PERIYAR UNIVERSITY

SALEM – 636011

DEGREE OF BACHELOR OF SCIENCE

(CHOICE BASED CREDIT SYSTEM)

B.Sc., BIOTECHNOLOGY

OBE REGULATIONS AND SYLLABUS

SEMESTER PATTERN

(For Candidates admitted in the Colleges affiliated to

Periyar University from 2026-2027 onwards)

REGULATIONS

1. PREAMBLE AND OBJECTIVES OF THE COURSE

The B.Sc. Biotechnology program is designed to provide students with a strong interdisciplinary foundation integrating biological sciences with the technology for the manipulation and application of living systems. It emphasizes the study of cellular and molecular biology, genetic engineering, microbiology, immunology, bioprocess technology, and bioinformatics that underpin modern biotechnological innovation. The course integrates theoretical knowledge with practical laboratory and industrial exposure, enabling students to design, analyze, and apply biotechnological tools in agriculture, healthcare, environment, and industry. By fostering scientific temper, research aptitude, entrepreneurial thinking, and ethical responsibility, the program prepares graduates for diverse careers in academics, research organizations, biotech and pharmaceutical industries, and government sectors, while also encouraging lifelong learning and adaptability to emerging technological advancements.

The major objectives of B.Sc., Biotechnology course are

- To study the structure, function, and organization of cells, biomolecules, and the molecular basis of genetic information.
- To understand the principles, instrumentation, and applications of microscopy, centrifugation, chromatography, electrophoresis, and spectroscopy in biological analysis.
- To learn the fundamentals of cell biology, genetics, microbiology, immunology, and molecular biology essential for understanding host-pathogen interactions and biological regulation.
- To explore recombinant DNA technology, genetic engineering, genome editing, and their applications in developing improved organisms and products.
- To gain knowledge of plant and animal tissue culture techniques, transgenic technology, and their applications in agriculture and healthcare.
- To gain practical exposure to enzyme technology, biopharmaceuticals, vaccine development, and diagnostic tool design.
- To acquire practical skills through hands-on laboratory experiments, data analysis, and interpretation of biotechnological results.
- To prepare graduates for careers in research laboratories, biotechnology and pharmaceutical industries, agricultural biotech firms, and academic institutions.

- To emphasize laboratory safety, biosafety regulations, bioethics, and responsible handling of genetically modified and biological materials.
- To connect fundamental biotechnological knowledge with applications in environmental biotechnology, waste management, and sustainable resource utilization.
- To encourage innovation, entrepreneurship, and start-up culture in biotechnology-based product development.
- To promote eco-friendly biotechnological practices, green technology approaches, and conservation of biodiversity.
- To explore the applications of artificial intelligence and machine learning in genomics, drug discovery, protein structure prediction, and biological data-driven decision making.
- To understand the principles of bioprocess engineering, fermentation technology, downstream processing, and industrial-scale production of biotechnological products.
- To acquire skills in bioinformatics, computational biology, and database analysis for genomic, proteomic, and molecular data interpretation.

LEARNING OUTCOMES Guidelines for Curriculum Framework for OBE Syllabus for Undergraduate Programme	
Programme:	**B.Sc. BIOTECHNOLOGY**
Duration:	**3 years [UG]**
Programme Outcomes	
PO1	**Disciplinary knowledge**: Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines that form a part of an undergraduate programme of study
PO2	**Communication Skills**: Ability to express thoughts and ideas effectively in writing and orally; Communicate with others using appropriate media; confidently share one's views and express herself/himself; demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner to different groups.
PO3	**Critical thinking**: Capability to apply analytic thought to a body of knowledge; analyze and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence; identify relevant assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development.
PO4	**Problem solving**: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non- familiar problems, rather than replicate curriculum content knowledge; and apply one's learning to real life situations.
PO5	**Analytical reasoning**: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyze and synthesize data from a variety of sources; draw valid conclusions and support them with evidence and examples, and addressing opposing viewpoints.
PO6	**Research-related skills**: A sense of inquiry and capability for asking relevant/appropriate questions, problem arising, synthesising and articulating; Ability to recognise cause-and-effect relationships, define problems, formulate hypotheses, test hypotheses, analyse, interpret and draw conclusions from data, establish hypotheses, predict cause-and- effect relationships; ability to plan, execute and report the results of an experiment or investigation
PO7	**Cooperation/Team work**: Ability to work effectively and respectfully with diverse teams; facilitate cooperative or coordinated effort on the part of a group, and act together as a group or a team in the interests of a common cause and work efficiently as a member of a team.
PO8	**Scientific reasoning**: Ability to analyse, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.

PO9	**Reflective thinking**: Critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society.
P10	**Information/digital literacy**: Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
P11	**Self-directed learning**: Ability to work independently, identify appropriate resources required for a project, and manage a project through to completion.
P12	**Multicultural competence**: Possess knowledge of the values and beliefs of multiple cultures and a global perspective; and capability to effectively engage in a multicultural society and interact respectfully with diverse groups.
P13	**Moral and ethical awareness/reasoning**: Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights; appreciating environmental and sustainability issues; and adopting objective, unbiased and truthful actions in all aspects of work.
P14	**Leadership readiness/qualities**: Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, in a smooth and efficient way.
P15	**Lifelong learning**: Ability to acquire knowledge and skills, including learning how to learn, that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling.

PROGRAMME SPECIFIC OUTCOMES (PSOs)	
On successful completion of the B.Sc. Biotechnology programme, students will be able to gain the following benefits:	
PSO1	**Foundation & Disciplinary Knowledge:** Demonstrate comprehensive disciplinary knowledge of cellular and molecular biology, biomolecules, microbiology, genetics, and bioprocess technology, and apply this understanding to analyze biological systems and their functions.
PSO2	**Skill Development:** Acquire proficiency in handling modern biotechnological instrumentation and techniques including chromatography, electrophoresis, spectroscopy, recombinant DNA technology, genome editing, and tissue culture, and apply scientific reasoning to interpret experimental data with accuracy and reliability.
PSO3	**Research & Development (R&D):** Develop research-related skills through hands-on laboratory training, hypothesis formulation, experimental design, and data analysis, enabling them to plan, execute, and report independent or collaborative investigations in biotechnology and allied fields.
PSO4	**Placement & Employability:** Apply problem-solving and critical thinking abilities to address real-world challenges in agriculture, healthcare, environment, and industry through the design and application of biotechnological products, processes, and diagnostic tools, preparing graduates for careers in research, industry, and academia.
PSO5	**Utilizing Innovation & Technology:** Utilize information and digital literacy skills, including bioinformatics tools, computational biology, and artificial intelligence/machine learning applications, to access, analyze, and interpret genomic, proteomic, and biological data for globally relevant, technology-driven solutions.
PSO6	**Entrepreneurship & Ethical Responsibility:** Exhibit ethical responsibility, biosafety awareness, and sustainable practices in the handling of biological materials and genetically modified organisms, while demonstrating leadership, teamwork, entrepreneurial thinking, and commitment to lifelong learning for the betterment of society.

MAPPING PROGRAM OUTCOME WITH PROGRAM SPECIFIC OUTCOME

PSO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
PSO1	3	1	2	1	1	1	--	2
PSO2	2	1	1	1	3	2	1	3
PSO3	2	2	3	2	2	3	1	2
PSO4	1	2	2	3	1	1	1	1
PSO5	1	1	2	1	2	1	-	1
PSO6	1	1	1	1	-	-	3	-

3 – Strong, 2- Medium, 1- Low

HIGHLIGHTS OF THE REVAMPED CURRICULUM

B.Sc. Biotechnology Syllabus – 2026 Onwards

- Student-centric curriculum meeting the demands of industry and society, incorporating hands-on training, skill enhancement modules, an integrated mini project with entrepreneurship training, industrial internship, and exposure to regulatory and entrepreneurial skills, while sustaining the quality of core components.
- Core subjects are reorganized to consolidate foundational concepts early (Cell & Developmental Biology, Genetics & Molecular Biology in Semester I) and progressively build toward advanced application areas such as Genetic Engineering, Stem Cell & Tissue Engineering, and Industrial Bioprocess Technology.
- Artificial Intelligence (AI) is formally introduced into the curriculum for the first time through the Skill Enhancement Course "Research Methodology & AI in Biotechnology", exposing students to AI/ML tools and computational approaches such as sequence alignment (BLAST) alongside traditional research methodology.
- The curriculum strengthens the Industry–Academia interface through new Skill Enhancement Courses in Medical Laboratory Technology & GLP, and Clinical Research, Regulatory Affairs & GMP, preparing students for clinical, diagnostic, and pharmaceutical industry roles.
- Elective baskets are redesigned to offer flexible specialisation tracks — Bioinformatics & Biostatistics, Bioentrepreneurship, and IPR/Bioethics/Biosafety under one elective slot — allowing students to align their electives with individual career interests.
- Summer Internship/Industrial Training in the fifth semester gives students professional workplace exposure, connecting classroom knowledge with real-world biotechnology practice.
- The Mini Project/Entrepreneurship Training in the final semester enables students to translate a real-world problem into a viable project or start-up idea, with structured training in business model development, costing, IPR awareness, and pitching to industry mentors - a first-of-its-kind integrated research-cum-entrepreneurship component.
- The Non-Major Elective (NME) basket is broadened to five discipline-specific offerings (Mushroom Cultivation, Agri-Biotechnology, Sericulture & Apiculture, Forensic Science, and Pharmaceutical Biotechnology), extending the department's interdisciplinary outreach to students of other departments.

Value Additions in the Revamped Curriculum

Semester	Newly Introduced / Restructured Components	Outcome / Benefits
I & II	Merged Core Foundation Papers – Cell & Developmental Biology combined with Genetics & Molecular Biology (Core I & II) in Semester I itself, with a single integrated Core Practical I	• Early consolidation of foundational cell and molecular concepts, avoiding fragmentation across semesters • Stronger conceptual base before students move into specialised biotechnology papers • Reduced practical redundancy through a combined laboratory course
II	Microbiology elevated to a full Core paper (Core III) with a dedicated Core Practical, instead of being offered only as an elective	• Ensures every student acquires core microbiological competence, essential for downstream biotech applications • Strengthens the base for later papers in Immunology, Genetic Engineering and Industrial Biotechnology
III	New Skill Enhancement Course – Medical Lab Technology & Good Laboratory Practices (GLP); Bioinstrumentation repositioned as Elective I (moved earlier from Semester IV)	• Builds employability in clinical/diagnostic laboratory careers from an early stage • Introduces GLP and quality-compliant practices required by regulatory and industry bodies • Earlier exposure to instrumentation strengthens practical skills before advanced core papers
IV	Elective II restructured as a basket of three industry-relevant options – Bioinformatics & Biostatistics / Bioentrepreneurship / IPR, Bioethics & Biosafety; New Skill Enhancement Course – Clinical Research, Regulatory Affairs & Good Manufacturing Practices (GMP)	• Gives students flexibility to specialise toward computational, entrepreneurial, or regulatory-legal career tracks • Direct alignment with pharmaceutical and biotech industry requirements (GMP, regulatory affairs, IPR) • Prepares industry-ready graduates for clinical research organisations (CROs) and quality assurance roles
V	New Skill Enhancement Course – Research Methodology & AI in Biotechnology (introducing AI/ML tools, sequence alignment tools such as BLAST); Environmental Biotechnology combined with Nanobiotechnology as a single	• First-of-its-kind integration of Artificial Intelligence into the core biotechnology curriculum, keeping students current with emerging computational tools in research • Strengthens research aptitude and scientific writing skills ahead of the final-year mini project

	Elective III; Human Anatomy & Physiology repositioned to this semester; Summer Internship/Industrial Training	• Combined elective broadens exposure to sustainability-linked and emerging nanotechnology applications • Internship provides real workplace exposure and connects classroom learning to industry practice
VI	Project and Entrepreneurship Development merged into a single integrated course – Mini roject/Entrepreneurship Training (with business model development, costing, IPR awareness, and prototype/proof-of-concept components); New dedicated Core papers – Stem Cell & Tissue Engineering, Industrial Bioprocess Technology, and Food Biotechnology	• Bridges the gap between academic research and start-up readiness in a single applied course • Trains students in market research, IPR, biosafety compliance, and pitching ideas to industry mentors • Dedicated papers on emerging application areas (stem cells, bioprocess scale-up, food biotechnology) enhance domain depth and industry alignment
I & VI	Non-Major Elective (NME) basket broadened to five discipline-specific offerings for students of other departments – Mushroom Cultivation, Agri-Biotechnology, Sericulture & Apiculture, Forensic Science, and Pharmaceutical Biotechnology	• Widens interdisciplinary outreach of the Biotechnology department across the institution • Exposes non-major students to applied, skill-oriented biotechnology domains • Creates avenues for cross-departmental enrolment and visibility of the department's expertise
All Semesters	Course Outcomes (COs) explicitly mapped to Bloom's Taxonomy levels (K1–Remember through K6–Create) for every paper, in line with the Outcome-Based Education (OBE) framework	• Ensures graded cognitive progression from basic recall to higher-order creation and evaluation skills • Strengthens compliance with NEP/OBE accreditation requirements (NAAC/NBA) • Provides transparent, measurable learning outcomes for each course

Value Additions in the Revamped Curriculum

Skills Acquired from the Courses

Disciplinary Knowledge, Laboratory & Analytical Skills, Research Aptitude, AI & Computational Literacy, Regulatory & Quality Compliance Awareness, Entrepreneurial & Start-up Readiness, Professional Communication, and Transferable Employability Skills.

2. ELIGIBILITY FOR ADMISSION

Candidate for admission to the first year of B.Sc., Degree Course in Biotechnology shall be required to have passed the Higher Secondary Examination **with any one of the Biological Sciences (Botany, Zoology, Biology, Microbiology, Biochemistry) / any of the Academic or Vocational stream (Agri, Home Science, Nursing, Poultry)** under higher secondary board of examination, Tamil Nadu or as per norms set by the Government of Tamil nadu or an examination accepted as Equivalent thereto by the syndicate.

Admission Eligibility for Diploma courses (Lateral Entry) for B. Sc., Biotechnology course includes the following

Diploma in Chemical Engineering (DCHEE), Diploma in Environmental Engineering and Pollution Control (DENVE & PC), Diploma in Sugar Technology (DSTEC), Diploma in Leather Technology (DLTEC), Diploma in Pharmacy (D. Pharm), Diploma in Health Inspector (DHI), Diploma in Medical Lab Technology (DMLT), Diploma in Nutrition & Dietetics (DN&D), Diploma in Nursing (D. Nursing), Diploma in Horticulture (D. Hort.), Diploma in Agriculture (D. Agri.), Diploma in Food Technology (D. Food Tech.), Diploma in Biomedical Electronics (DBE), Diploma in Agricultural Technology (D. Agri Tech.)

Preparation of Rank – list for UG course: For admission to Under Graduate Courses (UG), a candidate must have passed the Higher Secondary Examinations of Tamil Nadu or an examination (like the CBSE) recognized by the Universities as equivalent there to. Admission should be made based on the +2 marks only. The Rank – list will be out of 400 marks comprising a subject – component of 400 and admission to Government/ Government Aided/ Self – Financing Colleges order of merit/ rank list against the priority of choices recorded by applicants.

(a) Rank list should be prepared based on the marks obtained by the students in the subject component out of total 400 marks under Part III in the Higher Secondary Examination held in the current Academic year. Eligibility of students for admission to UG courses in the colleges shall be as per the eligibility norms and guidelines of the Universities concerned. Apportionment of seats for each course with different streams (80% Academic/ 20% Vocational) and also Apportionment of seats among students who have studied different subjects in the Higher Secondary (+2) shall be made as per the existing

norms. For the students passed Higher Secondary (+2) prior to 2018-19 the marks can be converted to current stream i.e., to 400 instead of 800.

(b) If more than one allied is offered for a particular major subject, 50% of the seats shall be given to each allied.

Group – II: Biotechnology

For the students studied Botany, Zoology, Biology or Chemistry, Rank is based on the marks in Part – III out of 400. Student should have studied Chemistry compulsorily.

3. DURATION OF THE COURSE

The duration of the course is three academic years comprising six semesters.

4. COURSE OF STUDY

The B.Sc. Biotechnology course comprises the following subjects in the syllabus,

- Foundation Courses : Languages - I, II, III, IV and English – I, II, III, IV
- Core Theory : Core I to Core XI
- Core Practical : Core Practical I to VIII
- Allied I : Biochemistry
- Allied Practical I : Biochemistry
- Allied II : Computer Science
- Allied Practical II : Computer Science
- Elective : I, II, III
- Skill Enhancement Course (SEC) : I, II, III
- Non - Major Elective Course (NME) : I, II

(NME may be chosen by the respective colleges and the same must be communicated to the University).

- Summer Internship / Industrial Training: 15 days (at the end of Second year)

(Attendance & Internship Certificate should be enclosed with the Internship Report and submitted to the department)

- Mini Project/ Entrepreneurship Start – Up: 3 Hours/ week (during the final semester)

(Attendance/ Review I & II, Submission of Mini – project report/ Presentation/ Viva-Voce)

- **Common Papers for all UG Programmes** (Part – IV)
    - Value Education
    - Disaster Management
    - Health and Wellness
    - Environmental Science (EVS)
    - Extension Activity
    - NMSDC ("Naan Mudhalvan")

5. EXAMINATIONS

There shall be six semester examinations for three years – two semester examination per year. Candidates failing in any subject / subjects will be permitted to reappear for failed subject / subjects in subsequent examinations. The syllabus has been divided into six semesters. The odd semester examinations (I, III and V) will be held in November/ December and even semester examinations (II, IV and VI) will be held in April / May. The practical examination I will be held at the end of I year (II-semester). II will be held at the end of II year (IV-semester). III and IV will be held at the end semester of III year (VI-semester).

6. PASSING MINIMUM

A candidate shall be declared to be passed the examination if he /she secure not less than 40% of the marks in each paper and practical. The candidates who do not secure the required minimum marks for pass in a paper and practical shall be required to reappear to pass the same at a subsequent appearance. For the practical the minimum pass includes the record mark too. There is no passing minimum for the record. However, submission of a record notebook is a must.

7. CLASSIFICATION OF SUCCESSFUL CANDIDATES

Candidates who secured not less than 60% of the aggregate marks in the whole examination shall be declared to have passed the examination in First Class. Candidates secured above 50% less than 60% shall be declared to have passed in Second Class. Candidates who obtain 75% and above in the aggregate shall be declared to have passed the examination in First Class with Distinction provided they pass all the examination in prescribed period at first appearance.

8. RANKING

Candidates who pass all the examinations for the prescribed course in the first

attempt/appearance and within a period of three academic years from the year of admission to the course only are eligible for University Ranking.

9. MAXIMUM DURATION FOR THE COMPLETION OF THE UG PROGRAMME

The maximum duration for completion of the UG Programme shall not exceed twelve semesters.

10. COMMENCEMENT OF THIS REGULATION

These regulations shall be effect from the academic year 2026-27 onwards for candidates admitted during the academic year 2026-27 and thereafter.

11. TRANSITORY PROVISION

Candidates who were admitted to the UG course of study before 2023-2024 shall be permitted to appear for the examinations under those regulations for a period of three years i.e. up to April / May 2028 examination. Thereafter, they will be permitted to appear for the examination only under the regulations therein force.

12. COURSES OFFERED BY THE BOARD AS NON – MAJOR ELECTIVE COURSE (NME)

Semester - I

- NME – I : (Select Any One Out of Two Papers)
  A. Mushroom Cultivation
  B. Public Health & Hygiene

Semester - II

- NME – II : (Select Any One Out of Two Papers)
  A. Organic Farming & Vermicomposting
  B. Herbal Biotechnology in Alternative Medicine

13. LIST OF ELECTIVE PAPERS

Semester – III

- Elective – I: (Select Any One Out of Two Papers)
  A. Bioinstrumentation
  B. IPR, Bioethics & Biosafety

Semester – IV

- Elective – II: (Select Any One Out of Two Papers)
  A) Bioinformatics & AI in Biotechnology

B) Nanobiotechnology

Semester – V

- Elective – III: (Select Any One Out of Two Papers)

  A) Environmental Biotechnology

  B) Bio – entrepreneurship

14. LIST OF SKILL ENHANCEMENT COURSE (SEC)

Semester - III

- SEC – I : Medical Lab Technology (MLT) & Good Laboratory Practice (GLP)

Semester - IV

- SEC – II: Clinical Research, Regulatory Affairs & Good Manufacturing Practice (GMP)

Semester - V

- SEC – III: Research Methodology & Biostatistics

15. A) ** NAAN MUDHALVAN – Courses external 25 marks will be assessed by Industry and Internal will be offered by respective course teacher.

