus: *Candida albicans* **Chemotherapy** - i) Chemoprophylaxis, ii) General principles of chemotherapy, iii) Mode of action of antimicrobial agents: a) Antibacterial drugs: Penicillin, Bacitracin, Streptomycin, Tetracycline, b) Antiviral drug: AZT,c) Antifungal drugs: Ketoconazole, Griseofulvin,d) Antiprotozoal drugs: Metranidazole.	**15**
	Credit II	
2	**Monoclonal Antibodies-** Introduction, Hybridoma Technology, Applications- Diagnostics , Therapeutics , Protein purification and Abzymes. **Biosensors-** Introduction, Principle, Types (Amperometric, Thermometric, Optical biosensor, Immuno biosensor), Applications **Gene Therapy –** Introduction , Approaches-*ex vivo* (Therapy for Adenosine deaminase deficiency) *and in vivo* gene therapy (Gene therapy strategy for cancer), Antigene and antisense therapy , antisense therapy for cancer. **Vaccines- Principle and Practices** Concept and types of vaccine, Subunit vaccines- Hepatitis B vaccine, Foot and Mouth disease Vaccine, AIDS Vaccine, DNA Vaccines, Edible Vaccines, Recombinant vaccines- Cholera Vaccine, Vaccinia Virus Vaccine.	**15**
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the characteristics of important human pathogens, antimicrobial agents, vaccines and gene therapy concepts.	Remember

CO2	Explain the pathogenesis, diagnosis, prevention, and control of bacterial, viral, protozoal and fungal diseases.	Understand
CO3	Apply the principles of chemotherapy, hybridoma technology, biosensors and vaccine development in medical biotechnology applications.	Apply
CO4	Analyze the mechanisms of action of antimicrobial agents, biosensors, monoclonal antibodies and gene therapy approaches.	Analyze
CO5	Evaluate the role of vaccines, antisense therapy, monoclonal antibodies and recombinant therapeutics in disease management.	Evaluate
CO6	Develop strategies for diagnosis, prevention, and treatment of diseases using modern biotechnological and immunological tools.	Create

References :

1. 1.**Ananthanarayan, R., &Paniker, C. K. J.***Textbook of Microbiology*. Universities Press, Hyderabad.
2. **Greenwood, D., Slack, R., &Peutherer, J.***Medical Microbiology*. Churchill Livingstone / Elsevier.
3. **Willey, J. M., Sherwood, L. M., &Woolverton, C. J.***Prescott's Microbiology*. McGraw-Hill Education.
4. **Pelczar, M. J., Chan, E. C. S., & Krieg, N. R.***Microbiology*. McGraw-Hill Book Company.
5. **Madigan, M. T., Martinko, J. M., & Bender, K. S.***Brock Biology of Microorganisms*. Pearson Education.
6. **Talaro, K. P., & Chess, B.***Foundations in Microbiology*. McGraw-Hill Education.

Major Elective P II (A)- Techniques in and Bioinformatics (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce biological databases, sequence retrieval systems and bioinformatics tools used in computational biology.	Remember
	To explain the principles of sequence analysis, phylogenetic analysis, protein structure visualization and molecular docking.	Understand
	To apply bioinformatics tools such as BLAST, ClustalW, PyMOL, ExPASy and ArgusLab for biological data analysis.	Apply
	To analyze nucleotide and protein sequences, phylogenetic relationships and structural properties of biomolecules using computational tools.	Analyze
	To evaluate molecular interactions, docking results and energy calculations of biomolecules using molecular modeling approaches.	Evaluate
	To develop computational strategies for sequence analysis, protein characterization and structure-based biological studies.	Create
Sr. No.	**Name of the Practical**	
1.	Introduction to PUBMED Central database using the ENTREZ search engine.	Minor
2.	Getting the amino acid sequence by exploring and querying the protein sequence database.	Minor
3.	Getting the gene sequence by exploring and querying the nucleic acid sequence database.	Minor
4.	Similarity search for nucleotide and protein using the BLASTn, BLASTp and interpretation of the results.	Major
5.	Protein and nucleic acid pair-wise sequence alignment by using ClustalW and Construction of Phylogenetic Tree using ClustalW.	Major
6.	Analysis of Secondary and tertiary structure of protein using visualizing software like Pymol or Rasmol.	Minor
7.	Calculation of PI/MW of protein and Prediction of the secondary structure of protein using ExPasy web tool (GOR method).	Major
8.	Molecular Docking of protein and ligand by Argus lab.	Major
9.	Energy calculation of the biomolecules using molecular mechanics and quantum mechanics. (Argus lab)	Minor
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the functions of biological databases and bioinformatics tools used in sequence and structural analysis.	Remember
CO2	Explain the principles of sequence retrieval, similarity searching, sequence alignment, phylogenetic analysis and molecular docking.	Understand
CO3	Apply bioinformatics tools such as ENTREZ, BLAST, ClustalW, ExPASy, PyMOL and ArgusLab for computational analysis of biological data.	Apply
CO4	Analyze protein and nucleotide sequences, phylogenetic relationships and secondary and tertiary protein structures using bioinformatics software.	Analyze
CO5	Evaluate molecular docking interactions, protein properties and biomolecular energy calculations using computational methods.	Evaluate
CO6	Develop computational workflows for sequence analysis, molecular modeling and structure-based bioinformatics research.	Create