B) ** Alternate SKILL Papers for "Naan Mudhalvan" reappear students

- Semester II - Mushroom Cultivation
- Semester III - Agri - Biotechnology
- Semester IV - Sericulture & Apiculture
- Semester V - Forensic Science
- Semester VI - Pharmaceutical Biotechnology

16. COURSE OF THE STUDY AND SCHEME OF EXAMINATIONS

S.No	Sem	Paper Code	Part	Course Group	Paper Type	Subject Title	Hrs/ Week	Exam Hrs	IA	EA	Total	Cred	Page No.
1	I		I	Foundation	Theory	Language – I	6	3	25	75	100	3	
2			II	Foundation	Theory	English – I	6	3	25	75	100	3	
3			III	Core I	Theory	Cell & Developmental Biology	4	3	25	75	100	4	
4			III	Core II	Theory	Genetics & Molecular Biology	4	3	25	75	100	4	
5			III	Core Practical I	Practical	Lab in Cell Biology, Developmental Biology, Genetics and Molecular Biology	4	6	40	60	100	4	
6			III	Allied – I	Theory	Biochemistry	3	3	25	75	100	4	
7			IV	NME - I	Theory	**Choose any one paper offered by other departments**	2	3	25	75	100	2	
8			IV	Value Education	Theory	Value Education – Yoga	1	3	25	75	100	1	
Total							**30**					**25**	

S.No	Sem	Paper Code	Part	Course Group	Paper Type	Subject Title	Hrs/ Week	Exam Hrs	IA	EA	Total	Cred	Page No.
1	II		I	Foundation	Theory	Language – II	6	3	25	75	100	3	
2			II	Foundation	Theory	English – II	6	3	25	75	100	3	
3			III	Core III	Theory	Microbiology	5	3	25	75	100	4	
4			III	Core Practical II	Practical	Lab in Microbiology	4	6	40	60	100	4	
5			III	Allied Practical I	Practical	Allied Practical Biochemistry	3	3	40	60	100	4	
6			IV	NME - I	Theory	**Choose any one paper offered by other departments**	2	3	25	75	100	2	
7			IV	Disaster Management	Theory	Disaster Management	2	3	25	75	100	1	
8			IV	NMSDC	Theory	"Naan Mudhalvan" Skill Development Course (NMSDC)	2	3	25	75	100	2	
Total							**30**					**23**	

S.No	Sem	Paper Code	Part	Course Group	Paper Type	Subject Title	Hrs/ Week	Exam Hrs	IA	EA	Total	Cred	Page No.
1	III		I	Foundation	Theory	Language – III	6	3	25	75	100	3	
2			II	Foundation	Theory	English – III	6	3	25	75	100	3	
3			III	Core IV	Theory	Immunology & Immunotechnology	4	3	25	75	100	4	
4			III	Core Practical III	Practical	Lab in Immunology & Immunotechnology	3	6	40	60	100	4	
5			III	Allied - II	Theory	Computer Science	3	3	25	75	100	4	
6			III	Elective - I	Theory	A. Bio Instrumentation B. IPR, Bioethics & Biosafety	3	3	40	60	100	3	
7			IV	Skill Enhancement Course -I	Theory	Medical Lab Technology (MLT) & Good Laboratory Practice (GLP)	2	3	25	75	100	2	
8			IV	Health & Wellness	Report	Health & Wellness	1	3	40	60	100	1	
9			IV	NMSDC	Theory	"Naan Mudhalvan" Skill Development Course (NMSDC)	2	3	25	75	100	2	
Total							**30**					**26**	

S.No	Sem	Paper Code	Part	Course Group	Paper Type	Subject Title	Hrs/ Week	Exam Hrs	IA	EA	Total	Cred	Page No.
1	IV		I	Foundation	Theory	Language – IV	6	3	25	75	100	3	
2			II	Foundation	Theory	English – IV	6	3	25	75	100	3	
3			III	Core V	Theory	Genetic Engineering	4	3	25	75	100	4	
4			III	Core Practical IV	Practical	Lab in Genetic Engineering	4	6	40	60	100	4	
5			III	Allied Practical - II	Practical	Lab in Computer Science	3	3	40	60	100	4	
6			III	Elective - II	Theory	A. Bioinformatics & AI in Biotechnology B. Nanobiotechnology	3	3	40	60	100	3	
7			IV	Skill Enhancement Course -II	Theory	Clinical Research, Regulatory Affairs & Good Manufacturing Practice (GMP)	2	3	25	75	100	2	
8			IV	NMSDC	Theory	"Naan Mudhalvan" Skill Development Course (NMSDC)	2	3	25	75	100	2	
Total							**30**					**25**	

S.No	Sem	Paper Code	Part	Course Group	Paper Type	Subject Title	Hrs/ Week	Exam Hrs	IA	EA	Total	Cred	Page No.
1	V		III	Core VI	Theory	Human Anatomy & Physiology	5	3	25	75	100	4	
2			III	Core VII	Theory	Plant Biotechnology	4	3	25	75	100	4	
3			III	Core VIII	Theory	Animal Biotechnology	4	3	25	75	100	4	
4			III	Core Practical - V	Practical	Lab in Plant Biotechnology	4	6	40	60	100	4	
5			III	Core Practical - VI	Practical	Lab in Animal Biotechnology	4	6	40	60	100	4	
6			III	Elective - III	Theory	A. Environmental Biotechnology B. Bio entrepreneurship	3	3	25	75	100	3	
7			IV	Skill Enhancement Course -III	Theory	Research Methodology & Biostatistics	2	3	25	75	100	2	
8			IV	Internship Training	Training Report	Summer Internship/ Industrial Training	0	6	40	60	100	2	
9			IV	E.V.S	Theory	Environmental Studies	2	3	25	75	100	2	
10			IV	NMSDC	Theory	"Naan Mudhalvan" Skill Development Course (NMSDC)	2	3	25	75	100	2	
Total							**30**					**31**	

S.No	Sem	Paper Code	Part	Course Group	Paper Type	Subject Title	Hrs/ Week	Exam Hrs	IA	EA	Total	Cred	Page No.
1	VI		III	Core IX	Theory	Stem Cell & Tissue Engineering	6	3	25	75	100	4	
2			III	Core X	Theory	Industrial Bioprocess Technology	6	3	25	75	100	4	
3			III	Core XI	Theory	Food Biotechnology	6	3	25	75	100	4	
4			III	Core Practical – VII	Practical	Lab in Industrial Bioprocess and Food Biotechnology	6	6	40	60	100	4	
5			IV	Mini project	Practical	Mini Project/ Entrepreneurship/ Start up Activity	4	6	40	60	100	3	
6			IV	Extension Activity	-	Extension Activity	0	0	25	75	100	1	
7			IV	NMSDC	Theory	"Naan Mudhalvan" Skill Development Course (NMSDC)	2	3	25	75	100	2	
Total							**30**					**22**	

"NAAN MUDHALVAN - NMSDC"

S.No	Sem	Paper Code	Part	Course Group	Paper Type	Subject Title	Hrs/ Week	Exam Hrs	IA	EA	Total	Cred	Page No.
1	**II**		IV	Skill Paper (Alt. to NM)	Theory	Mushroom Cultivation	2	3	25	75	100	2	
2	**III**		IV	Skill Paper (Alt. to NM)	Theory	Agri – Biotechnology	2	3	25	75	100	2	
3	**IV**		IV	Skill Paper (Alt. to NM)	Theory	Sericulture & Apiculture	2	3	25	75	100	2	
4	**V**		IV	Skill Paper (Alt. to NM)	Theory	Forensic Science	2	3	25	75	100	2	
5	**VI**		IV	Skill Paper (Alt. to NM)	Theory	Pharmaceutical Biotechnology	2	3	25	75	100	2	

17. TOTAL PAPERS – 50 (45 + 5 NM)

Part - I	Total Papers	Part - II	Total Papers	Part III	Total Papers- 22		Part - IV	Total Papers
Language Tamil	4	Language English	4	Core	18	11 (Theory) 7 (Practical)	NME	2
				Allied	4	2 (Theory) 2 (Practical)	SEC	3
				Elective	3	3 (Theory)	VE	1
							DM	1
							HW	1
							EVS	1
							Extension	1
							Internship	1
							Mini project	1
							NM	5

Language Part I – Total Papers – 4

Language Part II – Total Papers – 4

Part III: Core – Total Papers – 18 [11 (Theory) & 7 (Practical)]

Part III: Allied – Total Papers – 4 [2 (Theroy) & 2 (Practical)]

Part III: Elective – 3

Part IV: NME - 2

Part IV: SEC – Total Papers – 3

Part IV: Value Education – 1

Part IV: Disaster Management – 1

Part IV: Health & Wellness – 1

Part IV: EVS – 1

Part IV: Extension Activity – 1

Part IV: Internship – 1

Part IV: Mini Project – 1

Part IV: NMSDC – 5

18. CREDIT DISTRIBUTION

Part	Title of the Course	Total No. of Papers	Credits	Total credits
Part I	Tamil	4 (Theory)	12 (Each 3 Credits)	**24 Credits**
Part II	English	4 (Theory)	12 (Each 3 Credits)	
Part III	Core Course	18 (11 Theory + 7 Practical)	72 (Each 4 Credits)	**97 Credits**
Part III	Allied Course	4 (2 Theory + 2 Practical)	16 (Each 4 Credits)	
Part III	Elective Course	3 (Theory)	9 (Each 3 Credits)	
Part IV	Non Major Elective	2 (Theory)	4 (Each 2 Credits)	**18 Credit**
Part IV	Skill Enhancement Course	3 (Theory)	6 (Each 2 Credits)	
Part IV	Value Education	1 (Theory)	1 Credit	
Part IV	Disaster Management	1 (Theory)	1 Credit	
Part IV	Health & Wellness	1 (Report)	1 Credit	
Part IV	EVS	1 (Theory)	2 Credit	
Part IV	Extension Activity	_	1 Credit	
Part IV	Internship	1 (Training Report) - Commended / Highly Commended	2 Credit	
Part IV	Mini Project	1 (Project Report) & Viva Voce	3 Credit	
Part IV	Mini Project	1 (Project Report) & Viva Voce	3 Credit	**3 Credits**
Part IV	"Naan Mudhalvan"	5 (Exam Online) Theory (Offline)	10 (Each 2 Credits)	**10 Credits**
Total Credits for UG Programme				**142+10=152**

19. PATTERN OF QUESTION PAPER

Time: Three Hours Maximum: 75 marks

Part A - (15 x 1 = 15 marks)

Answer All Questions

(a), (b), (c), (d) Multiple Choices

(Three Questions from Each Unit)

Part B - (2 x 5 = 10 marks)

Answer any TWO Questions out of FIVE

(One Question from Each Unit)

Part C – (5 x 10 = 50 marks)

Answer All Questions

Either (or) Type FIVE Questions

(One Set of Question from Each Unit)

20. INTERNAL MARKS & EXTERNAL MARKS

	Internal Marks	**External Marks**
Theory	25	75
Practical	40	60
Project	25	75
Internship/ Health & Wellness	Commended/ Highly Commended	

21. GENERAL TEACHING METHODS, TEACHING AIDS & ASSESMENT METHODS

Suggested Teaching Methods

Category	Method	Description
Traditional	Lecture method	Chalk & talk or slides; core theory delivery
	Demonstration	Step-by-step lab technique walkthroughs
	Tutorial & seminar	Small group discussion and Q&A sessions
	Team-based learning (TBL)	Structured group work with individual accountability
Active & Inquiry-Based	Problem-based learning (PBL)	Solve real biotech scenarios; drug design, fermentation issues
	Case-based learning (CBL)	Industry and research case studies for critical thinking
	Flipped classroom	Pre-recorded content; in-class time for application & discussion
	Jigsaw & peer teaching	Each student masters a sub-topic and teaches peers
	Lab-based / hands-on learning	PCR, gel electrophoresis, ELISA, cell culture, HPLC
	Research-based learning	Mini-projects, literature review, hypothesis testing
	Simulation & role play	Ethics debates, biosafety drills, patent simulation games
Experiential & Digital	Industrial visits & internships	Biotech firms, hospitals, agricultural research stations
	Guest lectures	Scientists, industry experts & alumni as speakers
	MOOC & blended learning	Coursera, edX, NPTEL combined with face-to-face classes
	Journal club	Weekly discussion of current research papers

Suggested Teaching Aids

Category	Aid	Description
Visual Aids	Presentation slides	PowerPoint, Prezi, Canva; structured topic delivery
	Charts, diagrams & models	Metabolic pathways, cell models, 3D molecular kits
	Blackboard / whiteboard	Biochemical reaction schemes, derivations, diagrams
	Posters & banners	Lab safety protocols, biosafety levels, procedure charts
	Specimens & museum charts	Preserved biological specimens, herbarium sheets

Audio-Visual Aids	Documentary & lecture videos	YouTube, NPTEL, Khan Academy, MIT OpenCourseWare
	Animations & simulations	NCBI 3D viewer, BioRender, molecular docking animations
	Virtual lab software	Labster, PhET, OLABS; simulate experiments virtually
	Podcasts & webinars	Live/recorded expert sessions on current biotech topics
Digital & e-Resources	LMS platforms	Moodle, Google Classroom, Blackboard; course management
	Bioinformatics tools	BLAST, PyMOL, Clustal Omega, SnapGene, MEGA
	e-Journals & databases	PubMed, ScienceDirect, Scopus, Web of Science
	Interactive apps & AR/VR	Visible Body, Merge EDU; immersive anatomy & cell biology
	Actual lab equipment	Spectrophotometer, PCR machine, centrifuge, ELISA reader
	Microscopy systems	Light, phase-contrast, fluorescence microscopes
	Biosafety & containment aids	Laminar flow hoods, autoclaves, BSL-1/2 lab setup

Suggested Internal Assessment & Evaluation Methods

Category	Method	Description
Formative (Continuous)	Class tests & quizzes	Weekly/unit-wise MCQs, short-answer, fill-in-blanks
	Assignments & homework	Problem sets, review writing, mechanism diagrams
	Viva voce	Oral questioning during or after lab sessions
	Lab record & notebook	Observation books, data recording, result interpretation
	Seminar & topic presentations	Student presentations on assigned topics; peer feedback
	Online quizzes & polls	Kahoot, Google Forms, Mentimeter in real time
Summative (End-of-Term)	University theory exam	Long-answer, short-answer, MCQ papers as per syllabus
	Practical examination	Spotting, experiment performance, result interpretation
	Internal assessment (IA)	Mid-sem tests contributing to final grade
	Research project / dissertation	Original experimental work with thesis submission (PG)
	Mini-project & field	Short research tasks or agricultural/industrial

Project & Performance-Based	project	field work
	Portfolio assessment	Curated collection of student work across the semester
	Poster presentation	Conference-style research poster; evaluated by jury panel
	Peer & self-assessment	Structured rubric-based evaluation of group projects
Advanced & Skill-Based	Objective Structured Practical Exam (OSPE)	Timed stations testing different lab skills & knowledge
	Case study evaluation	Written analysis of a research/industry scenario
	Competency-based assessment	Rubric for lab skills: pipetting, sterile technique, etc.

Semester – I
Part - III
Core – I: Cell & Developmental Biology

COURSE OBJECTIVE

To provide students with a comprehensive understanding of the structural and functional organization of the cell, and to introduce the fundamental principles governing animal and plant development from fertilization to organogenesis.

LEARNING OBJECTIVE		
On successful completion of the course, students will be able to		
LO1	Explore the historical development of cell biology and classify cellular and acellular biological systems, including prokaryotes, eukaryotes, viruses, viroids, and prions	
LO2	Learn the structure and functions of cellular components, organelles, and cytoskeletal elements, and explain their roles in maintaining cellular organization and function.	
LO3	Illustrate the mechanisms regulating the cell cycle, cell signaling, cell communication, and cellular processes involved in growth, division, and apoptosis.	
LO4	Examine the structural and functional specialization of animal and plant cells and evaluate the biological significance of stem cells in development and regenerative medicine.	
LO5	Understand the concepts and fundamental principles of developmental biology, including gametogenesis, fertilization, embryogenesis, differentiation, organogenesis, and regeneration	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Describe the structural organisation of prokaryotic and eukaryotic cells.	K1 - Remember
CO2	Explain the structure, function, and biogenesis of cell organelles.	K2 - Understand
CO3	Apply the principles of the cell cycle and cell signalling pathways to biological problems.	K3 - Apply
CO4	Analyse the process of gametogenesis, fertilisation, and cleavage.	K4 - Analyze
CO5	Evaluate the mechanisms underlying gastrulation and organogenesis.	K5 - Evaluate
CO6	Design conceptual models explaining the molecular basis of animal development.	K6 - Create

COURSE CONTENT

Unit	**Content**	**No. of Hours**
I	Historical overview of Cell Biology; Cell Theory; Structure and organization of prokaryotic (bacteria) and eukaryotic cells (plant and animal cells); non-	12

	cellular life forms (Viruses, Viroids, Prions); Brief introduction to model organisms in cell biology research (*E. coli*, *S. cerevisiae*, and *Drosophila*).	
II	Structure and Functions of Cell wall, Cell membrane (Fluid Mosaic Model), Cytoplasm, Nucleus, and Chromosomes. Endomembrane system: Endoplasmic reticulum, Ribosomes, Golgi bodies, and Lysosomes; Semiautonomous organelles: Mitochondria and Chloroplasts (Endosymbiotic theory). Cytoskeleton (Microfilaments, Intermediate filaments and Microtubules).Vacuoles, Microbodies, and Cilia/Flagella.	12
III	Cell cycle phases, molecular regulation of cell cycle checkpoints (Cyclins and CDKs); Mitosis and Meiosis (stage & significance); Programmed Cell Death (Apoptosis) and Necrosis; Cell junctions (anchoring, tight, and gap junctions), Cell adhesion molecules (CAMs), Extracellular Matrix (ECM); Principles of Cell signaling - receptors and second messengers; Signal transduction pathways - MAPK, JAK-STAT overview	12
IV	Biology of specialized cells: Nerve cells and Nerve impulse conduction; Muscle cells and Molecular mechanism of muscle contraction. Plant specialized tissues: Shoot and Root apical meristems, Parenchyma, Xylem, and Phloem structural variations, floral transition. Stem cell: Properties & Types.	12
V	Gametogenesis: Spermatogenesis and Oogenesis in mammals. Structure of gametes and hormonal regulation; Molecular events of Fertilization. Cleavage types, blastula formation, gastrulation, and formation of three germ layers in animals. Fate maps and cell lineage tracing; Neurulation and neural tube development; Organogenesis (overview); Molecular basis of pattern formation - Hox genes, morphogens	12
Total		**60**

Text Books

1	T. Devasena (2012), Cell Biology, Oxford University Press.
2	Gupta, Renu & Makhija, Seema & Toteja, Ravi. (2018). Cell Biology: Practical Manual.
3	Gilbert, S.F. 2016. Developmental Biology, 11th edition. Sinauer Associates Inc. Publishers, MA. USA.
4	Bruce Alberts, 6th Edition (2014). Molecular Biology of the cell, W. W. Norton & Company.
5	James D. Watson (2001), The Double Helix: A personal account of the Discovery of the Structure of DNA, Touchstone Publishers.
6	Pijushroy .,2010,Plant Anatomy,New Central Book Agency,Put Lit.,New Delhi
7	P.S.Verma &V.K.Agarwal.,(2016-Reprint)-Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S.Chand Publishing Company Pvt Ltd,New Delhi.
8.	Geoffrey M. Cooper & Robert E. Hausman (2007). The Cell: A Molecular Approach, Fourth Edition, Sinauer Associates Inc.

9.	Jonathan M. W. Slack, Leslie Dale (2021), Essential Developmental Biology, Fourth Edition, Wiley-Blackwell Publishers.
Reference Books	
1	Karp‟s Cell and Molecular Biology: Concepts and Experiments. 8th Edition (2015). Wiley Publications.
2	James D. Watson, 7th Edition (2014), Molecular Biology of the Gene, Pearson Publications.
3	Geoffrey M. Cooper, 7th Edition (2015). The Cell: A Molecular Approach, Sinauer Associates, Qxford University Press.
4	Karp‟s Cell and Molecular Biology: Concepts and Experiments. 8th Edition (2015). Wiley Publications.
5	James D. Watson, 7th Edition (2014), Molecular Biology of the Gene, Pearson Publications.
Web Resources	
1	http://www.cellbiol.com/education.php. CellBiol Education Resources – Tutorials and educational content on cell biology and microscopy
2	https://global.oup.com/uk/orc/biosciences/cellbiology/wang/student/weblinks/ch16/ Oxford University Press Cell Biology Web Links – Supplementary resources on cell communication and signaling.
3	https://dnalc.cshl.edu/websites/ DNA Learning Center (DNALC) – Genetics, molecular biology, and biotechnology educational resources
4	https://www.cellsignal.com/contents/science/cst-pathways/science-pathways. Cell Signaling Technology Science Pathways – Interactive pathway maps and signaling networks
5	https://nptel.ac.in/courses/102/106/102106025/11. NPTEL Cell Biology Course – Video lectures and online learning materials from IIT faculty.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester – I

Part - III

Core – II: Genetics & Molecular Biology

COURSE OBJECTIVE

To impart knowledge on the principles of classical and molecular genetics, and to develop an understanding of the mechanisms of inheritance, gene expression, and its regulation.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Provide a thorough understanding of the principles of heredity — Mendelian and non-Mendelian — and the chromosomal basis of inheritance.	
LO2	Introduce students to the molecular architecture of chromatin alongside the organisation of prokaryotic and eukaryotic genomes.	
LO3	Develop conceptual clarity on the molecular mechanisms of DNA replication, repair, and recombination.	
LO4	Enable students to understand the gene expression from transcription through RNA processing and RNA editing process.	
LO5	Equip students with knowledge of translation and protein synthesis and significance of post translational modifications	
LO6	To familiarize the students about gene regulations, the molecular basis of mutation, and consequences in genetic diseases.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Recall the principles of Mendelian inheritance, chromosomal theory, and the molecular structure of DNA, RNA, and chromatin.	K1 - Remember
CO2	Explain genome organization in prokaryotes and eukaryotes, the central dogma, and the enzymology of replication, transcription, and translation.	K2 - Understand
CO3	Solve problems related to inheritance patterns, chromosome mapping, and the flow of genetic information in living systems.	K3 - Apply
CO4	Examine the molecular mechanisms of DNA repair, recombination, and gene regulation in prokaryotes and eukaryotes including epigenetic control.	K4 - Analyze
CO5	Assess the molecular basis of mutations, their classification, and consequences in the context of genetic diseases and cancer.	K5 - Evaluate

CO6	Formulate experimental approaches to investigate gene structure, expression, and regulatory mechanisms.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Principles of Inheritance & Chromosomal basis of heredity** Mendel's laws of inheritance and monohybrid/dihybrid/ trihybrid crosses; Incomplete dominance, codominance, multiple alleles; Gene interactions - epistasis, complementation. Chromosome structure and karyotyping, Linkage, crossing over, recombination, and chromosome mapping. Sex determination and sex-linked inheritance; Lyon hypothesis and dosage compensation. Extra-chromosomal inheritance: Mitochondrial and chloroplast inheritance	12
II	**Chromosomal aberrations, Human Genetics Genome organization** Chromosomal aberrations: Structural and numerical changes; associated genetic disorders. Human genetics: Pedigree analysis, Hardy-Weinberg equilibrium, polygenic inheritance, and heritability. Chromatin organization: Nucleosome and chromatin structure. Genome organization in prokaryotes: Chromosomes, plasmids, transposons, and mobile genetic elements. Genome organization in eukaryotes: Repetitive DNA, satellite DNA, C-value paradox, gene families, and organellar genomes.	12
III	**DNA Structure and Replication -** Experimental evidence for DNA as genetic material; Watson-Crick model of DNA and DNA topology; Types of DNA, Chargaff's rules, and DNA stability; Enzymology of DNA replication - prokaryotic and eukaryotic replication; Replication fork and origin of replication; DNA repair mechanisms; Recombination mechanisms.	12
IV	**Transcription** RNA polymerases and promoter recognition; Mechanism of transcription in prokaryotes and eukaryotes; Post-transcriptional modifications & RNA processing- capping, polyadenylation, splicing, alternative splicing, RNA editing. Types and functions of RNA..	12
V	**Translation and Gene Regulation** Genetic code and its properties; Mechanism of translation - initiation, elongation, termination; Translation & Protein synthesis in prokaryotes and eukaryotes. Post-translational modifications and protein targeting in eukaryotes. Gene regulation in Prokaryotes: Operon concept - lac and trp operon; Eukaryotic gene regulation. Mutations: Types and their molecular basis, Types of mutagens, biological significance of mutations;	12

Total		60
Text Books		
1	Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular Biology of the Gene* (7th Ed.). Cold Spring Harbor Laboratory Press / Pearson Education.	
2	Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., & Martin, K. (2021). *Molecular Cell Biology* (9th Ed.). W.H. Freeman and Company.	
3	Hartwell, L.H., Goldberg, M.L., Fischer, J.A., & Hood, L. (2018). *Genetics: From Genes to Genomes* (6th Ed.). McGraw-Hill Education.	
4	Russell, P.J. (2010). *iGenetics: A Molecular Approach* (3rd Ed.). Pearson Education.	
5	Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell* (7th Ed.). W.W. Norton & Company.	
6	Nelson, D.L., & Cox, M.M. (2021). *Lehninger Principles of Biochemistry* (8th Ed.). W.H. Freeman and Company.	
7	Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2017). *Genes XII* (12th Ed.). Jones & Bartlett Learning.	
Reference Books		
1	De Robertis, E.D.P., & De Robertis Jr., E.M.F. (2001). *Cell and Molecular Biology* (8th Ed.). Lippincott Williams & Wilkins.	
2	Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., & Killian, D. (2019). *Concepts of Genetics* (12th Ed.). Pearson Education.	
3	Malacinski, G.M., & Freifelder, D. (1998). *Essentials of Molecular Biology* (4th Ed.). Jones & Bartlett Publishers.	
4	Stryer, L., Berg, J.M., & Tymoczko, J.L. (2015). *Biochemistry* (8th Ed.). W.H. Freeman and Company.	
5	Freifelder, D. (1990). *Molecular Biology* (2nd Ed.). Narosa Publishing House	
Web Resources		
1	https://www.biointeractive.org. Animations for DNA replication, transcription, translation, PCR, and CRISPR-Cas9	
2	https://www.ncbi.nlm.nih.gov/education. Genome and gene databases; PubMed; bioinformatics tutorials	
3	https://ocw.mit.edu (Course 7.01SC). Lecture notes, problem sets, and videos on Fundamentals of Biology	
4	https://nptel.ac.in. IIT and IISc lecture series on Genetics, Molecular Biology, and Biochemistry	
5	https://www.khanacademy.org/science/ap-biology. Structured modules with practice questions on genetics and molecular biology	
6	https://www.nature.com/scitable. Peer-reviewed topic pages on genetics, cell biology, and molecular biology	

7	https://learn.genetics.utah.edu. Interactive modules on DNA, inheritance, epigenetics, and gene expression
8	https://www.labster.com. Virtual experiments on PCR, gel electrophoresis, CRISPR, and protein synthesis
9	https://www.ensembl.org. Genome browser for gene structure, annotation, and comparative genomics
10	https://pubmed.ncbi.nlm.nih.gov. Free access to life sciences and biomedical literature

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

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	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - I

Part - III

Core Practical – I: Lab in Cell Biology & Developmental Biology, Genetics & Molecular Biology

COURSE OBJECTIVE

To provide hands-on training in microscopy, cytological techniques, genetic analysis, and basic molecular biology methods that reinforce the theoretical concepts covered in Cell Biology, Genetics and Molecular Biology.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Develop proficiency in microscopic techniques for the observation and identification of prokaryotic and eukaryotic cells, cellular organelles, and stages of mitosis and meiosis.	
LO2	Understand and examine key developmental processes by identifying embryonic stages and developmental patterns in model organisms using preserved specimens and microscopic observations.	
LO3	Apply cytogenetic techniques to visualize sex chromatin, construct human karyotypes, and identify common chromosomal abnormalities using laboratory and computational tools.	
LO4	Acquire practical skills in the isolation and purification of genomic and plasmid DNA from microbial and plant sources using standard molecular biology protocols	
LO5	Perform molecular biology techniques for nucleic acid quantification, quality assessment, separation, and amplification using spectrophotometry, agarose gel electrophoresis, and PCR.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Differentiate prokaryotic and eukaryotic cells, identify cellular structures, and recognize various stages of mitosis and meiosis through microscopic analysis.	K1 - Remember
CO2	Analyze embryonic developmental stages including cleavage, blastula, gastrula, neurula, and developmental progression in chick or zebrafish embryos..	K2 - Understand
CO3	Demonstrate the ability to prepare and interpret Barr body preparations and human karyotypes for the detection of normal and abnormal chromosomal constitutions.	K3 - Apply

CO4	Isolate genomic and plasmid DNA from bacterial and plant samples and check the effectiveness of nucleic acid extraction procedures.	K4 - Analyze
CO5	Quantify, analyze, and interpret DNA samples using spectrophotometry, agarose gel electrophoresis, and PCR-based amplification techniques	K5 - Evaluate
CO6	Standardize protocol for DNA/protein separation through agarose/PAGE electrophoresis	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Cell Biology** 1. Study of prokaryotic and eukaryotic cells using light microscopy (bacterial, plant and animal cells) 2. Preparation of temporary mounts of plant and animal cells 3. Measurement of cell size using ocular micrometer 4. Vital staining and observation of live cells	16
II	**Cell Division & Genetics** 5. Observation of mitotic stages in onion root tip squash preparation. 6. Study of meiosis in flower buds of onion (*Allium cepa*) or lily (*Lilium* sp.) or Study of meiosis in grasshopper testis (using permanent slides) 7. Study of polytene chromosomes in Drosophila salivary gland (using permanent slides) 8. Buccal smear preparation - Barr body study (sex chromatin in buccal epithelial cells)	16
III	**Genetics & Developmental Biology** 9. Monohybrid and dihybrid cross problems - Chi-square analysis 10. Study of *Drosophila melanogaster* - wild type/mutant identification 11. Human pedigree analysis exercises 12. Preparation of human karyotype and identification of chromosomal abnormalities using photographs/software tools 13. Identification and study of embryonic stages: cleavage, blastula, gastrula, and neurula using permanent slides/models 14. Observation of developmental stages in chick embryo or zebrafish embryo (preserved specimens/images)	8
IV	**Molecular Biology** 15. Isolation of genomic DNA from bacterial (*E. coli*)	12

	16. Isolation of genomic DNA from plant tissues (banana/ onion leaves) 17. Quantification of DNA by spectrophotometry 18. Isolation of RNA (Demonstration) 19. Purity and yield analysis of isolated nucleic acids	
V	20. Agarose gel electrophoresis of isolated DNA 21. Estimation of DNA fragment size using markers (using semi-log graph or Excel software tool) 22. SDS-PAGE - (Demonstration) 23. Documentation and interpretation of gel images using gel documentation system (Demonstration)	8
Total		**60**

Text Books	
1	K.V. Chaitanya, (2013), *Cell and molecular biology*: Lab manual, PHI publishers,. ISBN 978-81-203-800-4
2	J. Celis, (2005), *Cell biology: A laboratory handbook*, Academic Press, ISBN 978-01-216-4730-8
3	S. Gakhar, M. Miglani, A. Kumar, (2013), *Molecular biology: A laboratory manual*, I.K. International Publishing House, ISBN 978-93-823-3230-5
4	A. Nigam, A. Ayyagari, (2007), *Lab manual in biochemistry, immunology and biotechnology*, Tata McGraw-Hill Education, ISBN 978-00-706-1717-9
5	P. Gunasekaran, (2008), *Laboratory manual in microbiology*, New Age International Publishers, ISBN 978-81-224-0783-9
6	S.M. Reddy, S.R. Reddy, (2016), *Microbiology: A laboratory manual*, Scientific Publishers, ISBN 978-93-946-4551-6
Reference Books	
1	G. Karp, (2013), Cell and molecular biology: Concepts and experiments, John Wiley & Sons, ISBN 978-11-182-0673-7
2	D.L. Spector, R.D. Goldman, (2006), *Basic methods in microscopy: Protocols and concepts from cells: A laboratory manual*, Cold Spring Harbor Laboratory Press, ISBN 978-08-796-9751-8
3	M.R. Green, J. Sambrook, (2012), *Molecular cloning: A laboratory manual*, Cold Spring Harbor Laboratory Press, ISBN 978-19-361-1342-2
4	I. Ravi, M. Baunthiyal, J. Saxena, (2012), *Advances in biotechnology: A practical approach*, Springer Science & Business Media, ISBN 978-14-614-4905-8
5	J.G. Cappuccino, C.T. Welsh, (2019), *Microbiology: A laboratory manual*, Pearson Education, ISBN 978-01-351-8899-6
6	Michael J. Pelczar, E.C.S. Chan, N.R. Krieg, (1993), *Microbiology: Concepts and applications*, McGraw-Hill Publishers, ISBN 978-00-704-9258-

Web Resources	
1	https://dnalc.cshl.edu. DNA Learning Center (DNALC): Genetics, genomics, biotechnology, and molecular biology learning resources.
2	https://www.nature.com/scitable. Nature Scitable: Peer-reviewed educational content in life sciences and biotechnology.
3	https://www.vlab.co.in. Virtual Labs (VLab): Online practical simulations for microbiology and biotechnology experiments.
4	https://www.jove.com/education. JoVE Education: Video demonstrations of laboratory techniques and scientific experiments
5	https://www.biointeractive.org. HHMI BioInteractive: Interactive resources, animations, and virtual laboratories in biological sciences
6	https://ocw.mit.edu. MIT OpenCourseWare: Open-access course materials in biology and biotechnology
7	https://www. learn.genetics.utah.edu. Learn.Genetics (University of Utah): Interactive genetics and genomics educational modules
8	https://www.bio-rad.com/en-in/category/explorer-classroom-resources. Bio-Rad Explorer Classroom Resources: Biotechnology laboratory protocols and teaching resources

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Hands-on individual practice, Supervised bench work	Lab equipment, Microscopes, Reagents, Glassware
Unit 2	Pre-lab briefing, Demonstration by faculty	Lab manual, Charts, Models, Permanent slides, Images
Unit 3	Pre-lab briefing, Demonstration by faculty	Lab manual, Charts, Models, Permanent slides, Images
Unit 4	Group experimentation, Peer-checking of results	Instruments, Specimens, Cultures, Tissue samples
Unit 5	Group experimentation, Peer-checking of results	Gel documentation, Instruments, Specimens, Cultures, Chemicals and reagents

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - II
Part - III
Core – III: Microbiology

COURSE OBJECTIVE

To provide a thorough understanding of the diversity, structure, growth, and metabolism of microorganisms, and to introduce their industrial, environmental, and medical significance.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Understand the historical development, scope, classification, diversity, and microscopy techniques used in microbiology.	
LO2	Explain the ultrastructure, organization, and functions of prokaryotic cells and distinguish between different microbial groups	
LO3	Demonstrate knowledge of microbial cell structures, viruses, and various staining techniques used for identification and characterization of microorganisms.	
LO4	Analyze microbial nutrition, growth, cultivation, sterilization, preservation, and metabolic processes relevant to biotechnology applications	
LO5	Evaluate the role of microorganisms in industry, environment, food systems, and human health, including beneficial and pathogenic microorganisms	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the history, classification, nomenclature, diversity of microorganisms, and principles of different microscopy techniques	K1 - Remember
CO2	Illustrate the structure and functions of bacterial cellular components, including cell wall, membrane, capsule, flagella, pili, endospores, and ribosomes.	K2 - Understand
CO3	Perform staining techniques for microbial identification and diagnosis and differentiate major microbial groups.	K3 - Apply
CO4	Investigate the microbial nutritional requirements, growth dynamics, cultivation methods, sterilization procedures, and metabolic pathways including respiration and fermentation.	K4 - Analyze
CO5	Assess the applications of microorganisms in industrial production, environmental management, food microbiology, and understand the etiology and significance of major bacterial, viral, and fungal diseases affecting humans	K5 - Evaluate
CO6	Formulate applications of microorganisms in industry and the environment.	K6 - Create

COURSE CONTENT		
Unit	**Content**	**No. of Hours**
I	History and development of microbiology; Contributions of Antonie van Leeuwenhoek, Louis Pasteur, Robert Koch, and Alexander Fleming. Scope and branches of microbiology. Classification and nomenclature of microorganisms. General characteristics of Bacteria, Archaea, Fungi, Algae, Protozoa, and Viruses. Microscopy: Bright-field, Dark-field, Phase-contrast, Fluorescence, and Electron microscopy (SEM & TEM).	15
II	Prokaryotic cell organization: Ultrastructure and functions of bacterial cell wall (gram positive & gram negative), plasma membrane, capsule, flagella, pili, and endospores. Cytoplasmic inclusions and ribosomes.	15
III	Gram-positive and Gram-negative bacteria. Structure of fungal, algal, and protozoan cells. Structure and classification of viruses; plant virus, animal virus and bacteriophages. Stains and staining techniques: Principles and methods - simple staining, differential staining (Grams staining and Acid fast staining), negative staining, endospore staining, flagellar staining, cell wall staining, metachromatic granule staining, fluorescent staining and silver impregnation staining.	15
IV	Nutritional requirements of microorganisms. Culture media: Types, preparation, and applications. Microbial growth curve and factors affecting growth. Methods of microbial cultivation and preservation. Principle and applications of sterilization and disinfection methods (physical and chemical methods). Introduction to microbial metabolism: Aerobic and anaerobic respiration. Fermentation and industrial importance.	15
V	Industrial microbiology and microbial products: antibiotics, enzymes, organic acids and vaccines. Food microbiology and food spoilage. Water and air microbiology, environmental microbiology and bioremediation. Beneficial microorganisms. Pathogenic microorganisms causing human disease: Bacteria (tetanus, tuberculosis, pneumonia and cholera); Virus (common cold, influenza, COVID-19, hepatitis, HIV, rabies) Disease and fungi (candidiasis, aspergillosis, blastomycosis).	15
Total		**75**

Text Books

1	Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (1993). *Microbiology* (5th Ed.). Tata McGraw-Hill Education Pvt. Ltd., New Delhi.
2	Ananthanarayan, R., & Paniker, C.K.J. (2021). *Textbook of Microbiology* (11th Ed.). Universities Press (India) Pvt. Ltd., Hyderabad.