References:-

1. **Mount, D. W**. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press, New York.
2. **Lesk, A. M.** *Introduction to Bioinformatics*. Oxford University Press, Oxford.
3. **Baxevanis, A. D. and Ouellette, B. F. F.** *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. Wiley-Interscience Publications, New York.
4. **Ghosh, Z. and Mallick, B**. *Bioinformatics: Principles and Applications*. Oxford University Press, New Delhi.
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9. **Attwood, T. K. and Parry-Smith, D. J.** *An Introduction to Bioinformatics*. Pearson Education, Singapore.
10. **Sharma, V., Munjal, A. and Shankar, A.** *A Textbook of Bioinformatics*. Rastogi Publications, Meerut.

Major Elective P II (B)- Techniques in Medical Biotechnology. (2Cr)

	Course Objectives	**Bloom's Level**
	To introduce the principles of clinical microbiology, serology, haematology, urine analysis and immunological techniques.	Remember
	To explain the procedures for isolation, identification and characterization of clinically important pathogens and diagnostic tests.	Understand
	To apply microbiological, serological, haematological and biochemical techniques for laboratory diagnosis of diseases.	Apply
	To analyze clinical samples using antibiotic sensitivity testing, MIC determination, blood analysis, urine examination and immunological assays.	Analyze
	To evaluate diagnostic results obtained from microbiological, serological, haematological and immunological investigations.	Evaluate
	To develop laboratory skills for clinical diagnosis, pathogen identification and biomedical analysis in medical biotechnology.	Create
Sr. No.	**Name of the Practical**	
1.	Isolation and identification of following pathogens by morphological, cultural and biochemical characteristics from clinical samples like urine/blood/medical waste – a) *Staphylococcus aureus* b) *Candida albicans*	Major
2.	Determination of sensitivity of common pathogens to antibiotics by paper disc method	Minor
3.	Determination of MIC of antibiotic against *E.coli*by agar well diffusion method.	Major
4.	Serological tests – a) ASO test b) Dengue NS-1 Ag test	Monor
5.	Snyder test	Minor
6.	Haematology a) Blood group detection b) Hb detection by Sahli's method c) Determination of ESR d) Total and differential blood cell count	Major
7.	Urine analysis a) Physical examination – Volume, color, appearance, odour, pH b) Chemical examination – Test for protein, ketone bodies, bile salt, sugar c) Microscopic examination - Presence of crystals, RBCs, pus cells and bacteria.	Major
8.	Immunoglobulin G Purication.	
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of pathogen identification, antibiotic sensitivity testing, serology, haematology, urine analysis and immunoglobulin purification.	Remember
CO2	Explain the procedures involved in isolation and identification of pathogens, serological tests, haematological analysis and urine examination.	Understand
CO3	Perform laboratory techniques including microbial isolation, antibiotic sensitivity testing, MIC determination, blood analysis, urine analysis and IgG purification.	Apply