3	Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. (2021). *Brock Biology of Microorganisms* (16th Ed.). Pearson Education.
4	Willey, J.M., Sherwood, L.M., & Woolverton, C.J. (2020). *Prescott's Microbiology* (11th Ed.). McGraw-Hill Education.
5	Powar, C.B., & Daginawala, H.F. (2010). *General Microbiology* (2nd Revised Ed.). Himalaya Publishing House Pvt. Ltd., Mumbai.
Reference Books	
1	Tortora, G.J., Funke, B.R., & Case, C.L. (2019). *Microbiology: An Introduction* (13th Ed.). Pearson Education.
2	Moat, A.G., Foster, J.W., & Spector, M.P. (2002). *Microbial Physiology* (4th Ed.). Wiley-Liss, John Wiley & Sons.
3	Alcamo, I.E. (2001). *Fundamentals of Microbiology* (10th Ed.). Jones & Bartlett Learning.
4	Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A., & Mietzner, T.A. (2024). *Jawetz, Melnick & Adelberg's Medical Microbiology* (28th Ed.). McGraw-Hill Education.
5	Atlas, R.M., & Bartha, R. (1998). *Microbial Ecology: Fundamentals and Applications* (4th Ed.). Benjamin/Cummings Publishing Company.
Web Resources	
1	https://www.biointeractive.org. Animations for DNA replication, transcription, translation, PCR, and CRISPR-Cas9
2	https://www.ncbi.nlm.nih.gov/education. Tutorials, microbial databases, and microbiology learning resources
3	https://ocw.mit.edu (Course 7.01SC). Free microbiology and biological science course materials
4	https://nptel.ac.in. IIT and IISc lecture series on Microbiology, Microbial Physiology, and Biotechnology
5	https://www.khanacademy.org/science/ap-biology. Introductory microbiology and cell biology modules
6	https://www.nature.com/scitable. Peer-reviewed topic pages on genetics, cell biology, and molecular biology
7	https://learn.genetics.utah.edu. Educational resources from the American Society for Microbiology
8	https://www.labster.com. Virtual microbiology experiments and simulations
9	https://www.ensembl.org. Learning materials and microbiology updates
10	https://pubmed.ncbi.nlm.nih.gov. Research articles and microbiology literature

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - II
Part - III
Core Practical – II: Lab in Microbiology

COURSE OBJECTIVE

To provide practical training in aseptic technique, staining, culturing, and identification of microorganisms, reinforcing the theoretical concepts of Microbiology.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Understand microbiology laboratory safety practices, aseptic techniques, and sterilization procedures for handling microorganisms. Develop practical skills in the preparation of culture media, isolation, cultivation, and enumeration of microorganisms.	
LO2	Apply staining techniques and microscopic methods for the observation and identification of bacteria and fungi.	
LO3	Understand the motility of bacteria and analyze biochemical characteristics of bacteria	
LO4	Analyze microbial growth patterns and antimicrobial susceptibility tests for microbial characterization.	
LO5	Assess the microbiological quality of environmental samples such as water and soil.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Demonstrate laboratory safety, aseptic handling, and sterilization techniques in microbiological investigations. Prepare culture media, isolate pure microbial cultures, and quantify microbial populations using standard microbiological methods.	K1, K2 – Remember/ Understand
CO2	Perform staining procedures, microscopic examination, and understand the cellular morphological characteristics for microbial identification.	K3 - Apply
CO3	Investigate microbial characteristics through biochemical tests and motility characteristics of bacteria.	K4 - Analyze
CO4	To perform growth curve analysis and antibiotic sensitivity assays.	K5 - Evaluate
CO5	Conduct microbiological analysis of environmental samples and interpret experimental results using scientific reasoning and laboratory skills.	K6 - Create

COURSE CONTENT

Unit	**Content**	**No. of Hours**

I	1. Microbiology laboratory safety, biosafety practices, and aseptic techniques. 2. Preparation, sterilization, and quality control of culture media. 3. Isolation of microorganisms by streak plate, spread plate, and pour plate methods. 4. Enumeration of bacteria by serial dilution and viable plate count methods.	16
II	5. Observing cellular morphology of bacteria using: Simple staining, differential staining (Gram staining & Acid – Fast staining), negative staining, endospore and flagellar staining of bacteria. Colony morphology of bacteria. 6. Observation of fungal structures using Lactophenol Cotton Blue staining.	12
III	7. Motility determination of bacteria (Hanging drop method). 8. Biochemical characterization of bacteria (IMViC tests and catalase test).	12
IV	9. Antibiotic sensitivity testing by Kirby–Bauer disc diffusion method. 10. Determination of microbial growth curve.	12
V	11. Microbiological analysis of water by Most Probable Number (MPN) method. 12. Isolation and characterization of soil microorganisms (bacteria & fungi)	8
Total		**60**

Text Books

1	Willey, J.M., Sherwood, L.M., & Woolverton, C.J. (2020). *Prescott's Microbiology* 11th Edition. McGraw-Hill Education.
2	Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (1993). *Microbiology*. 5th Edition. Tata McGraw-Hill Education.
3	Madigan, M.T. et al. (2021). *Brock Biology of Microorganisms*. 16th Edition. Pearson Education.
4	Tortora, G.J., Funke, B.R., & Case, C.L. (2019). *Microbiology: An Introduction*. 13th Edition**.** Pearson Education.
5	Ananthanarayan, R., & Paniker, C.K.J. (2021). *Textbook of Microbiology*. 11th Edition. Universities Press.
6	Powar, C.B., & Daginawala, H.F. (2010). *General Microbiology*. 2nd Revised Edition. Himalaya Publishing House.

Reference Books

1	Cappuccino, J.G., & Sherman, N. (2020). *Microbiology: A Laboratory Manual* (12th Ed.). Pearson Education.
2	Leboffe, M.J., & Pierce, B.E. (2021). *Microbiology: Laboratory Theory and Application* (4th Ed.). Morton Publishing Company.

3	Brown, A.E. (2018). *Benson's Microbiological Applications: Laboratory Manual in General Microbiology* (14th Ed.). McGraw-Hill Education.
4	Dubey, R.C., & Maheshwari, D.K. (2002). *Practical Microbiology*. S. Chand Publishing.
5	Brown, A.E. (2018). *Microbiological Applications: Laboratory Manual in General Microbiology* (14th Ed.). McGraw-Hill Education.
6	Pepper, I.L., Gerba, C.P., & Gentry, T.J. (Eds.). (2015). *Manual of Environmental Microbiology* (4th Ed.). ASM Press.
Web Resources	
1	Virtual Labs (Microbiology) – Virtual microbiology experiments and laboratory simulations.
2	JoVE Education – Video demonstrations of microbiological techniques.
3	DNA Learning Center (DNALC) – Educational resources in microbiology, genetics, and biotechnology.
4	HHMI BioInteractive – Interactive animations, videos, and virtual laboratories.
5	MIT OpenCourseWare Biology Courses – Open-access biology and microbiology learning materials.
6	Bio-Rad Explorer Classroom Resources – Laboratory protocols and biotechnology teaching resources

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Pre-lab briefing, Demonstration by faculty, Individual hands on practice	Lab manual, Charts, Models, Lab equipment, Reagents, Glassware
Unit 2	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware
Unit 3	Hands-on individual practice, Group experimentation, Supervised bench work, Peer-checking of results	Instruments, Specimens, Cultures
Unit 4	Group experimentation, Supervised bench work, Peer-checking of results	Instruments, Specimens, Cultures
Unit 5	Group experimentation, Supervised bench work, Peer-checking of results	Instruments, Specimens, Cultures

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CLO1	2	2	1	3	2	1	3	3	-
CLO2	2	2	1	3	-	1	2	3	-
CLO3	2	3	1	3	-	1	3	3	-
CLO4	2	3	1	3	1	2	2	3	1
CLO5	2	3	2	3	3	2	2	3	1
TOTAL	**10**	**13**	**6**	**15**	**6**	**7**	**12**	**15**	**2**
AVERAGE	**2.0**	**2.6**	**1.2**	**3.0**	**1.2**	**1.4**	**2.4**	**3.0**	**0.4**

Semester - III
Part - III
Core – IV: Immunology & Immunotechnology

COURSE OBJECTIVE

To provide a foundational understanding of the components and mechanisms of the immune system, and to introduce the principles underlying immune disorders and immunodiagnostic techniques.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Understand fundamental concepts of Immunology,including innate and acquired immunity immune cells and lymphoid organs.	
LO2	Explain the structure and functions of antigens ,antibodies ,MHC molecules, cytokines and complement proteins involved in immune response.	
LO3	Demonstrate knowledge of antigen processsing and presentation and the development of B and T lymphocytes.	
LO4	Apply immunological technniques such as ELISA , RIA, Western blotting, immuno diffusion and immuno electrophoresis in research and diagnostics.	
LO5	Analyze antigen - antibody interaction and evaluate the role of vaccine ,monoclonal antibodies and cytokines in disease prevention and therapy.	
LO6	Interpret the mechanisms of hypersensitivity ,autoimmunity and transplantation immunity and their clinical significance.Develop problem - solving and research skills for immuno disorders and biomedical applications.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the structure and functions of the immune system, immune cells, lymphoid organs, antigens, and antibodies.	K1 - Remember
CO2	Explain the mechanisms of innate and adaptive immunity, antigen presentation, and complement pathways	K2 - Understand
CO3	Demonstrate the use of immunological techniques such as ELISA, immuno diffusion, and immuno electrophoresis for laboratory applications.	K3 - Apply
CO4	Differentiate various immune responses and analyze the roles of cytokines, vaccines, and immune mediators in health and disease	K4 - Analyze
CO5	Assess the immunological basis of hypersensitivity, autoimmune disorders, transplantation, and immunodeficiency diseases.	K5 - Evaluate

CO6	Design and propose immunological approaches for disease diagnosis, prevention, and therapeutic interventions. CO5	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	Introduction & Historical perspectives of Immunology, Theories of Immunity. Types of Immunity: Innate & Acquired; Active and Passive acquired immunity, Humoral & Cell mediated Immune response, Primary and Secondary Immune response. Cells involved in immune response, Organs of immune system: Primary, Secondary & Tertiary lymphoid organs. Hematopoiesis and Development of B and T Lymphocytes	12
II	Antigen: Characteristics and types, Haptens, Adjuvants. Antibody: Structure & Types of Immunoglobulin, properties, distribution and their biological Function. Production of monoclonal antibodies- Hybridoma technology: Applications of Monoclonal antibodies in biomedical research. MHC molecules: structure, types and functions. Antigen processing and presentation by MHC molecule. HLA tissue typing.	12
III	Antigen – Antibody interactions: Agglutination and precipitation reactions, Immunodiffusion and Immuno electrophoresis, Principle and application of ELISA, RIA, Fluorescent antibody technique, Western Blotting and Flow cytometry technique. Purification of antibodies.	12
IV	The complement system and activation and regulation. Types: Classical, alternative and Lectin pathway. Biological function of complement proteins. Cytokines- Structure, types and biological functions. Vaccines: Types, Production and application. Recent strategies in vaccine production.	12
V	Hypersensitivity Reactions: Types I, Type II, Type III and Type IV hypersensitivity reactions. Auto immunity and autoimmune disorders: Types and immune response. Transplantation immunology, Types of graft, Graft vs Host reaction mechanism of graft rejection, Immunosuppressive therapy, Organ transplantation. Tumor immunology: Oncogenes, Tumor antigens, immune response to tumors.	12
Total		**60**

Text Books

1	Jenni Punt, Sharon Stranford, Patricia Jones, Judy Owen (2019). **Kuby Immunology** (8th Edition), W.H. Freeman/Macmillan Learning.
2	Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt (2017). **Roitt's Essential Immunology** (13th Edition), Wiley-Blackwell.
3	Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai. **Cellular and Molecular Immunology** (10th Edition), Elsevier

4	Richard Coico, Geoffrey Sunshine. **Immunology** (6th Edition), Wiley-Blackwell Publisher.
5	Kenneth Murphy, Casey Weaver. **Janeway's Immunobiology** (9th Edition), Garland Science
Reference Books	
1	William E. Paul. **Fundamental Immunology** (7th Edition), Lippincott Williams & Wilkins
2	Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai. **Basic Immunology: Functions and Disorders of the Immune System** (6th Edition), Elsevier
3	Ian R. Tizard. **Immunology: An Introduction** (10th Edition), Cengage/Saunders
4	Edward A. Greenfield (Ed.), **Antibodies: A Laboratory Manual** (2nd Edition), Cold Spring Harbor Laboratory Press
5	David Male, Jonathan Brostoff, David B. Roth, Ivan Roitt. **Immunology** (8th Edition), Elsevier
6.	J.W. Goding, **Immunology** (3rd Edition), Academic Press
Web Resources	
1	**NCBI Bookshelf – Immunobiology (Janeway)**: https://www.ncbi.nlm.nih.gov/books/NBK27114/
2	**British Society for Immunology – Bitesized Immunology**: https://www.immunology.org/public-information/bitesized-immunology
3	**NPTEL – Basic Immunology**: https://onlinecourses.nptel.ac.in (search "Immunology" course listings)
4	**Cold Spring Harbor Protocols – Immunology**: https://www.cshprotocols.org/subjects/immunology
5	**American Association of Immunologists (AAI)**: https://www.aai.org
6	**Sino Biological – Immunology Resource Hub**: https://www.sinobiological.com/resource/immunology
7	**Thermo Fisher – Immunology Resource Center**: https://www.thermofisher.com/in/en/home/life-science/antibodies/immunology.html
8	**HHMI BioInteractive – Immune System Resources**: https://www.biointeractive.org

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models

Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - III
Part - III
Core – III: Practical III: Lab in Immunology & Immunotechnology

COURSE OBJECTIVE

To provide hands-on experience in immunological and immunodiagnostic techniques, reinforcing the theoretical concepts covered in Immunology.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To train students in blood collection and serum separation.	
LO2	To demonstrate agglutination and precipitation reactions.	
LO3	To familiarise students with ELISA-based diagnostic techniques.	
LO4	To demonstrate immunodiffusion techniques.	
LO5	To introduce differential leukocyte counting.	
LO6	To train students in interpretation of immunodiagnostic results.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Demonstrate blood collection and serum/plasma separation techniques.	K1 - Remember
CO2	Perform blood grouping and Rh typing by agglutination.	K2 - Understand
CO3	Apply the Widal test principle for antibody detection.	K3 - Apply
CO4	Demonstrate radial immunodiffusion/Ouchterlony double diffusion.	K4 - Analyze
CO5	Analyze antigen-antibody reactions using ELISA (demonstration).	K5 - Evaluate
CO6	Evaluate differential leukocyte count from a blood smear.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Serological techniques** 1. Separation of Serum and Plasma 2. RBC & WBC Counting using Haemocytometer 3. Differential Blood Count	12
II	**Agglutination based assay** 4. Blood Grouping and Rh Typing 5. Widal Slide test 6. ASO (Anti-Streptolysin O) test 7. CRP (C-Reactive Protein) test	12

	8. RPR (Rapid Plasma Reagin) test 9. Pregnancy test	
III	**Precipitation based assay** 10. Single Radial Immunodiffusion assay 11. Ouchterlony Double Immunodiffuion assay 12. Immunoelectrophoresis	12
IV	**Immuno assay** 13. ELISA (Demonstration) 14. Western Blotting (Demonstration)	12
V	**Animal handling and cell separation techniques** 15. Handling of Laboratory animals (Demonstration) 16. Isolation of Peripheral Blood Mononuclear Cells (PBMC) (Demonstration)	12
Total		**60**

Text Books	
1	Hay, F.C., & Westwood, O.M.R. (2002). *Practical Immunology* (4th ed.). Blackwell Science/Wiley-Blackwell.
2	Kaufman, S.H., Detrick, B., & Hamilton, R.G. *Practical Handbook of Immunology*. ASM Press.
3	Vinayak, V.K. *Practical Manual of Immunology*. ICMR Publication.
4	Chakravarty, A.K. *Laboratory Manual of Immunological Techniques*. CRC Press.
5	Sood, R. *Medical Laboratory Technology: A Procedure Manual for Routine Diagnostic Tests*. McGraw Hill Education.
6	Gupta, V. *Immunology: A Laboratory Manual*. CBS Publishers.
Reference Books	
1	Greenfield, E.A. (Ed.). (2013). *Antibodies: A Laboratory Manual* (2nd ed.). Cold Spring Harbor Laboratory Press.
2	Coligan, J.E., et al. (Eds.). *Current Protocols in Immunology*. Wiley.
3	Macey, M.G. (Ed.). *Flow Cytometry: Principles and Applications*. Humana Press.
4	Detrick, B., Hamilton, R.G., & Folds, J.D. (Eds.). *Manual of Clinical Laboratory Immunology* (7th ed.). ASM Press.
5	World Health Organization. (2003). *Manual of Basic Techniques for a Health Laboratory* (2nd ed.). WHO.
6	Hau, J., & Schapiro, S.J. (Eds.). *Handbook of Laboratory Animal Science* (3rd ed.). CRC Press
Web Resources	
1	WHO – Manual of Basic Techniques for a Health Laboratory: https://www.who.int
2	WHO – Manual of Basic Techniques for a Health Laboratory: https://www.who.int

3	Cold Spring Harbor Protocols – Immunology: https://www.cshprotocols.org/subjects/immunology
4	Bio-protocol – Immunology Techniques: https://bio-protocol.org
5	CPCSEA Guidelines for Laboratory Animal Handling (India): https://cpcsea.gov.in
6	Sigma-Aldrich/Merck – ELISA and Western Blotting Protocols: https://www.sigmaaldrich.com/IN/en/technical-documents
7	Abcam Protocols – Immunoassay and PBMC Isolation: https://www.abcam.com/protocols
8	Thermo Fisher – Protein and Antibody Techniques: https://www.thermofisher.com/in/en/home/life-science/protein-biology.html
9	CDC Laboratory Training – Serological Testing Procedures: https://www.cdc.gov/laboratory

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Pre-lab briefing, Demonstration by faculty, Individual hands on practice	Lab manual, Charts, Models, Lab equipment, Reagents, Glassware
Unit 2	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware
Unit 3	Group experimentation, Peer-checking of results	Lab equipment, Reagents, Glassware
Unit 4	Pre-lab briefing, Demonstration by faculty, Peer-checking	Lab equipment, Reagents, Glassware
Unit 5	Pre-lab briefing, Demonstration by faculty, Peer-checking	Lab equipment, Reagents, Glassware

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - III
Part - III
Elective - I: A. Bioinstrumentation

COURSE OBJECTIVE

To familiarize students with the principles, construction, and operation of instruments commonly used in biological research and diagnostic laboratories

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To introduce the principles of microscopy and cell fractionation.	
LO2	To explain the principles of centrifugation techniques.	
LO3	To describe spectroscopic methods of biomolecule analysis.	
LO4	To explain the principles of chromatographic separation techniques.	
LO5	To describe electrophoretic techniques and their applications.	
LO6	To familiarize students with pH, radioisotope, and other analytical instruments.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Describe the principles of light, phase-contrast, and electron microscopy.	K1 - Remember
CO2	Explain the principles and types of centrifugation techniques.	K2 - Understand
CO3	Apply spectroscopic principles to quantify biomolecules.	K3 - Apply
CO4	Analyse chromatographic techniques for separation of compounds.	K4 - Analyze
CO5	Evaluate electrophoretic techniques for macromolecule analysis.	K5 - Evaluate
CO6	Formulate appropriate instrumentation choices for a given biological analysis.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	General principles of instrumentation: sensitivity, accuracy, precision, calibration and errors; pH and buffers, Henderson-Hasselbalch equation, Calibration and measurement using pH meter; Principles of light, phase-contrast, fluorescence, confocal, scanning and transmission electron microscopy; principles of X-ray diffraction and its role in biomolecular structure determination	9
II	Spectroscopic Techniques: Beer-Lambert law and its deviations. UV-Visible spectrophotometry; Fluorescence spectroscopy; Infrared (IR) and FT-IR spectroscopy; Atomic absorption spectroscopy (AAS) and Flame	9

	photometry; NMR spectroscopy; Mass spectrometry (MALDI-TOF, ESI), Raman spectroscopy	
III	Chromatographic Techniques: Principles of paper and thin-layer chromatography (TLC); Column chromatography, Ion-exchange chromatography, Gel filtration/molecular sieve chromatography, Affinity chromatography; Gas chromatography (GC); High-performance liquid chromatography (HPLC) and its variants (RP-HPLC, GPC)	9
IV	Electrophoresis techniques: Paper electrophoresis, Agarose gel, PAGE (native and SDS-PAGE), isoelectric focusing and 2D-electrophoresis	9
V	Centrifugation: Principles and types of centrifugation, RCF & Sedimentation concepts, Types of rotors; Differential and Density gradient centrifugation, Ultracentrifugation. Radioisotopes in biology: Types of radiation, Detection (GM counter, scintillation counting), Autoradiography and safety in handling radioisotopes. Applications of radioisotopes in biology.	9
Total		**45**

Text Books

1	Wilson, K. and Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology (8th Edition). Cambridge University Press
2	Sharma, B.K.(2019). Instrumental Methods of Chemical Analysis (27th Edition). Goel Publishing House, Meerut
3	Veerakumari, L.(2020).Bioinstrumentation. (2nd Edition).MJP Publishers, Chennai
4	Chatwal, G.R. and Anand, S.K.(2017). Instrumental Methods of Chemical Analysis (5th Edition). Himalaya Publishing House, Mumbai
5	Skoog, D.A., Holler, F.J. and Crouch, S.R. (2017). Principles of Instrumental Analysis (7th Edition). Cengage Learning, Boston
6	Upadhyay, A., Upadhyay, K. and Nath, N. (2019). Biophysical Chemistry: Principles and Techniques (4th Edition). Himalaya Publishing House, Mumbai

Reference Books

1	Freifelder, D.(2016).Physical Biochemistry: Applications to Biochemistry and Molecular Biology (2nd Edition). W.H. Freeman & Co., New York
2	Cantor, C.R. and Schimmel, P.R. (2015). Biophysical Chemistry (Part II: Techniques for the Study of Biological Structure and Function (1st Edition). W.H. Freeman & Co., New York
3	Boyer, R.F.(2012).Modern Experimental Biochemistry (3rd Edition). Pearson Education, New Delhi
4	Plummer, D.T. (2017). An Introduction to Practical Biochemistry (3rd Edition). Tata McGraw Hill, New Delhi
5	Bloomfield, V.A., Crothers, D.M. and Tinoco, I.(2000). Nucleic Acids: Structures, Properties, and Functions (1st Edition). University Science Books, California

6	Gurumani, N. (2018). Research Methodology for Biological Sciences (3rd Edition). MJP Publishers, Chennai
Web Resources	
1	NPTEL – Biophysical and Structural Chemical BiologyIIT/NPTEL, Govt. of Indiahttps://nptel.ac.in
2	NPTEL – Cell Biology & Bioinstrumentation coursesIIT/NPTEL, Govt. of Indiahttps://nptel.ac.in
3	SwayamPrabha/SWAYAM Online Courses in Life SciencesMinistry of Education, Govt. of Indiahttps://swayam.gov.in
4	Khan Academy – Spectroscopy and Chemical AnalysisKhan Academyhttps://www.khanacademy.org
5	Thermo Fisher Scientific – Learning Center (Chromatography & Spectroscopy)Thermo Fisher Scientifichttps://www.thermofisher.com/in/en/home/references.ht
6	Bio-Rad Laboratories – Electrophoresis & Chromatography Learning ResourcesBio-Rad Laboratorieshttps://www.bio-rad.com
7	National Center for Biotechnology Information (NCBI) BookshelfNCBI, National Library of Medicine, USAhttps://www.ncbi.nlm.nih.gov/books
8	Board of Radiation and Isotope Technology (BRIT) – Radioisotope Applications & SafetyDepartment of Atomic Energy, Govt. of Indiahttps://britatom.gov.in

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester
Part - III
Elective – I: B. IPR, Bioethics & Biosafety

COURSE OBJECTIVE

To develop an understanding of intellectual property rights, bioethical principles, and biosafety regulations governing biotechnological research and its applications.