CO4	Analyze clinical samples and interpret microbiological, serological, haematological and biochemical test results.	Analyze
CO5	Evaluate the effectiveness of diagnostic methods and antimicrobial susceptibility testing for clinical applications.	Evaluate
CO6	Develop laboratory approaches for disease diagnosis, pathogen characterization and biomedical investigations.	Create
	References:- 1. Hugo, W. B. and Russell, A. D. *Pharmaceutical Microbiology*. Blackwell Scientific Publications, Oxford. 2. Ananthanarayan, R. and Paniker, C. K. J. *Textbook of Microbiology*. Universities Press, Hyderabad. 3. Collee, J. G., Fraser, A. G., Marmion, B. P. and Simmons, A. *Mackie and McCartney Practical Medical Microbiology*. Churchill Livingstone, New York. 4. Bailey, W. R. and Scott, E. G. *Diagnostic Microbiology*. Mosby Publications, St. Louis. 5. Mukherjee, K. L. *Medical Laboratory Technology*. Tata McGraw Hill Publishing Company Ltd., New Delhi. 6. Dacie, J. V. and Lewis, S. M. *Practical Haematology*. Churchill Livingstone, London. 7. Pelczar, M. J., Chan, E. C. S. and Krieg, N. R. *Microbiology*. McGraw Hill Book Company, New York. 8. Prescott, L. M., Harley, J. P. and Klein, D. A. *Microbiology*. McGraw Hill Publications, New York.	

VSC III Major Specific (P) Techniques in Stem Cell Biotechnology (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the basic principles and laboratory practices involved in stem cell culture techniques.	Remember
	To explain the procedures for preparation and maintenance of stem cell culture media, stem cell isolation and cryopreservation techniques.	Understand
	To apply laboratory techniques such as stem cell viability testing, subculturing and maintenance of *in vitro* stem cell cultures.	Apply
	To analyze stem cell growth and viability using Trypan Blue dye exclusion method and colony formation assays.	Analyze
	To evaluate the effectiveness of cryopreservation, thawing, recovery and maintenance procedures for stem cells.	Evaluate
	To develop protocols for stem cell culture, preservation and analysis for research and therapeutic applications.	Create
Sr. No.	**Name of the Practical**	
1	Introduction to Stem Cell Culture Laboratory and Safety Practices.	Minor
2	Preparation and maintenance of stem cell culture media.	Major
3	Isolation of stem cells from bone marrow/ peripheral blood (Demonstration).	Major
4	Cell viability test using Trypan Blue dye exclusion method.	Minor
5	In vitro stem cell culture and maintenance (Demonstration).	Minor
6	Cryopreservation, thawing and recovery of cryopreserved stem cells	Major
7	Stem cell passaging (sub culturing) technique (Demonstration).	Minor
8	Stem cell colony formation assay (Demonstration).	Minor
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the principles of stem cell culture, stem cell isolation and cryopreservation techniques.	Remember
CO2	Explain the procedures involved in preparation of stem cell culture media, stem cell maintenance and viability testing.	Understand
CO3	Perform stem cell culture techniques including viability testing, subculturing, cryopreservation and recovery of stem cells.	Apply
CO4	Analyze stem cell growth and viability using Trypan Blue exclusion method and colony formation assays.	Analyze
CO5	Evaluate the efficiency of stem cell preservation, recovery and maintenance procedures under in vitro conditions.	Evaluate
CO6	Develop laboratory protocols for stem cell culture and handling for research and biomedical applications.	Create
	References	

	1. **Peterson, S., Loring, J. F., Wesselschmidt, R. L. and Schwartz, P. H.** Human Stem Cell Manual: A Laboratory Guide. Academic Press / Elsevier. 2. **Subbiah, S. K., Higuchi, A. and Mok, P. L.** Stem Cell Laboratory Techniques: A Guide for Researchers and Students. Elsevier. 3. **Stein, G. S., Lian, J. B. and van Wijnen, A. J.** Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual. Wiley-Blackwell. 4. **Ulrich, H. and Negraes, P. D.** Working with Stem Cells. Springer. 5. **Kannan, N. and Beer, P.** Stem Cell Assays: Methods and Protocols. Humana Press / Springer. 6. **Rameshwar, P.** Stepwise Culture of Human Adult Stem Cells. River Publishers. 7. **Freshney, R. I.** Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell. 8. **Masters, J. R. W.** Animal Cell Culture: A Practical Approach. Oxford University Press.	