LEARNING OBJECTIVE:	
On successful completion of the course, students will be able to	
LO1	To introduce the fundamental concepts and types of Intellectual Property Rights relevant to biotechnology.
LO2	To familiarize students with the patenting process and patent-related case studies in the biotech sector.
LO3	To create awareness of bioethical principles and issues in biomedical and biotechnological research.
LO4	To explain biosafety regulations, containment levels and the institutional regulatory framework in India.
LO5	To develop an understanding of national and international regulatory frameworks governing GMOs, biopiracy and benefit sharing.

COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Explain the concept, types and significance of Intellectual Property Rights relevant to biotechnology.	K2 - Understand
CO2	Describe the patenting process and analyze case studies of biotechnology-related patent disputes.	K4 - Analyse
CO3	Discuss key bioethical issues arising in healthcare, research and biotechnology applications.	K2 - Understand
CO4	Explain biosafety regulations, containment levels and the institutional regulatory framework in India.	K2 - Understand
CO5	Evaluate national and international regulatory frameworks governing GMOs, biopiracy and benefit sharing.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	**Introduction to Intellectual Property Rights**: Concept, nature and significance of Intellectual Property Rights (IPR); Types of IP: patents, trademarks, copyrights and related rights, industrial designs, trade secrets,	9

	geographical indications, plant variety protection; International framework: WIPO, TRIPS Agreement, Paris Convention, Budapest Treaty; National IPR Policy of India (2016) and its objectives; Relevance and significance of IPR to biotechnology research and innovation; IPR management in academic institutions and R&D organisations.	
II	**Patents and the Patenting Process** The Indian Patent Act, 1970 and subsequent amendments; patentable and non-patentable subject matter; Patentability criteria: novelty, inventive step, industrial applicability; Patenting of biological material, micro-organisms and living inventions; Budapest Treaty on deposit of micro-organisms; Patent application process: filing, examination, publication, grant; Patent Cooperation Treaty (PCT); Patent infringement, licensing and compulsory licensing; Case studies: Basmati rice, turmeric and neem patent disputes; biopiracy and traditional knowledge protection.	9
III	**Bioethics**: Concept, scope and evolution of bioethics; Bioethics in healthcare: patient confidentiality, informed consent, euthanasia, assisted reproductive technologies, prenatal diagnosis; Bioethics in research: human and animal experimentation, animal rights and welfare, clinical trial ethics; Ethical issues in cloning, stem cell research, gene therapy and genetic screening; Ethical concerns in genetically modified organisms, foods and crops; ICMR National Ethical Guidelines for Biomedical and Health Research involving human participants (overview)	9
IV	**Concept and scope of biosafety**: biosafety levels (BSL 1 to 4) and containment facilities. Recombinant DNA Safety Guidelines by Department of Biotechnology, Government of India. Regulatory framework in India: Institutional Biosafety Committee (IBSC), Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Appraisal Committee (GEAC), State Biotechnology Coordination Committee (SBCC). Biosafety in genetically modified crops and food; environmental risk assessment. Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP). Handling, transport and disposal of hazardous biological materials.	9
V	**International Regulatory Frameworks and Case studies**: Cartagena Protocol on Biosafety and the Convention on Biological Diversity (CBD). OECD Consensus Documents and Codex Alimentarius guidelines on GM food safety. GM food labelling regulations: Food Safety and Standards Authority of India (FSSAI). Biopiracy, access and benefit sharing - the Nagoya Protocol. Comparative overview of biosafety and bioethics regulation: India, USA and the European Union. Case studies: Bt cotton, Golden Rice, and public perception of GM technology.	9
Total		**45**

Text Books	
1	Sateesh, M.K. (2008). Bioethics and Biosafety. 1st Edition, I.K. International Publishing House, New Delhi.
2	Sreekrishna, V. (2007). Bioethics and Biosafety in Biotechnology. (1st Edition). New Age International Publishers, New Delhi.
3	Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. Tata McGraw-Hill, New Delhi.
Reference Books	
1	Kuhse, H. & Singer, P. (2006). (Eds.). Bioethics: An Anthology. (2nd Edition), Wiley-Blackwell, Malden, MA.
2	Recombinant DNA Safety Guidelines, Department of Biotechnology, Ministry of Science and Technology, Government of India.
3	National IPR Policy (2016) Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry, Government of India.
4	Cartagena Protocol on Biosafety to the Convention on Biological Diversity, Secretariat of the Convention on Biological Diversity.
5	Narayanan, P. Patent Law. 4th Edition, Eastern Law House, Kolkata.
Web Resources	
1	**Intellectual Property India, Office of the CGPDTM.** https://ipindia.gov.in. Official portal for patent, trademark, design and GI filing and search relevant to Units I & II.
2	**Department of Biotechnology (DBT), Government of India.** https://dbtindia.gov.in. Recombinant DNA Safety Guidelines, biosafety regulations and biotechnology policy documents relevant to Unit IV.
3	**WIPO — World Intellectual Property Organization.** https://www.wipo.int. International treaties (TRIPS, Paris Convention, Budapest Treaty) and IP education resources relevant to Unit I.
4	**Convention on Biological Diversity (CBD) Secretariat.** https://www.cbd.int. Text and resources on the Cartagena Protocol on Biosafety and the Nagoya Protocol relevant to Unit V.
5	**Food Safety and Standards Authority of India (FSSAI).** https://www.fssai.gov.in. Regulations on GM food labelling and safety assessment relevant to Units IV & V.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models

Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**
CLO1	3	2	1	2	1	2	3	1
CLO2	3	3	2	2	1	2	3	2
CLO3	2	2	3	3	2	3	2	3
CLO4	2	2	3	2	2	2	3	2
CLO5	2	3	3	3	3	3	3	3
TOTAL	12	12	12	12	9	12	14	11
AVERAGE	2.4	2.4	2.4	2.4	1.8	2.4	2.8	2.2

Semester - III
Part - IV
Skill Enhancement Course - I: Medical Lab Technology (MLT) & Good Laboratory Practices (GLP)

COURSE OBJECTIVE

To equip students with practical skills and knowledge of medical laboratory organization, common diagnostic procedures, quality control, and good laboratory practices required for clinical laboratory employment.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**	
LO1	To introduce the organisation and functioning of a clinical laboratory.
LO2	To explain sample collection, handling, and processing procedures.
LO3	To describe routine haematological and clinical biochemistry tests.
LO4	To explain principles of quality control and quality assurance.
LO5	To familiarise students with biomedical waste management.
LO6	To introduce Good Laboratory Practice (GLP) standards and accreditation.

COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the organisation, sections, and workflow of a clinical laboratory.	K1 - Remember
CO2	Explain correct procedures for sample collection and preservation.	K2 - Understand
CO3	Apply knowledge of routine haematological and biochemical tests.	K3 - Apply
CO4	Analyse quality control charts and error sources in laboratory testing.	K4 - Analyze
CO5	Evaluate biomedical waste segregation and disposal practices.	K5 - Evaluate
CO6	Formulate a laboratory workflow compliant with GLP/NABL standards.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	Clinical/Medical laboratory: definition, organization, sections and workflow Laboratory design, layout and infrastructure requirements as per clinical laboratory standards. Sample collection, labelling, transport and preservation of blood, urine, stool, sputum and CSF; pre-analytical, analytical and post-analytical phases. Laboratory safety: biosafety levels (BSL 1-4), PPE,	6

	standard precautions and biomedical waste management (categories and colour coding).	
II	Clinical biochemistry: estimation of blood glucose, urea, creatinine, bilirubin and lipid profile; overview of LFT and RFT. Hematology: complete blood count (CBC) - hemoglobin estimation, RBC and WBC counts, differential count. ESR, PCV (hematocrit) and blood indices (MCV, MCH, MCHC); blood smear preparation and staining. Coagulation studies: bleeding time, clotting time, PT and APTT - principle and clinical significance.	6
III	Clinical microbiology workflow: specimen collection, culture media and sterilization; Gram staining and AFB staining. Culture and identification of common bacterial pathogens; antibiotic susceptibility testing (Kirby-Bauer disc diffusion method). Serology and immunodiagnostics: agglutination tests and rapid card tests. Quality control in microbiology: reference strains, media QC and biosafety cabinet practices.	6
IV	Histopathology: tissue fixation, processing, sectioning (microtomy) and routine H&E staining. Cytology: FNAC and Pap smear preparation, staining and screening for cervical abnormalities. Blood banking: ABO and Rh blood grouping, cross-matching and donor screening (TTI testing). Blood components (PRBC, FFP, platelets); transfusion reactions - types and management.	6
V	Good Laboratory Practices (GLP): definition, scope and OECD GLP principles; Standard Operating Procedures (SOPs) and documentation. Quality control (QC) and quality assurance (QA): internal quality control (IQC) and external quality assessment (EQAS). Laboratory accreditation: introduction to NABL and ISO 15189:2012 for medical laboratories. Bioethics, informed consent and data integrity (ALCOA principles) in laboratory and clinical research. Laboratory audits, inspections, corrective and preventive action (CAPA), non-conformance reporting and continual quality improvement.	6
Total		**30**

Text Books

1	Ramnik Sood (2020) Medical Laboratory Technology: Methods and Interpretations (7th Edition) Jaypee Brothers Medical Publishers, New Delhi
2	Godkar, P.B. and Godkar, D.P. (2014). Textbook of Medical Laboratory Technology (3rd Edition). Bhalani Publishing House, Mumbai
3	Mukherjee, K.L. (2017). Medical Laboratory Technology: A Procedure Manual for Routine Diagnostic Tests (Vol. I–III) (2nd Edition). Tata McGraw Hill, New Delhi
4	Chawla, R. (2014). Practical Clinical Biochemistry: Methods and Interpretations (4th Edition) Jaypee Brothers Medical Publishers, New Delhi

5	Baker, F.J., Silverton, R.E. and Pallister, C.J. (2001). Baker & Silverton's Introduction to Medical Laboratory Technology (7th Edition). Bounty Press/Arnold, London
6	Collins, C.H., Lyne, P.M., Grange, J.M. and Falkinham, J.O. (2004). Collins and Lyne's Microbiological Methods (8th Edition). Arnold Publishers/CRC Press, London
Reference Books	
1	Dacie, J.V. and Lewis, S.M. (Bain, B.J., Bates, I. and Laffan, M.A., Eds.). (2016). Dacie and Lewis Practical Haematology (12th Edition). Elsevier, London
2	Mackie, T.J. and McCartney, J.E. (Collee, J.G. et al., Eds.). (2006).Mackie & McCartney Practical Medical Microbiology (14th Edition). Churchill Livingstone/Elsevier, London
3	Bancroft, J.D. and Layton, C.(2018).Bancroft's Theory and Practice of Histological Techniques (8th Edition). Elsevier, London
4	Cheesbrough, M.(2006).District Laboratory Practice in Tropical Countries (Part 1 & 2) (2nd Edition). Cambridge University Press, Cambridge
5	Hoffbrand, A.V. and Moss, P.A.H.(2019). Essential Haematology (7th Edition). Wiley-Blackwell, Oxford.
6	Turgeon, M.L. (2016).Linne & Ringsrud's Clinical Laboratory Science: Concepts, Procedures and Clinical Applications (7th Edition). Elsevier/Mosby, St. Louis
Web Resources	
1	NABL – National Accreditation Board for Testing and Calibration LaboratoriesQuality Council of Indiahttps://www.nabl-india.org
2	ISO 15189:2012 – Medical Laboratories: Requirements for Quality and CompetenceInternational Organization for Standardizationhttps://www.iso.org
3	OECD Principles of Good Laboratory PracticeOrganisation for Economic Co-operation and Developmenthttps://www.oecd.org
4	Biomedical Waste Management Rules and GuidelinesCentral Pollution Control Board, Govt. of Indiahttps://cpcb.nic.in
5	NPTEL – Medical Laboratory Technology / Clinical Biochemistry coursesIIT/NPTEL, Govt. of Indiahttps://nptel.ac.in
6	World Health Organization – Laboratory Biosafety ManualWorld Health Organizationhttps://www.who.int
7	National AIDS Control Organisation – Blood Transfusion Services GuidelinesNACO, Ministry of Health & Family Welfare, Govt. of Indiahttps://naco.gov.in
8	Lab Tests Online – Understanding Laboratory TestsAmerican Association for Clinical Chemistry (AACC)https://labtestsonline.org

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts

Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - IV
Part - III
Core – V: Genetic Engineering

COURSE OBJECTIVE

To provide students with a thorough understanding of the principles, tools, and techniques of recombinant DNA technology and their applications in biotechnology.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To introduce the historical development and scope of genetic engineering.	
LO2	To describe the enzymes and vectors used in recombinant DNA technology.	
LO3	To explain methods of gene cloning and library construction.	
LO4	To describe techniques for gene transfer into host cells.	
LO5	To explain methods of screening and expression of cloned genes.	
LO6	To familiarise students with applications of genetic engineering.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Describe the historical milestones and scope of genetic engineering.	K1 - Remember
CO2	Explain the role of restriction enzymes, ligases, and cloning vectors.	K2 - Understand
CO3	Apply principles of gene cloning to construct genomic and cDNA libraries.	K3 - Apply
CO4	Analyse methods of gene transfer into prokaryotic and eukaryotic hosts.	K4 - Analyze
CO5	Evaluate techniques for screening and expression of recombinant clones.	K5 - Evaluate
CO6	Formulate applications of genetic engineering in medicine and agriculture.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Introduction & basic concepts**: History & scope of genetic engineering and recombinant DNA technology. Natural gene transfer systems: transformation, conjugation, transduction. Applications of genetic engineering: medical, agricultural, industrial, environmental biotechnology.	12
II	**Tools of genetic engineering**: DNA manipulation enzymes - Restriction endonucleases, DNA ligases, polymerases, nucleases, reverse transcriptase,	12

	alkaline phosphatase, linkers and adaptors. **Vectors**: Plasmids, bacteriophages (e.g., λ), cosmids, phagemids, BACs, YACs, shuttle vectors, replacement vectors and expression vectors. **Cloning hosts**: *E. coli* and other bacteria, yeast, plant and animal cells as hosts. Reporter and selectable markers.	
III	**Gene cloning strategies & analysis:** Construction of recombinant DNA: Restriction–ligation cloning, cohesive and blunt ends, TA cloning, directional cloning. Construction of genomic and cDNA libraries; expression libraries**.**	12
IV	**Transformation and transfection methods**: Chemical methods ($CaCl_2$), electroporation, microinjection, lipofection, viral vectors. **Screening and selection of recombinants**: Blue–white screening, antibiotic selection, colony hybridization, PCR-based screening. **Analysis of recombinant clones**: Restriction mapping, Southern, Northern, and Western blotting (principle and applications), DNA sequencing methods (Sanger's and Next Generation Sequencing)	12
V	**Genome mapping and molecular markers:** RFLP, RAPD, AFLP, microsatellites, SNP markers, applications in trait mapping and diagnostics. Genome editing: Principles of site-directed mutagenesis and modern genome editing tools, especially CRISPR-Cas systems, and their applications in model organisms, agriculture, and medicine. Ethical, legal, and social issues in Genetic engineering.	12
Total		**60**

Text Books

1	Primrose, S.B. and Twyman, R.M.2006Principles of Gene Manipulation and Genomics7th EditionBlackwell Publishing, Oxford
2	Brown, T.A.2020Gene Cloning and DNA Analysis: An Introduction8th EditionWiley-Blackwell, Oxford
3	Glick, B.R., Pasternak, J.J. and Patten, C.L.2017Molecular Biotechnology: Principles and Applications of Recombinant DNA5th EditionASM Press, Washington D.C.
4	Sandhya Mitra2018Genetic Engineering: Principles and Practice2nd EditionMacmillan Publishers India, New Delhi
5	Chawla, H.S.2018Introduction to Plant Biotechnology3rd EditionCRC Press/Science Publishers, New Delhi
6	Ranga, M.M.2019Genetic Engineering3rd EditionAgrobios (India), Jodhpur

Reference Books

1	Sambrook, J. and Russell, D.W.(2001). Molecular Cloning: A Laboratory Manual (Vol. I–III)(3rd Edition). Cold Spring Harbor Laboratory Press, New York

2	Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R.(2013). Molecular Biology of the Gene (7th Edition). Pearson/Cold Spring Harbor Laboratory Press, New York
3	Old, R.W. and Primrose, S.B.(1994). Principles of Gene Manipulation: An Introduction to Genetic Engineering (5th Edition). Blackwell Scientific Publications, Oxford
4	Winnacker, E.L.(1987). From Genes to Clones: Introduction to Gene Technology (1st Edition) VCH Publishers, Weinheim
5	Lewin, B. (Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T., Eds.(2018). Lewin's Genes XII (12th Edition). Jones & Bartlett Learning, Burlington
6	Singh, B.D. and Singh, A.K. (2019). Marker-Assisted Plant Breeding: Principles and Practices (2nd Edition). Springer, New Delhi
Web Resources	
1	NPTEL – Genetic Engineering and Recombinant DNA Technology courses IIT/NPTEL, Govt. of India https://nptel.ac.in
2	Addgene – Plasmid Repository and Cloning Education Resources Addgene, Cambridge, MA https://www.addgene.org
3	New England Biolabs (NEB) – Restriction Enzymes and Molecular Cloning Resources New England Biolabs Inc. https://www.neb.com
4	National Center for Biotechnology Information (NCBI) Bookshelf NCBI, National Library of Medicine, USA https://www.ncbi.nlm.nih.gov/books
5	Department of Biotechnology (DBT) – Guidelines for Genetic Engineering & Biosafety DBT, Ministry of Science & Technology, Govt. of India https://dbtindia.gov.in
6	Genetic Engineering Appraisal Committee (GEAC) – Regulatory Framework Ministry of Environment, Forest and Climate Change, Govt. of India https://geacindia.gov.in
7	Broad Institute – CRISPR/Cas9 Genome Engineering Resources Broad Institute of MIT and Harvard https://www.broadinstitute.org
8	SWAYAM – Online Courses in Molecular Biology & Genetic Engineering Ministry of Education, Govt. of India https://swayam.gov.in

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts

Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester -IV
Part - III
Core Practical – IV: Lab in Genetic Engineering

COURSE OBJECTIVE

To provide hands-on training in recombinant DNA techniques, including plasmid isolation, restriction digestion, PCR, and transformation, reinforcing the concepts of Genetic Engineering.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To train students in isolation and quantification of plasmid DNA.	
LO2	To demonstrate restriction digestion and ligation techniques.	
LO3	To familiarise students with the polymerase chain reaction.	
LO4	To train students in bacterial transformation techniques.	
LO5	To demonstrate screening of recombinant colonies.	
LO6	To introduce basic bioinformatics tools for sequence analysis.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Perform isolation and quantification of plasmid DNA.	K1 - Remember
CO2	Demonstrate restriction digestion and analysis by gel electrophoresis.	K2 - Understand
CO3	Apply PCR technique for amplification of a target DNA sequence.	K3 - Apply
CO4	Perform bacterial transformation using competent cells.	K4 - Analyze
CO5	Analyse recombinant colonies through blue-white screening.	K5 - Evaluate
CO6	Evaluate DNA sequences using basic bioinformatics tools.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	1. Isolation of genomic DNA from bacteria 2. Isolation of genomic DNA from plant tissue 3. Isolation of genomic DNA from animal tissue 4. Quality assessment of genomic DNA (A260/280). 5. Agarose gel electrophoresis of genomic DNA	12
II	6. Isolation of plasmid DNA from bacteria and analysis by agarose gel electrophoresis. 7. Restriction digestion of plasmid DNA and analysis of fragments by gel electrophoresis. 8. Ligation of an insert into plasmid vector	12

III	9. Preparation of competent *E. coli* cells (chemical method) and transformation with plasmid DNA 10. Screening of transformants using antibiotic selection and blue–white screening.	12
IV	11. Southern Blotting (Demo) 12. PCR amplification of a target gene and analysis using agarose gel electrophoresis (Demo)	12
V	13. In silico restriction mapping, primer design, basic CRISPR guide design using online tools	12
Total		**60**

Text Books	
1	Sambrook, J. and Russell, D.W. (2001). Molecular Cloning: A Laboratory Manual (Vol. I–III) (3rd Edition). Cold Spring Harbor Laboratory Press, New York.
2	Ausubel, F.M., Brent, R., Kingston, R.E., Moore, D.D., Seidman, J.G., Smith, J.A. and Struhl, K. (2002) Short Protocols in Molecular Biology (5th Edition). John Wiley & Sons, New York
3	Wilson, K. and Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology. (8th Edition). Cambridge University Press
4	Green, M.R. and Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual (4th Edition, Vol. I–III) (4th Edition) Cold Spring Harbor Laboratory Press, New York
5	Brown, T.A. (2020). Gene Cloning and DNA Analysis: An Introduction. (8th Edition). Wiley-Blackwell, Oxford
6	Rapley, R. (Ed.) (2000). The Nucleic Acid Protocols Handbook (1st Edition). Humana Press, New Jersey
Reference Books	
1	Primrose, S.B. and Twyman, R.M.(2006). Principles of Gene Manipulation and Genomics (7th Edition). Blackwell Publishing, Oxford
2	Old, R.W. and Primrose, S.B.(1994). Principles of Gene Manipulation: An Introduction to Genetic Engineering (5th Edition). Blackwell Scientific Publications, Oxford
3	Southern, E.M. (2006). Southern Blotting and Microarrays (Methods in Molecular Biology series contributions) (1st Edition). Humana Press, New Jersey
4	Dieffenbach, C.W. and Dveksler, G.S. (Eds.) (2003).PCR Primer: A Laboratory Manual (2nd Edition) Cold Spring Harbor Laboratory Press, New York
5	Glick, B.R., Pasternak, J.J. and Patten, C.L. (2017). Molecular Biotechnology: Principles and Applications of Recombinant DNA (5th Edition). ASM Press, Washington D.C.
6	Surzycki, S.(2000). Basic Techniques in Molecular Biology (1st Edition). Springer-Verlag, Berlin
Web Resources	

1	New England Biolabs (NEB) – Protocols for Restriction Digestion, Ligation and TransformationNew England Biolabs Inc.https://www.neb.com
2	Addgene – Plasmid Cloning and Bacterial Transformation ProtocolsAddgene, Cambridge, MAhttps://www.addgene.org
3	Thermo Fisher Scientific – Molecular Biology Protocols and GuidesThermo Fisher Scientifichttps://www.thermofisher.com
4	NCBI Primer-BLAST – Online Primer Design ToolNational Center for Biotechnology Information, USAhttps://www.ncbi.nlm.nih.gov/tools/primer-blast
5	NEBcutter – Online Restriction Mapping ToolNew England Biolabs Inc.https://nc3.neb.com
6	Benchling – CRISPR Guide RNA Design and Molecular Biology ToolsBenchling Inc.https://www.benchling.com
7	NPTEL – Recombinant DNA Technology and Genetic Engineering Lab coursesIIT/NPTEL, Govt. of Indiahttps://nptel.ac.in
8	Cold Spring Harbor Laboratory (CSHL) – DNA Learning Center ProtocolsCold Spring Harbor Laboratoryhttps://www.dnalc.org

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Pre-lab briefing, Demonstration by faculty, Hands-on individual practice, Supervised bench work	Lab manual, Charts, Models, Lab equipment, Reagents, Glassware, cultures & samples
Unit 2	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware
Unit 3	Group experimentation, Peer-checking of results	Instruments, Specimens, reagents, glassware
Unit 4	Demonstration by faculty incharge, result analysis	Instruments, Specimens, reagents, glassware, Observation records, Sample reports
Unit 5	Individual hands on practice in Bioinformatics insilico analysis	On line tools, internet connection.

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - IV
Part - III
Elective – II: A. Bioinformatics & AI in Biotechnology

COURSE OBJECTIVE

This course builds on the foundations of bioinformatics and extends them into the rapidly growing domain of Artificial Intelligence (AI) and Machine Learning (ML) as applied to biological data. Students will first strengthen their understanding of biological databases, sequence alignment and structural bioinformatics, before progressing to the core concepts of machine learning, deep learning and their transformative applications in genomics, protein structure prediction, drug discovery and precision medicine. The course is designed to equip students with the computational and analytical skills required to work at the interface of biotechnology and AI-driven research and industry.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To introduce the scope and applications of bioinformatics in biological research.	
LO2	To familiarize students with major biological databases and data retrieval systems.	
LO3	To provide hands-on understanding of sequence alignment algorithms and tools.	
LO4	To explain the principles of genome annotation, protein structure prediction, molecular phylogenetics and evolutionary analysis	
LO5	To develop understanding of the fundamental concepts of artificial intelligence and machine learning and develop an understanding of the ethical and practical considerations of applying AI in biotechnology.	
LO6	To explain the applications of AI and deep learning in genomics, protein structure prediction and drug discovery	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	List the major biological databases and their applications in bioinformatics.	K1 - Remember
CO2	Explain the principles of pairwise and multiple sequence alignment and database search tools.	K2 - Understand
CO3	Apply genome annotation and protein structure prediction methods to biological data.	K3 - Apply
CO4	Analyze biological datasets using machine learning algorithms such as classification and clustering.	K4 - Analyze
CO5	Evaluate the role of deep learning tools such as AlphaFold in protein structure prediction and drug discovery.	K5 - Evaluate
CO6	Design AI-assisted workflows for genomic and biomedical data analysis, considering ethical implications.	K6 - Create

COURSE CONTENT		
Unit	**Content**	**No. of Hours**
I	**Introduction to Bioinformatics**: Scope, history and applications of bioinformatics, nucleotide sequence databases - GenBank, EMBL, DDBJ, protein sequence databases - SwissProt, PIR, structural databases - PDB, data retrieval systems - Entrez and SRS.	9
II	**Sequence Alignment**: Concepts of homology and similarity, pairwise sequence alignment - Needleman-Wunsch and Smith-Waterman algorithms, scoring matrices - PAM and BLOSUM, multiple sequence alignment using CLUSTAL, database similarity search tools - BLAST and FASTA.	9
III	**Genome and Proteome Analysis**: Gene prediction methods, open reading frame (ORF) analysis, genome annotation, levels of protein structure, secondary structure prediction methods, homology modeling, Ramachandran plot and structure validation. Molecular Phylogenetics: Concepts of molecular evolution, phylogenetic tree construction methods - UPGMA, Neighbor-Joining, Maximum Parsimony and Maximum Likelihood, tree visualization tools, concept of molecular clock.	9
IV	**Artificial Intelligence and Machine Learning**: Introduction to artificial intelligence, machine learning and deep learning, types of machine learning - supervised, unsupervised and reinforcement learning; Basics of artificial neural networks, introduction to Python-based ML libraries (scikit-learn, TensorFlow) for biological data analysis.	9
V	**AI Applications in Biotechnology** Structural bioinformatics and protein-ligand docking; Deep learning-based protein structure prediction - AlphaFold and RoseTTAFold, Computer-aided drug design & AI in computer-aided drug discovery and virtual screening, generative AI models (GANs, transformers, large language models) for protein and molecule design, AI-driven analysis of Next Generation Sequencing (NGS) data, Applications of AI in precision medicine and genomic diagnostics, ethical, data privacy and bias considerations in AI-driven biological research.	9
Total		**45**

Text Books	
1	Rastogi, S.C., Mendiratta, N. and Rastogi, P. (2019).Bioinformatics: Methods and Applications - Genomics, Proteomics and Drug Discovery (5th Edition). PHI Learning Pvt. Ltd., New Delhi
2	Attwood, T.K., Pettifer, S. and Thorne, D. (2016). Bioinformatics Challenges at the Interface of Biology and Computer Science (1st Edition). Wiley-Blackwell, Oxford

3	Lesk, A.M. (2019). Introduction to Bioinformatics (5th Edition). Oxford University Press, Oxford
4	Ghosh, Z. and Mallick, B. 2008. Bioinformatics: Principles and Applications. Oxford University Press.
5	Jones, N.C. and Pevzner, P.A. 2004. An Introduction to Bioinformatics Algorithms. MIT Press
6	Xiong, J. (2006). Essential Bioinformatics (1st Edition). Cambridge University Press, Cambridge
Reference Books	
1	Mount, D.W. (2004). Bioinformatics: Sequence and Genome Analysis (2nd Edition). Cold Spring Harbor Laboratory Press, New York
2	Baxevanis, A.D. and Ouellette, B.F.F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (3rd Edition). John Wiley & Sons, New York
3	Higgs, P.G. and Attwood, T.K. (2005). Bioinformatics and Molecular Evolution (1st Edition). Blackwell Publishing, Oxford
4	Pevsner, J. 2015. Bioinformatics and Functional Genomics (3rd Edition). Wiley-Blackwell.
5	Mitchell, T.M. 1997. Machine Learning. McGraw-Hill.
Web Resources	
1	https://www.ncbi.nlm.nih.gov — National Center for Biotechnology Information (NCBI)
2	https://www.ebi.ac.uk — European Bioinformatics Institute (EMBL-EBI)
3	https://blast.ncbi.nlm.nih.gov/Blast.cgi — BLAST: Basic Local Alignment Search Tool (NCBI)
4	https://alphafold.ebi.ac.uk — AlphaFold Protein Structure Database (EMBL-EBI / DeepMind)
5	https://www.rcsb.org — RCSB Protein Data Bank (PDB)
6	https://nptel.ac.in — NPTEL: National Programme on Technology Enhanced Learning
7	https://www.tensorflow.org — TensorFlow: An End-to-End Machine Learning Platform
8	https://www.nature.com/subjects/machine-learning — Nature: Machine Learning Subject Portal

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models, e-learning resources and NPTEL / MOOC video lectures

Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos, bioinformatics software and online tools (BLAST, CLUSTAL),
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts, Python/Jupyter Notebook demonstrations, online simulations
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations, online tools (AlphaFold),

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**
CLO1	3	1	2	3	1	2	3	1
CLO2	1	2	3	1	2	3	1	2
CLO3	3	1	2	3	1	2	3	1
CLO4	1	2	3	1	2	3	1	2
CLO5	2	3	1	2	3	1	2	3
CLO6	3	1	2	3	1	2	3	1
Total	**13**	**10**	**13**	**13**	**10**	**13**	**13**	**10**
Average	**2.1**	**1.6**	**2.1**	**2.1**	**1.6**	**2.1**	**2.1**	**1.6**

Semester- IV
Part - III
Elective – II: B. Nanobiotechnology

COURSE OBJECTIVE

This course introduces students to the rapidly emerging interdisciplinary field of Nanobiotechnology, which integrates the principles of nanotechnology with biological systems. The course covers the fundamentals of nanoscale science, synthesis and characterization of nanomaterials, and their diverse applications in medicine, agriculture, food and environmental sectors. Emphasis is placed on nanomedicine, nanodiagnostics and the emerging regulatory and ethical dimensions of nanobiotechnology, equipping students with the conceptual and applied knowledge required for careers in nanoscience-driven biotechnology research and industry.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To introduce the fundamental concepts and scale of nanoscience and nanotechnology.	
LO2	To familiarize students with the various methods of synthesis of nanomaterials.	
LO3	To provide knowledge on characterization techniques used for nanomaterials.	
LO4	To explain the role of nanomaterials in drug delivery and nanomedicine.	
LO5	To create awareness on applications of nanobiotechnology in agriculture, food and environment.	
LO6	To develop an understanding of the ethical, safety and regulatory aspects of nanotechnology.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Define the basic concepts, scale and dimensions of nanoscience and nanotechnology.	K1 - Remember
CO2	Explain the physical, chemical and biological methods of nanoparticle synthesis.	K2 - Understand
CO3	Apply appropriate characterization techniques to analyze nanomaterials.	K3 - Apply
CO4	Analyze the role of nanomaterials in targeted drug delivery and nanodiagnostics.	K4 - Analyze
CO5	Evaluate the applications and impact of nanobiotechnology in agriculture, food and environmental remediation.	K5 - Evaluate
CO6	Develop nanotechnology-based solutions considering ethical, safety and regulatory guidelines.	K6 - Create
COURSE CONTENT		

Unit	Content	No. of Hours
I	**Introduction to Nanotechnology** History and evolution of nanotechnology, nanoscience vs nanotechnology, scale and dimensions of the nanoworld, classification of nanomaterials - nanoparticles, nanotubes, nanowires, quantum dots and dendrimers, size-dependent properties of nanomaterials, top-down and bottom-up approaches to nanofabrication.	9
II	**Synthesis of Nanomaterials** Physical methods - ball milling, laser ablation, sputtering; chemical methods - sol-gel, chemical reduction, hydrothermal synthesis; biological (green) synthesis of nanoparticles using plants, bacteria, fungi and algae; synthesis of gold, silver, and metal oxide nanoparticles.	9
III	**Characterization of Nanomaterials** Principles and applications of UV-Visible spectroscopy, Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS) and zeta potential analysis.	9
IV	**Nanomedicine and Nanodiagnostics** Nanoparticles as carriers for drug delivery - liposomes, dendrimers, polymeric and magnetic nanoparticles; nanotechnology in cancer diagnosis and therapy; quantum dots in bioimaging; nanobiosensors; theranostics; principles of nanotoxicology.	9
V	**Applications and Emerging Trends** Nanobiotechnology in agriculture - nanofertilizers and nanopesticides; applications in food packaging and preservation; nanobioremediation of pollutants; nanotechnology in cosmetics; intellectual property rights, safety and regulatory issues in nanobiotechnology.	9
Total		**45**

Text Books

1	Goodsell, D.S. 2004. Bionanotechnology: Lessons from Nature. Wiley-Liss.
2	Niemeyer, C.M. and Mirkin, C.A. 2004. Nanobiotechnology: Concepts, Applications and Perspectives. Wiley-VCH.
3	Mansoori, G.A. 2005. Principles of Nanotechnology. World Scientific Publishing
4	Malsch, N.H. 2005. Biomedical Nanotechnology. CRC Press.
5	Niemeyer, C.M. 2007. Nanobiotechnology II: More Concepts and Applications. Wiley-VCH.

Reference Books

1	Ratner, M. and Ratner, D. 2003. Nanotechnology: A Gentle Introduction to the Next Big Idea. Prentice Hall.
2	Kumar, C.S.S.R. 2005. Nanotechnologies for the Life Sciences. Wiley-VCH.
3	Bhushan, B. 2010. Springer Handbook of Nanotechnology (3rd Edition). Springer.
4	Vollath, D. 2013. Nanomaterials: An Introduction to Synthesis, Properties and Applications (2nd Edition). Wiley-VCH.
5	Ahmed, W. and Jackson, M.J. 2016. Nanofabrication: Techniques and Principles. Elsevier.
Web Resources	
1	https://www.nano.gov — National Nanotechnology Initiative (U.S. Government)
2	https://www.nature.com/subjects/nanobiotechnology — Nature: Nanobiotechnology Subject Portal
3	https://www.ncbi.nlm.nih.gov/pmc/ — PubMed Central (PMC): Free Full-Text Biomedical Literature Archive
4	https://nptel.ac.in — NPTEL: National Programme on Technology Enhanced Learning
5	https://www.sciencedirect.com/journal/nano-today — Nano Today (ScienceDirect/Elsevier Journal)
6	https://www.rsc.org/journals-books-databases/ — Royal Society of Chemistry: Journals, Books & Databases
7	https://www.dst.gov.in — Department of Science and Technology, Government of India
8	https://www.who.int/health-topics/nanotechnology — World Health Organization: Nanotechnology Health Topic Page

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3
CLO1	3	1	2	3	1	2	3	1
CLO2	2	2	3	1	2	2	1	2
CLO3	3	2	2	3	1	2	3	1
CLO4	1	2	2	1	2	3	1	2
CLO5	2	3	1	2	3	1	2	3
CLO6	3	1	2	3	1	2	3	1
Total	**14**	**11**	**12**	**13**	**10**	**12**	**13**	**10**
Average	**2.3**	**1.8**	**2.0**	**2.1**	**1.6**	**2.0**	**2.1**	**1.6**

Semester - IV
Part - IV
Skill Enhancement Course – II: Clinical Research, Regulatory Affairs & Good Manufacturing Practices (GMP)

COURSE OBJECTIVE

To introduce students to the principles of clinical research, drug development, regulatory affairs, and good manufacturing practices essential for careers in the pharmaceutical and biotechnology industry.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**	
LO1	To introduce the drug discovery and development process and the phases and designs of clinical trials.
LO2	To familiarize students with the ethical and regulatory requirements for conducting clinical trials.
LO3	To explain the regulatory framework and drug approval process in India and major global markets.
LO4	To develop an understanding of Good Manufacturing Practices and quality systems in pharmaceutical and biotech manufacturing.
LO5	To build foundational skills for careers in clinical research, regulatory affairs and quality assurance.

COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Explain the drug development process and the phases and designs of clinical trials.	K2 - Understand
CO2	Describe the ethical and regulatory requirements for the conduct of clinical trials as per ICH-GCP and Indian guidelines.	K2 - Understand
CO3	Outline the regulatory framework and drug approval process in India and other major regulatory jurisdictions.	K2 - Understand
CO4	Apply the principles of Good Manufacturing Practices to pharmaceutical and biotech manufacturing processes.	K3 - Apply
CO5	Distinguish Quality Assurance and Quality Control functions and outline documentation and audit practices used in the industry.	K4 - Analyse

COURSE CONTENT

Unit	**Content**	**No. of Hours**

I	**Introduction to Clinical Research**: Overview of the drug discovery and development process, Pre-clinical development: pharmacology and toxicology studies. Phases of clinical trials: Phase I, II, III and IV — objectives and design. Clinical trial designs: randomised controlled trials, parallel-group, cross-over, cohort and case-control studies. Key stakeholders: sponsor, investigator, Contract Research Organisation (CRO), Clinical Research Associate (CRA), monitor. Career pathways in clinical research: CRA, CRC, data management and biostatistics roles	6
II	**Clinical Trial Managament and Ethics**: ICH Harmonised Guideline for Good Clinical Practice E6(R2): principles and scope. Institutional Ethics Committee / Institutional Review Board: composition, functions and registration. Informed consent process and documentation. Clinical trial protocol, Investigator's Brochure and Case Report Forms (CRF). Pharmacovigilance: adverse event and serious adverse event reporting; Pharmacovigilance Programme of India (PvPI). Roles and responsibilities of investigators, sponsors and monitors in trial conduct.	6
III	**Regulatory Affairs:** Regulatory authorities: CDSCO and DCGI (India), US FDA, EMA; role of ICH. New Drugs and Clinical Trials Rules, 2019 — key provisions and Ethics Committee requirements. Regulatory submissions: Investigational New Drug (IND), New Drug Application (NDA), Abbreviated New Drug Application (ANDA). Common Technical Document (CTD) and electronic CTD (eCTD) format. Drug approval process in India: overview of timelines and licensing authority. Overview of biosimilars: definition, development pathway and regulatory requirements.	6
IV	**Good Manufacturing Practices (GMP):** Concept and principles of Good Manufacturing Practices. Schedule M of the Drugs and Cosmetics Rules, 1945 — an overview. WHO Good Manufacturing Practices guidelines. Quality Management System: documentation, Standard Operating Procedures (SOPs), batch manufacturing records. Facility design, personnel hygiene and environmental control in manufacturing. Equipment qualification and process validation — an overview.	6
V	**Quality Assurance, Quality Control and Industry Practices:** Quality Assurance (QA) versus Quality Control (QC) in the pharmaceutical and biotech industry. Overview of Good Laboratory Practices (GLP). Internal audits, self-inspection and regulatory inspections. Deviation management, Corrective and Preventive Action (CAPA) and Out-of-Specification (OOS) handling. Documentation practices: Good Documentation Practices (GDocP). Emerging skill requirements and career opportunities in clinical research, regulatory affairs and quality functions.	6
Total		**30**