SEC III (Theory) Stem Cell Biotechnology (T) (2Cr)		
	Course Objectives	**Bloom's Level**
	To introduce the history, basic concepts, and biological properties of stem cells.	Remember
	To explain the types of stem cells, stem cell markers, and mechanisms involved in stem cell differentiation and self-renewal.	Understand
	To apply knowledge of stem cell niches and regulation mechanisms involved in maintenance and differentiation of stem cells.	Apply
	To analyze hematopoietic stem cells, their microenvironment, and their differentiation into various blood cell lineages.	Analyze
	To evaluate the characteristics and regulatory mechanisms of cancer stem cells and their role in tumor progression and angiogenesis.	Evaluate
	To design approaches for stem cell isolation, expansion, and potential applications in regenerative medicine and cancer research.	Create
Topic No.	**Credit I**	**Lectures 30**
1	**Introduction and Basic Biology of Stem Cells** Introduction and history of stem cell research. Concept of stemness and basic properties of stem cells. Types of stem cells: embryonic stem cells, adult stem cells and induced pluripotent stem cells (iPSCs). Stem cell markers and identification of stem cells. Types of adult stem cells: bone marrow stem cells, adipose tissue stem cells, cord blood stem cells and placental stem cells. Stem cell differentiation and transdifferentiation. Stem cell niches and regulation of stem cell niches in different tissues. Overview of pluripotent stem cells and basic concepts of self-renewal.	**15**
	Credit II	
2	**Hematopoietic and Cancer Stem Cells** Introduction to hematopoietic stem cells (HSCs) and bone marrow microenvironment. Isolation and basic characterization of hematopoietic stem cells. Hematopoietic stem cell mobilization and differentiation into different blood cell lineages. Basic concepts of ex vivo expansion of stem cells. Introduction to cancer and cancer stem cells. Stem cell origin of cancer and characteristics of cancer stem cells. Isolation and characterization of cancer stem cells. Role of signaling pathways in cancer stem cell regulation and tumor progression. Introduction to tumor angiogenesis and role of pericytes.	**15**
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Recall the history, types, and basic properties of stem cells including embryonic, adult, and induced pluripotent stem cells.	Remember
CO2	Explain the mechanisms of stem cell self-renewal, differentiation, stem cell markers, and stem cell niches.	Understand
CO3	Apply concepts of stem cell biology in understanding stem cell maintenance, differentiation, and regulation in different tissues.	Apply

CO4	Analyze the biology of hematopoietic stem cells, their microenvironment, and processes involved in blood cell lineage differentiation.	Analyze
CO5	Evaluate the role of cancer stem cells, signaling pathways, and tumor angiogenesis in cancer development.	Evaluate
CO6	Develop strategies for stem cell isolation, expansion, and therapeutic applications in regenerative medicine and oncology.	Create

References :

1. **Lanza, R., Gearhart, J., Hogan, B., Melton, D., Pedersen, R. and Thomson, J.***Handbook of Stem Cells.* Academic Press, Elsevier.
2. **Rao, M. S. and Mattson, M. P.***Stem Cells and Regenerative Medicine.* Humana Press, Springer.
3. **Freshney, R. I.***Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications.* Wiley-Blackwell.
4. **Masters, J. R. W.***Animal Cell Culture: A Practical Approach.* Oxford University Press.
5. **Sasidhara, R.***Animal Biotechnology.* MJP Publishers.
6. **Haider, K. H.** (2021). *Stem Cells: Latest Advances* (1st Edition). Springer, Cham.
7. **Al-Anazi, K.** (2020). *Update on Mesenchymal and Induced Pluripotent Stem Cells.*InTechOpen.
8. **Slack, J. M. W.** (2017). *The Science of Stem Cells.* John Wiley & Sons, Inc.
9. **Sell, S.** (2013). *Stem Cells Handbook* (2nd Edition). Humana Press.

AEC-IV English(2Cr)		
	As per Syllabus of plane B. Sc. III programme	

IKS- II Major Specific Indian Knowledge System (IKS) in Biotechnology (2Cr)		
	Course Objectives	**Bloom's Level**
	Recall the basic concepts and sources of Indian Knowledge Systems related to life sciences.	Remember
	Explain contributions of ancient Indian scholars and classical texts to medicine, agriculture, and biological sciences.	Understand
	Apply traditional knowledge to understand modern domains of biotechnology such as medical, agricultural, food, and environmental biotechnology.	Apply
	Examine traditional practices such as Ayurveda, fermentation, and biodiversity conservation using scientific perspectives.	Analyze
	Assess the relevance of indigenous knowledge systems in modern biotechnology and sustainable development.	Evaluate
	Propose innovative approaches for integrating traditional knowledge with modern biotechnology applications.	Create
Topic No.	**Credit I**	**Lectures 30**
1	**Foundations of Indian Knowledge Systems:** Concept, scope, and scientific traditions in ancient India; sources of Indian knowledge including Vedic literature, classical scientific texts, and indigenous practices. **Development of Biological Sciences in Ancient India:** Contributions of scholars such as Charaka and Sushruta; early concepts of anatomy, physiology, and pharmacology; classical texts including Charaka Samhita and Sushruta Samhita. **Red Biotechnology – Traditional Medicine:** Principles of Ayurveda; medicinal plants, herbal formulations, and traditional pharmacology; relevance to drug discovery and phytopharmaceutical research. Tissue regeneration and wound healing, Skin grafting and reconstructive surgery in Sushruta, Samhita, Use of plant-based formulations for tissue repair, Rasayana therapy for cellular rejuvenation (anti-aging concepts) **Green Biotechnology – Traditional Agriculture:** Organic farming practices, natural pest management, seed preservation, and soil fertility management; plant science knowledge from texts such as Vrikshayurveda and Krishi-Parashara; relevance to sustainable agriculture and modern plant biotechnology.	**15**
	Credit II	
2	**Yellow and White Biotechnology – Traditional Fermentation and Food Biotechnology:** Microbial fermentation processes in traditional foods such as Idli, Dosa, and Dahi; indigenous food preservation techniques; microbial diversity and probiotic potential. **Blue Biotechnology – Marine and Aquatic Knowledge Systems:** Traditional knowledge of marine resources, coastal ecosystems, and aquatic biodiversity; relevance to marine biotechnology and natural product research. **Grey Biotechnology – Environmental Knowledge**	**15**

	and Biodiversity Conservation: Sacred groves, community forest management, and traditional ecological conservation practices; case study of biodiversity conservation in the Western Ghats; traditional water management systems including step wells and temple tanks. **Gold Biotechnology – Computational and Mathematical Traditions:** Logical and mathematical traditions supporting scientific knowledge; contributions of scholars such as Aryabhata; relevance to modern bioinformatics and computational biology. **Modern Integration of Traditional Knowledge:** Applications of Indian knowledge systems in modern biotechnology including drug discovery, functional foods, environmental biotechnology, and bioprospecting.	
CO	**Course Outcomes**-After completion of the course, students will be able to:	**Bloom's Level**
CO1	Explain the concept and significance of Indian Knowledge Systems in life sciences.	Remember
CO2	Describe the contributions of ancient Indian scholars and classical texts to medicine, plant science, and biological knowledge.	Understand
CO3	Identify connections between traditional knowledge systems and modern biotechnology domains such as medical, agricultural, microbial, and environmental biotechnology.	Apply
CO4	Analyse traditional practices including fermentation, herbal medicine, and ecological conservation using scientific principles.	Analyze
CO5	Evaluate the potential of indigenous knowledge for modern biotechnology applications including drug discovery, sustainable agriculture, and biodiversity conservation.	Evaluate
CO6	Develop integrative approaches linking Indian Knowledge Systems with modern biotechnology and life science research.	Create

References :

1. **R. K. Sharma** and **Bhagwan Dash**. *Charaka Samhita* (English Translation). Chowkhamba Sanskrit Series Office, Varanasi.
2. **K. R. Srikantha Murthy**. *Sushruta Samhita* (English Translation). ChaukhambhaOrientalia, Varanasi.
3. *Atharva Veda*. Various editions and translations, MotilalBanarsidass Publishers, Delhi.
4. **Surapala**. *Vrikshayurveda*. Asian Agri-History Foundation, Secunderabad.
5. *Publications of the***Ministry of AYUSH**, Government of India, New Delhi.
6. *Traditional Knowledge Digital Library (TKDL) Database*. **Council of Scientific and Industrial Research (CSIR)** and **Ministry of AYUSH**, Government of India.
7. **Kapil Kapoor**. *Indian Knowledge Systems: Knowledge Traditions and Practices of India*. Indian Institute of Advanced Study / D.K. Printworld, New Delhi.
8. **Various Authors**. Selected Research Articles on Regenerative Medicine and Ayurveda. Published in peer-reviewed journals.

FP(2Cr)
As per the guidelines of BOS and university rules.