Text Books	
1	Chowdary, K.P.R. A Textbook of Clinical Research and Pharmacovigilance. 1st Edition, Pharmamed Press, Hyderabad, 2021.
2	Pisano, D.J. & Mantus, D.S. (Eds.). FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices and Biologics. 3rd Edition, CRC Press, Boca Raton, 2014.
3	Willig, S.H. Good Manufacturing Practices for Pharmaceuticals: A Plan for Total Quality Control from Manufacturer to Consumer. 5th Edition, CRC Press / Marcel Dekker, New York, 2000.
Reference Books	
1	ICH Harmonised Tripartite Guideline for Good Clinical Practice E6(R2), International Council for Harmonisation (ICH).
2	New Drugs and Clinical Trials Rules, 2019, Central Drugs Standard Control Organisation (CDSCO), Ministry of Health and Family Welfare, Government of India.
3	National Ethical Guidelines for Biomedical and Health Research Involving Human Participants, Indian Council of Medical Research (ICMR), New Delhi, 2017.
4	WHO Expert Committee on Specifications for Pharmaceutical Preparations — WHO Good Manufacturing Practices, World Health Organization Technical Report Series.
5	Schedule M, Drugs and Cosmetics Rules, 1945, Government of India.
Web Resources	
1	**Central Drugs Standard Control Organisation (CDSCO).** https://cdsco.gov.in. New Drugs and Clinical Trials Rules 2019, regulatory guidance and approval status relevant to Unit III.
2	**International Council for Harmonisation (ICH).** https://www.ich.org. ICH-GCP E6(R2) guideline and other harmonised technical guidelines relevant to Unit II.
3	**Indian Council of Medical Research (ICMR).** https://www.icmr.gov.in. National Ethical Guidelines for Biomedical and Health Research relevant to Unit II.
4	**U.S. Food and Drug Administration (US FDA).** https://www.fda.gov. IND, NDA and ANDA submission requirements and drug approval process relevant to Unit III
5	**World Health Organization — Prequalification & GMP.** https://www.who.int. WHO GMP guidelines and prequalification programme documents relevant to Unit IV.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models

Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**
CLO1	2	2	1	2	1	2	3	2
CLO2	2	2	2	3	2	3	3	2
CLO3	3	2	2	2	2	2	3	2
CLO4	2	3	3	2	2	2	3	3
CLO5	2	3	3	2	3	2	3	3
TOTAL	11	12	11	11	10	11	15	12
AVERAGE	2.2	2.4	2.2	2.2	2	2.2	3	2.4

Semester - V

Part - III

Core – VI: Human Anatomy & Physiology

COURSE OBJECTIVE

To provide students with a comprehensive understanding of the structural organization and physiological functioning of the human body systems

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**	
LO1	To provide a systematic understanding of the structural organization of the human body.
LO2	To explain the physiological functioning of each organ system and their interrelationships.
LO3	To correlate anatomical structure with physiological function in maintaining homeostasis.
LO4	To build a foundation for advanced courses in medical biotechnology, physiology and clinical research.
LO5	To develop the ability to interpret physiological parameters relevant to diagnostic and clinical biotechnology applications

COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Recall the basic organisation of cells, tissues, organs and organ systems of the human body.	K1 - Remember
CO2	Explain the structure and physiological function of the skeletal, muscular and digestive systems.	K2 - Understand
CO3	Describe the working of the circulatory, respiratory and excretory systems.	K2 - Understand
CO4	Analyse the coordinated functioning of the nervous and endocrine systems in homeostasis.	K4 - Analyze
CO5	Evaluate the physiological basis of reproduction and immunity in the human body.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	**Levels of structural organization of human body:** Cell to organism; **Histology and Histopathology**: Epithelial, connective, muscular and nervous tissues; tissue repair and regeneration; Histopathological changes and terminology; Body cavities and anatomical terminology. Homeostasis -	15

	concept and regulatory mechanisms. **Integumentary System** – structure and functions of skin; epidermis, dermis and hypodermis; accessory organs; burns, ulcers, dermatitis and wound healing	
II	**Skeletal System:** Axial and appendicular skeleton; structure and classification of bones; bone development; joints and movements; common skeletal disorders: fractures, osteoporosis, osteoarthritis and rheumatoid arthritis. **Muscular System:** Types of muscles; skeletal muscle structure; sliding filament mechanism; neuromuscular junction; major muscle groups; muscular disorders including muscular dystrophy, myositis and tendinitis.	15
III	**Circulatory Systems:** Blood composition and functions; ABO and Rh blood groups; hematopoiesis; hemostasis and coagulation. **Cardiovascular System**: anatomy of heart; cardiac cycle; cardiac output; conduction system; ECG basics; coronary circulation; regulation of blood pressure. **Blood Vessels and Circulation**: arteries, veins and capillaries; systemic and pulmonary circulation; hypertension and atherosclerosis. **Respiratory System**: anatomy of respiratory tract; structure of lungs; mechanics of breathing; pulmonary ventilation; gas exchange; transport of oxygen and carbon dioxide; regulation of respiration. Respiratory Disorders – asthma, COPD, pneumonia, tuberculosis, pulmonary embolism and lung cancer.	15
IV	**Nervous Systems:** Nervous Tissue- neuron structure and function; neuroglial cells; nerve impulse conduction; synaptic transmission; neurotransmitters. Central Nervous System – cerebrum, cerebellum, diencephalon, brainstem and spinal cord; meninges; cerebrospinal fluid; blood-brain barrier. Peripheral and Autonomic Nervous Systems – cranial nerves; spinal nerves; sympathetic and parasympathetic systems; reflex action and reflex arc. **Sensory Organs** – eye and vision; ear and hearing; vestibular apparatus; smell and taste receptors; sensory pathways.	15
V	**Digestive System:** Digestive System – anatomy of alimentary canal; salivary glands; liver; gall bladder; pancreas. Physiology of Digestion – digestion and absorption of carbohydrates, proteins and lipids; gastrointestinal hormones; gut microbiota. Liver Functions – metabolism; detoxification; bile secretion; storage functions. Gastrointestinal Disorders – GERD, peptic ulcer, Crohn's disease, ulcerative colitis, hepatitis, cirrhosis and colorectal cancer. **Renal System**: kidney anatomy; nephron structure; urine formation; concentration and dilution of urine; acid-base balance; fluid and electrolyte regulation; RAAS mechanism; renal disorders and dialysis.	15
Total		**75**

Text Books

1	Waugh A. & Grant A. (2018). Ross and Wilson Anatomy and Physiology in Health and Illness (13th Edition). Elsevier, London.

2	Chatterjee C.C. (2016). Human Physiology (Vol. I & II) (11th Edition). CBS Publishers, New Delhi.
3	Tortora G.J. & Derrickson B. (2017). Principles of Anatomy and Physiology (15th Edition). Wiley, Hoboken
4	Ross M.H. & Pawlina W. (2019). Histology: A Text and Atlas (8th Edition). Wolters Kluwer, Philadelphia.
5	Vander A.J., Sherman J.H. & Luciano D.S. (2011). Vander's Human Physiology: The Mechanisms of Body Function (12th Edition). McGraw-Hill, New York.
6	Standring S. (Ed.) (2020). Gray's Anatomy: The Anatomical Basis of Clinical Practice (42nd Edition). Elsevier, London.
Reference Books	
1	Guyton A.C. & Hall J.E. (2020). Textbook of Medical Physiology (14th Edition). Elsevier, Philadelphia.
2	Sembulingam K. & Sembulingam P. (2019). Essentials of Medical Physiology (8th Edition). Jaypee Brothers Medical Publishers, New Delhi.
3	Wilson K.J.W. (2010). Ross and Wilson's Anatomy and Physiology in Health and Illness (11th Edition). Churchill Livingstone, Edinburgh
4	Snell R.S. (2018). Clinical Anatomy by Regions (10th Edition). Wolters Kluwer, Philadelphia.
5	Widmaier E.P., Raff H. & Strang K.T. (2018). Vander's Human Physiology: The Mechanisms of Body Function (14th Edition). McGraw-Hill, New York.
6	Junqueira L.C. & Mescher A.L. (2018). Junqueira's Basic Histology: Text and Atlas (15th Edition). McGraw-Hill, New York.
Web Resources	
1	NPTEL - Human Physiology: https://nptel.ac.in
2	Khan Academy - Human Anatomy and Physiology: https://www.khanacademy.org
3	National Library of Medicine, NIH: https://www.ncbi.nlm.nih.gov
4	Visible Body - 3D Human Anatomy and Physiology Atlas: https://www.visiblebody.com
5	TeachMeAnatomy - Anatomy Reference Resource: https://teachmeanatomy.info
6	InnerBody Research - Interactive Anatomy Guide: https://www.innerbody.com
7	OpenStax Anatomy and Physiology (Free Open Access Textbook): https://openstax.org
8	Physiology Web - Physiology Learning Resources: https://www.physiologyweb.com

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models

Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	2	1	2	1	1	1	2	1	1	1
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	12	8	11	8	7	8	12	8	8	8
AVERAGE	2.4	1.6	2.2	1.6	1.4	1.6	2.4	1.6	1.6	1.6

Semester - V
Part - III
Core – VII: Plant Biotechnology

COURSE OBJECTIVE

To introduce students to the principles and techniques of plant tissue culture, genetic transformation and molecular breeding for crop improvement.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To introduce the principles and techniques of plant tissue culture.	
LO2	To familiarize students with methods of genetic transformation in plants.	
LO3	To explain the applications of molecular markers in plant improvement.	
LO4	To create awareness of the commercial and agricultural applications of plant biotechnology.	
LO5	To create an understanding of the regulatory and biosafety aspects of genetically modified plants.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	State the fundamental principles of plant tissue culture and totipotency.	K1 - Remember
CO2	Explain methods of micropropagation, organogenesis and somatic embryogenesis.	K2 - Understand
CO3	Apply protoplast isolation and somatic hybridisation techniques.	K3 – Apply
CO4	Analyse methods of genetic transformation used to develop transgenic plants.	K4 – Analyze
CO5	Evaluate the applications of molecular markers and GM crops in agriculture.	K5 – Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	**Fundamentals of Plant Tissue Culture:** History and scope of plant biotechnology; Concept of totipotency and dedifferentiation; Laboratory organization and aseptic techniques; Nutrient media - composition and preparation (MS, B5); Plant growth regulators and their role in culture.	12
II	**Micropropagation and Morphogenesis:** Defintion, Stages of micropropagation, Organogenesis - direct and indirect, Somatic embryogenesis, Anther and pollen culture - haploid production;	12

	Somaclonal variation; Synthetic seed production and germplasm conservation.	
III	**Protoplast Culture and Somatic Hybridization:** Isolation and culture of protoplasts; Methods of protoplast fusion; Somatic hybrids and cybrids; Selection of hybrid cells; Applications of somatic hybridization.	12
IV	**Genetic Transformation in Plants:** Agrobacterium-mediated gene transfer - Ti plasmid; Direct gene transfer methods - particle bombardment, electroporation; Vectors used in plant transformation; Selectable and screenable marker genes; Confirmation of transgenics - PCR, Southern blotting.	12
V	**Molecular Markers and Applications:** RFLP, RAPD, AFLP and SSR markers; Marker-assisted selection in crop improvement. DNA barcoding. Transgenic crops - Bt cotton, herbicide-tolerant crops. Plantibodies. Molecular farming and secondary metabolite production. Genetically engineered plants conferring resistance to biotic and abiotic stress. Development of GM foods. Biosafety regulations for GM crops.	12
Total		**60**

Text Books

1	Chawla H.S. (2009). Introduction to Plant Biotechnology (3rd Edition). Science Publishers, Enfield.
2	Razdan M.K. (2003). Introduction to Plant Tissue Culture (2nd Edition). Science Publishers, Enfield.
3	Purohit S.S. (2005). Plant Tissue Culture (1st Edition). Agrobios, Jodhpur.
4	Ignacimuthu S. (2020). Plant Biotechnology (3rd Edition). Oxford & IBH Publishing, New Delhi.
5	Jha T.B. & Ghosh B. (2005). Plant Tissue Culture: Basic and Applied (1st Edition). Universities Press, Hyderabad.
6	Chandra S., Bandopadhyay R. & Kumar V. (Eds.) (2020). Plant Biotechnology: Progress in Genomic Era (1st Edition). Springer, Singapore.

Reference Books

1	Slater A., Scott N. & Fowler M. (2008). Plant Biotechnology: The Genetic Manipulation of Plants (2nd Edition). Oxford University Press, Oxford.
2	Singh B.D. (2015). Biotechnology: Expanding Horizons (4th Edition). Kalyani Publishers, New Delhi.
3	Bhojwani S.S. & Razdan M.K. (1996). Plant Tissue Culture: Theory and Practice (Revised Edition). Elsevier, Amsterdam.
4	Trigiano R.N. & Gray D.J. (Eds.) (2011). Plant Tissue Culture, Development, and Biotechnology (1st Edition). CRC Press, Boca Raton.

5	Christou P. & Klee H. (Eds.) (2004). Handbook of Plant Biotechnology (1st Edition). John Wiley & Sons, Chichester.
6	Chrispeels M.J. & Sadava D.E. (2003). Plants, Genes, and Crop Biotechnology (2nd Edition). Jones & Bartlett Publishers, Boston.
Web Resources	
1	NPTEL - Plant Biotechnology: https://nptel.ac.in
2	ISAAA - Global Status of GM Crops: https://www.isaaa.org
3	PubMed - Plant Biotechnology Journal articles: https://pubmed.ncbi.nlm.nih.gov
4	American Society of Plant Biologists (ASPB): https://aspb.org
5	Plantae - Global Plant Science Community: https://plantae.org
6	FAO - Biotechnology in Food and Agriculture: https://www.fao.org
7	USDA - Agricultural Biotechnology Information: https://www.usda.gov
8	Indian Council of Agricultural Research (ICAR): https://icar.org.in

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	13	9	11	9	8	9	13	9	9	9
AVERAGE	2.6	1.8	2.2	1.8	1.6	1.8	2.6	1.8	1.8	1.8

Semester - V
Part - III
Core – VIII: Animal Biotechnology

COURSE OBJECTIVE

To provide students with knowledge of animal cell culture, transgenic technology and reproductive biotechnology and their applications in medicine and research

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To provide knowledge of animal cell culture techniques and cell line maintenance.	
LO2	To explain methods for the production of transgenic animals.	
LO3	To familiarize students with modern reproductive biotechnologies.	
LO4	To highlight applications of animal biotechnology in medicine and research.	
LO5	To provide insight into cloning technologies used in animal biotechnology.	
LO6	To develop an awareness of the ethical and regulatory issues associated with animal biotechnology research.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Describe the basic principles of animal cell culture and cell lines.	K1 - Remember
CO2	Explain techniques used for primary and continuous cell culture.	K2 - Understand
CO3	Apply methods for producing transgenic animals and knockouts.	K3 – Apply
CO4	Analyse assisted reproductive technologies such as IVF and cloning.	K4 – Analyze
CO5	Evaluate applications of animal biotechnology in biopharming and disease diagnostics.	K5 – Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	**Fundamentals of Animal Cell Culture:** History and scope of animal biotechnology; Culture media and supplements - serum and serum-free media, Fetal bovine serum; Balanced salt solutions and buffering systems; Laboratory design and equipment for cell culture; Types of animal cell culture - primary, secondary, continuous culture. Biology of cultured cells.	12
II	**Cell Culture Techniques:** Disaggregation of tissue and primary culture initiation; Sub-culturing and cell line maintenance; Cell counting and	12

	viability assays; Cryopreservation and cell banking; Contamination and quality control in culture.	
III	**Transgenic Animal Technology:** Methods of gene transfer - microinjection, retroviral vectors; Embryonic stem cell-mediated gene transfer. Gene knockout and knock-in technology. Applications of transgenic mice in research. Ethical considerations in transgenic animal production.	12
IV	**Reproductive Biotechnology:** Superovulation and in vitro fertilisation (IVF); Embryo transfer technology; Somatic cell nuclear transfer and animal cloning; Sperm sexing and artificial insemination; Applications in livestock improvement.	12
V	**Applications of Animal Biotechnology:** Animal models of human disease; Biopharming: Production of therapeutic proteins; Culture scale up and mass production (Upstream processing); Harvesting and recovery of products, separation, purification and formulation (downstream processing); *Invitro* testing of drugs, Hybridoma technology and monoclonal antibodies and its applications; Diagnostic applications - ELISA, immunoassays. Biosafety, Ethics and Regulations in Animal Biotechnology.	12
Total		**60**

Text Books

1	Ignacimuthu S. (2019). Animal Biotechnology (2nd Edition). Alpha Science International, Oxford...
2	Singh B.D. (2015). Biotechnology: Expanding Horizons (4th Edition). Kalyani Publishers, New Delhi..
3	Gordon I. (2003). Laboratory Production of Cattle Embryos (2nd Edition). CABI Publishing, Wallingford.
4	Pinkert C.A. (Ed.) (2014). Transgenic Animal Technology: A Laboratory Handbook (3rd Edition). Academic Press, San Diego.
5	Verma A.K. (2015). Animal Biotechnology: Models in Discovery and Translation (1st Edition). Academic Press, San Diego.

Reference Books

1	Renneberg R. (2007). Biotechnology for Beginners (1st Edition). Academic Press, San Diego.
2	Primrose S.B. & Twyman R.M. (2006). Principles of Gene Manipulation and Genomics (7th Edition). Blackwell Publishing, Oxford
3	Butler M. (2004). Animal Cell Culture and Technology (2nd Edition). BIOS Scientific Publishers, Oxford
4	Niemann H. & Wrenzycki C. (Eds.) (2018). Animal Biotechnology 1: Reproductive Biotechnologies (1st Edition). Springer, Cham.

5	Freshney R.I. (2015). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (7th Edition). Wiley-Blackwell, Hoboken.
6	Houdebine L.M. (2003). Animal Transgenesis and Cloning (1st Edition). John Wiley & Sons, Chichester.
Web Resources	
1	NPTEL - Animal Biotechnology: https://nptel.ac.in
2	American Type Culture Collection (ATCC): https://www.atcc.org
3	NCBI - Animal Biotechnology resources: https://www.ncbi.nlm.nih.gov
4	International Embryo Technology Society (IETS): https://www.iets.org
5	USDA Animal and Plant Health Inspection Service: https://www.aphis.usda.gov
6	The Roslin Institute - Animal Biotechnology Research: https://www.ed.ac.uk/roslin
7	European Society for Domestic Animal Reproduction (ESDAR): https://www.esdar.org
8	Journal of Animal Science and Biotechnology (Open Access): https://jasbsci.biomedcentral.com

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	13	9	11	9	8	9	13	9	9	9
AVERAGE	2.6	1.8	2.2	1.8	1.6	1.8	2.6	1.8	1.8	1.8

Semester - V

Part - III

Core Practical - V: Lab in Plant Biotechnology

COURSE OBJECTIVE

To provide hands-on training in plant tissue culture, micropropagation and molecular techniques used in plant biotechnology

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**	
LO1	To provide hands-on training in aseptic techniques and plant tissue culture media preparation.
LO2	To train students in micropropagation and regeneration methods.
LO3	To develop practical skills in plant genomic DNA isolation and PCR-based analysis.
LO4	To familiarize students with Agrobacterium-mediated transformation procedures.
LO5	To develop competence in the aseptic maintenance and sub-culturing of plant tissue culture cultures.
LO6	To train students in the basic documentation and reporting of plant biotechnology laboratory experiments.

COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Prepare plant tissue culture media and perform sterilisation procedures.	K3 - Apply
CO2	Demonstrate callus induction and shoot/root regeneration from explants.	K3 - Apply
CO3	Perform isolation of genomic DNA from plant tissue.	K3 - Apply
CO4	Carry out PCR-based molecular marker analysis.	K4 - Analyze
CO5	Demonstrate Agrobacterium-mediated gene transfer in a model plant system.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	1. Preparation of Murashige and Skoog stock solution and culture medium 2. Surface sterilization of plant explants (leaf, node, shoot tip) and inoculation under aseptic conditions	12
II	3. Callus induction from leaf/nodal explants using different combinations of auxin & cytokinin	12

	4. Suspension culture initiation from callus 5. Direct and indirect organogenesis - shoot and root regeneration	
III	6. Micropropagation through axillary bud/shoot tip culture 7. Hardening and acclimatization of regenerated plantlets	12
IV	8. Isolation of genomic DNA from plant tissue 9. Agarose gel electrophoresis of isolated DNA 10. PCR amplification and RAPD analysis (Demonstration)	12
V	11. Isolation of protoplasts from leaf tissue 12. Synthetic seed preparation of somatic embryos/ shoot buds 13. Separation of chlorophyll pigments using Column chromatography 14. Estimation of chlorophyll content in plant tissue	12
Total		**60**

Text Books

1	Razdan M.K. (2003). Introduction to Plant Tissue Culture (2nd Edition). Science Publishers, Enfield.
2	Sambrook J. & Russell D.W. (2001). Molecular Cloning: A Laboratory Manual (3rd Edition). Cold Spring Harbor Laboratory Press, New York.
3	Purohit S.S. (2005). Plant Tissue Culture (1st Edition). Agrobios, Jodhpur.
4	Dixon R.A. & Gonzales R.A. (Eds.) (1994). Plant Cell Culture: A Practical Approach (2nd Edition). IRL Press/Oxford University Press, Oxford.
5	Trigiano R.N. & Gray D.J. (Eds.) (2016). Plant Tissue Culture, Development, and Biotechnology (1st Edition). CRC Press, Boca Raton.

Reference Books

1	Bhojwani S.S. & Razdan M.K. (1996). Plant Tissue Culture: Theory and Practice (Revised Edition). Elsevier, Amsterdam.
2	Dodds J.H. & Roberts L.W. (1995). Experiments in Plant Tissue Culture (3rd Edition). Cambridge University Press, Cambridger
3	Chawla H.S. (2009). Introduction to Plant Biotechnology: A Practical Manual (3rd Edition). Science Publishers, Enfield.
4	Slater A., Scott N. & Fowler M. (2008). Plant Biotechnology: The Genetic Manipulation of Plants (2nd Edition). Oxford University Press, Oxford.
5	Gamborg O.L. & Phillips G.C. (Eds.) (1995). Plant Cell, Tissue and Organ Culture: Fundamental Methods (1st Edition). Springer, Berlin.
6	George E.F., Hall M.A. & De Klerk G.J. (2008). Plant Propagation by Tissue Culture (3rd Edition). Springer, Dordrecht.

Web Resources

1	NPTEL - Plant Tissue Culture Techniques: https://nptel.ac.in
2	Bio-protocol - Plant Biology protocols: https://bio-protocol.org
3	PlantCellTechnology resource guides: https://www.plantcelltechnology.com

4	Plant Tissue Culture Protocols - Cold Spring Harbor Protocols: https://cshprotocols.cshlp.org
5	JoVE - Plant Biology Video Protocols: https://www.jove.com
6	Addgene - Plant Molecular Biology Resources: https://www.addgene.org
7	Sigma-Aldrich - Plant Tissue Culture Media Guide: https://www.sigmaaldrich.com
8	National Agri-Food Biotechnology Institute (NABI), India: https://nabi.res.in

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Pre-lab briefing, Demonstration by faculty, Hands-on individual practice, Supervised bench work	Lab manual, Charts, Models, Lab equipment, Reagents, Glassware, cultures & samples
Unit 2	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware
Unit 3	Group experimentation, Peer-checking of results	Instruments, Specimens, reagents, glassware
Unit 4	Demonstration by faculty incharge, result analysis	Instruments, Specimens, reagents, glassware, Observation records, Sample reports
Unit 5	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	3	2	2	2	2	2	3	2	2	2
CLO2	3	2	2	2	2	2	3	2	2	2
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	15	11	11	11	10	11	15	11	11	11
AVERAGE	3	2.2	2.2	2.2	2	2.2	3	2.2	2.2	2.2

Semester - V

Part - III

Core Practical - VI: Lab in Animal Biotechnology

COURSE OBJECTIVE

To provide practical training in aseptic methods in animal cell culture, culture maintenance and cytotoxicity assay.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To train students in aseptic techniques required for animal cell culture.	
LO2	To enable the students to learn the culture and maintenance techniques in cell culture	
LO3	To provide practical experience in cell viability and counting methods.	
LO4	To develop skills in molecular techniques in animal biotechnology.	
LO5	To familiarize students with cryopreservation and karyotyping procedures.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Prepare culture media and perform sterilization for animal cell culture.	K3 - Apply
CO2	Perform cell counting and viability assays.	K3 - Apply
CO3	Demonstrate cryopreservation of animal cells.	K3 - Apply
CO4	Perform an ELISA-based immunodiagnostic assay.	K4 - Analyze
CO5	Demonstrate karyotyping and chromosome analysis.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	1. Preparation and sterilization of animal cell culture media 2. Aseptic techniques and laminar air flow handling	12
II	3. Preparation of single cell suspension from chick embryo for establishing primary cell culture 4. Disaggregation of animal tissue 5. Trypsinization of established cell cultures. 6. Sub-culturing and passaging of a cell line	12
III	7. Cell counting using haemocytometer 8. Viability test using trypan blue dye exclusion assay 9. MTT viability assay	12
IV	10. Isolation of genomic DNA from animal cell tissue	12
V	11. Karyotyping and chromosome analysis (demonstration)	12

	12. Cryopreservation of animal cells - demonstration	
Total		**60**
Text Books		
1	Ignacimuthu S. (2019). Animal Biotechnology (2nd Edition). Alpha Science International, Oxford.	
2	Masters J.R.W. (Ed.) (2000). Animal Cell Culture: A Practical Approach (3rd Edition). Oxford University Press, Oxford.	
3	Doyle A. & Griffiths J.B. (Eds.) (1998). Cell and Tissue Culture: Laboratory Procedures in Biotechnology (1st Edition). John Wiley & Sons, Chichester.	
4	Harlow E. & Lane D. (1988). Antibodies: A Laboratory Manual (1st Edition). Cold Spring Harbor Laboratory Press, New York.	
Reference Books		
1	Coico R. & Sunshine G. (2015). Immunology: A Short Course (7th Edition). Wiley-Blackwell, Hoboken..	
2	Sambrook J. & Russell D.W. (2001). Molecular Cloning: A Laboratory Manual (3rd Edition). Cold Spring Harbor Laboratory Press, New York.	
3	Davis J.M. (Ed.) (2011). Animal Cell Culture: Essential Methods (1st Edition). Wiley, Chichester.	
4	Freshney R.I. (2015). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (7th Edition). Wiley-Blackwell, Hoboken.	
5	Butler M. (2004). Animal Cell Culture and Technology (2nd Edition). BIOS Scientific Publishers, Oxford.	
6	Phelan M.C. (2007). Basic Techniques in Mammalian Cell Tissue Culture (1st Edition). Current Protocols in Cell Biology, John Wiley & Sons, Hoboken.	
Web Resources		
1	NPTEL - Animal Cell Culture Technology: https://nptel.ac.in	
2	ATCC Animal Cell Culture Guide: https://www.atcc.org	
3	Bio-protocol - Cell Biology protocols: https://bio-protocol.org	
4	Coriell Institute for Medical Research - Cell Repository: https://www.coriell.org	
5	European Collection of Authenticated Cell Cultures (ECACC): https://www.culturecollections.org.uk	
6	JoVE - Animal Cell Culture Video Protocols: https://www.jove.com	
7	Cell Culture Dish - Industry Resource: https://cellculturedish.com	
8	National Centre for Cell Science (NCCS), India: https://www.nccs.res.in	

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Pre-lab briefing, Demonstration by faculty, Hands-on individual practice, Supervised bench work	Lab manual, Charts, Models, Lab equipment, Reagents, Glassware, cultures & samples
Unit 2	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware
Unit 3	Group experimentation, Peer-checking of results	Instruments, Specimens, reagents, glassware
Unit 4	Demonstration by faculty incharge, result analysis	Instruments, Specimens, reagents, glassware, Observation records, Sample reports
Unit 5	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	3	2	2	2	2	2	3	2	2	2
CLO2	3	2	2	2	2	2	3	2	2	2
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	15	11	11	11	10	11	15	11	11	11
AVERAGE	3	2.2	2.2	2.2	2	2.2	3	2.2	2.2	2.2

Semester - V
Part - III
Elective – III: A. Environmental Biotechnology

COURSE OBJECTIVE

This course provides an in-depth understanding of the application of biotechnological tools and processes to address environmental challenges. It covers the role of microorganisms in pollution control, waste water and solid waste management, bioremediation strategies and environmental monitoring. The course aims to develop student competence in eco-friendly and sustainable approaches for environmental conservation and pollution abatement using biotechnological interventions

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**	
LO1	To introduce the principles, scope and significance of environmental biotechnology and bioremediation.
LO2	To introduce the of environmental biotechnology.
LO3	To provide knowledge on solid waste management techniques.
LO4	To familiarize students with bioremediation strategies for pollutant removal.
LO5	To develop understanding of biodegradation of xenobiotics and environmental monitoring tools.
LO6	To create awareness on environmental legislations and impact assessment.

COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the role of microorganisms in environmental processes and biogeochemical cycles.	K1 - Remember
CO2	Explain the principles of aerobic and anaerobic waste water treatment.	K2 - Understand
CO3	Apply composting and vermicomposting techniques for solid waste management.	K3 - Apply
CO4	Analyze bioremediation strategies for treatment of heavy metals and xenobiotics.	K4 - Analyze
CO5	Evaluate biosensor-based approaches for environmental monitoring.	K5 - Evaluate
CO6	Design sustainable biotechnological solutions for pollution control considering environmental regulations.	K6 - Create

COURSE CONTENT

Unit	**Content**	**No. of Hours**

I	**Introduction to Environmental Biotechnology:** Scope and importance of environmental biotechnology, Role of microorganisms in environmental processes; Types and sources of environmental pollution (air, water, soil),	9
II	**Wastewater Treatment:** Sources and Characteristics of domestic and industrial waste water, primary, secondary and tertiary treatment processes, activated sludge process, trickling filters, aerobic and anaerobic treatment, Solid waste management - composting, vermicomposting; Biomining and bioleaching. Biogas production from waste water.	9
III	**Solid waste management:** Sources and classification of solid waste, composting and vermicomposting, sanitary landfill technology, biomethanation, management of e-waste and biomedical waste.	9
IV	**Bioremediation & Biodegradation:** Principles and types of bioremediation - in-situ and ex-situ, phytoremediation, bioremediation of heavy metals and Biodegradation of xenobiotics. Oil spill bioremediation, role of genetically engineered microorganisms in bioremediation. Biodegradation of pesticides and plastics.	9
V	**Biofuels & Bioenergy: B**iogas production and biodigesters; Bioethanol and biodiesel production; Microbial fuel cells - concept and applications; Biohydrogen production; Renewable energy from biomass. **Environmental Monitoring**: Bioindicators and biosensors for pollution monitoring. Environmental impact assessment, Environmental legislations and regulatory frameworks.	9
Total		**45**

Text Books

1	Bhattacharyya, B.C. and Banerjee, R. 2007. Environmental Biotechnology. Oxford University Press.
2	Rittmann B.E. & McCarty P.L. (2001). Environmental Biotechnology: Principles and Applications (1st Edition). McGraw-Hill, New York.
3	Chatterjee K.K. (2015). Introduction to Environmental Biotechnology (3rd Edition). PHI Learning, New Delhi.
4	Evans, G.M. and Furlong, J.C. 2011. Environmental Biotechnology: Theory and Application (2nd Edition). Wiley-Blackwell.
5	Bhatia S.C. (2008). Environmental Biotechnology (1st Edition). Atlantic Publishers, New Delhi.
6	Singh, S.N. (Ed.). 2017. Environmental Biotechnology: For Sustainable Future. Springer.

Reference Books

1	Jogdand S.N. (2010). Environmental Biotechnology (1st Edition). Himalaya Publishing House, Mumbai.
2	Scragg, A. 2005. Environmental Biotechnology (2nd Edition). Oxford University Press.

3	Evans G.M. & Furlong J.C. (2011). Environmental Biotechnology: Theory and Application (2nd Edition). Wiley, Chichester
4	Verma, P.S. and Agarwal, V.K. 2013. Environmental Biology (Principles of Environmental Biotechnology). S. Chand Publishing.
5	Vallero, D.A. 2010. Environmental Biotechnology: A Biosystems Approach. Academic Press.
6	Malik A. & Grohmann E. (Eds.) (2011). Environmental Protection Strategies for Sustainable Development (1st Edition). Springer, Dordrecht.
7	Forster, C.F. and Wase, D.A.J. 1987. Environmental Biotechnology. Ellis Horwood.
Web Resources	
1	NPTEL - Environmental Biotechnology: https://nptel.ac.in
2	US EPA - Bioremediation resources: https://www.epa.gov
3	https://www.cpcb.nic.in — Central Pollution Control Board (CPCB), Government of India
4	https://www.unep.org — United Nations Environment Programme (UNEP)
5	https://www.who.int/health-topics/environmental-health — World Health Organization: Environmental Health Topic Page
6	Centre for Science and Environment (CSE), India: https://www.cseindia.org
7	https://www.sciencedirect.com/journal/journal-of-environmental-management — Journal of Environmental Management (ScienceDirect/Elsevier
8	International Water Association (IWA): https://iwa-network.org

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	2	1	2	1	1	1	2	1	1	1
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	12	8	11	8	7	8	12	8	8	8
AVERAGE	2.4	1.6	2.2	1.6	1.4	1.6	2.4	1.6	1.6	1.6

Semester - V
Part - III
Elective – III: B. Bio - entrepreneurship

COURSE OBJECTIVE

To develop entrepreneurial competence among students by introducing the principles of business planning, funding, and management specific to biotechnology-based ventures.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To introduce the fundamental concepts and theories of entrepreneurship and bioentrepreneurship.	
LO2	To develop skills in business idea generation, feasibility analysis and business plan preparation.	
LO3	To familiarize students with funding sources and government support schemes for biotech start-ups.	
LO4	To create awareness of IPR, biosafety and regulatory frameworks governing biotechnology products.	
LO5	To build competency in designing and pitching a viable biotechnology-based business plan.	
LO6	To familiarise students with case studies of successful biotech start-ups.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Explain the fundamental concepts of entrepreneurship and identify opportunities in the biotechnology sector.	K2 - Understand
CO2	Generate and evaluate business ideas using feasibility analysis and business model tools.	K3 - Apply
CO3	Analyse funding sources and government support schemes available for bio-based start-ups.	K4 - Analyze
CO4	Interpret IPR provisions and regulatory requirements applicable to biotechnological products.	K2 - Understand
CO5	Design a business plan and pitch deck for a biotechnology-based enterprise.	K6 - Create
CO6	Formulate a business plan for a biotechnology-based product or service	K6- Create

COURSE CONTENT

Unit	**Content**	**No. of Hours**

I	**Foundation of Entrpreneurship**: Entrepreneurship: concept, definition, characteristics and types (small scale, agri, technology-based, women, social). Bioentrepreneurship: definition, scope and significance in the biotechnology sector. Emerging opportunities in biotechnology-based enterprises: agri-biotech, pharma-biotech, food-biotech, environmental biotech, bioinformatics. Role of entrepreneurship in national economic development and self-employment generation.	9
II	**Business idea generation and planning:** Sources of business ideas; techniques of idea generation: brainstorming, SCAMPER, mind mapping. Idea screening and feasibility analysis: technical, market, financial and legal feasibility. SWOT analysis and PESTLE analysis for biotech ventures. Business Model Canvas: value proposition, customer segments, revenue streams, key resources. Preparation of a Detailed Project Report (DPR) / Business Plan for a bio-based enterprise. Market survey and market research methods relevant to biotechnology products.	9
III	**Funding, Finance and Support Schemes:** Sources of finance: own capital, debt, equity, venture capital and angel investment. Financial statements and balance sheet. Break-even analysis and cost-volume-profit relationship for a start-up. Government schemes: Startup India, Make in India, MUDRA, Stand-Up India. Biotechnology-specific funding bodies: BIRAC (BIG, SBIRI, BIPP), DBT, DST-NIDHI, ICMR schemes. Role of Technology Business Incubators (TBIs), Bio-incubators, IIC and seed funding mechanisms	9
IV	**IPR & Regulatory framework**: Intellectual Property Rights (IPR): patents, trademarks, copyrights, trade secrets, geographical indications. Patenting process for biotechnological inventions; Indian Patent Act provisions relevant to biotech. Biosafety and biosecurity regulations: GEAC, RCGM, IBSC and their roles. Regulatory approvals for bio-based products: FSSAI, CDSCO, Environment (Protection) Act. Licensing, technology transfer and material transfer agreements (MTA). Ethical issues in bioentrepreneurship: bio-piracy, benefit sharing and access regulations.	9
V	**Start-up Ecosystem, Case studies and Pitching**: Indian and global biotech start-up ecosystem: incubators, accelerators and clusters. Case studies of successful bio-based start-ups (agri-biotech, diagnostics, biopharma, bioinformatics). Marketing strategies and branding for biotechnology products and services. Elements of an effective pitch deck; investor pitching and negotiation basics. Risk management and common causes of start-up failure. Hands-on: drafting a mini business plan and mock pitch presentation for a bio-enterprise idea.	9
Total		**45**

Text Books	
1	Shimasaki, Craig (Ed.). *Biotechnology Entrepreneurship: Leading, Managing and Commercializing Innovative Technologies*. 2nd Edition, Academic Press, 2020.
2	Khanka, S.S. *Entrepreneurial Development*. 5th Edition, S. Chand Publishing, New Delhi, 2013.
3	Desai, Vasant. *The Dynamics of Entrepreneurial Development and Management*. 5th Revised Edition, Himalaya Publishing House, 2017.
4	Agarwal, Swati, Kumari, Sonu & Khan, Suphiya (Eds.). *Bioentrepreneurship and Transferring Technology Into Product Development*. IGI Global Scientific Publishing, 2021.
Reference Books	
1	Onetti, A. & Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. 1st Edition, Routledge, 2014.
2	National Biotechnology Development Strategy, Department of Biotechnology (DBT), Government of India. (Current version — check dbt.gov.in for latest edition)
3	BIRAC Annual Report and Scheme Guidelines, Biotechnology Industry Research Assistance Council. (Annually updated — cite the current year's edition)
4	Ganguli, P. *Intellectual Property Rights: Unleashing the Knowledge Economy*. Tata McGraw-Hill, New Delhi, 2001.
5	Startup India Handbook, Department for Promotion of Industry and Internal Trade (DPIIT), Government of India. (Periodically revised — check startupindia.gov.in for latest edition).
Web Resources	
1	**Department of Biotechnology (DBT), Government of India** — https://dbtindia.gov.in — Nodal agency for biotechnology R&D funding, schemes, and the National Biotechnology Development Strategy.
2	**BIRAC (Biotechnology Industry Research Assistance Council)** — https://www.birac.nic.in — Information on BIG, SBIRI, BIPP and other biotech start-up funding schemes covered in Unit III.
3	**Startup India Portal, DPIIT, Government of India** — https://www.startupindia.gov.in — DPIIT recognition, Startup India Seed Fund Scheme, tax exemptions, and IPR fast-tracking for start-ups.
4	**Intellectual Property India, Office of the CGPDTM** — https://ipindia.gov.in — Official portal for patent, trademark, and design filing; relevant to Unit IV's IPR and patenting content.
5	**WIPO — IP for Business (SMEs Division)** — https://www.wipo.int/sme — International resources on IP management, licensing, and technology transfer for small and biotech enterprises.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - V
Part - IV
Skill Enhancement Course – III: Research Methodology & Biostatistics

COURSE OBJECTIVE

This course introduces undergraduate Biotechnology students to the fundamental principles and practice of scientific research. It equips students with the ability to identify a research problem, review relevant literature, design experiments, collect and statistically analyze biological data, and communicate findings through scientific writing while adhering to research and publication ethics.

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LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To introduce the basic concepts, types and process of scientific research..	
LO2	To develop skills in literature review, hypothesis formulation and experimental design. To develop skills in scientific writing, referencing and data handling.	
LO3	To familiarize students with the basic concepts, types and process of scientific research.	
LO4	To train students in fundamental biostatistical tools for the analysis of biological data.	
LO5	To develop skills in the ethical conduct of research, including plagiarism awareness and data integrity.	
LO6	To equip students with scientific writing skills, publication ethics and awareness of intellectual property rights	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Explain the meaning, types and scope of research and identify a suitable research problem in biotechnology.	K2 - Understand
CO2	Conduct a systematic literature review using scientific databases and formulate a testable research hypothesis.	K3 - Apply
CO3	Design appropriate experimental layouts and apply standard data collection procedures and laboratory practices.	K3- Apply
CO4	Analyse biological data using appropriate statistical tools and interpret the results.	K4 - Analyse
CO5	Compose a scientific report/research paper following ethical publication norms and IPR guidelines.	K5/K6 - Evaluate / Create

COURSE CONTENT

Unit	**Content**	**No. of Hours**

I	**Research**: meaning, definition, characteristics and objectives. Motivation and purpose of research in biotechnology. Types of research: basic, applied, descriptive, exploratory, experimental and translational research. **Research approaches**: quantitative and qualitative. Steps in Research process; Identification and formulation of a research problem; Criteria for a good research problem; research design – Definition and features of a good design Scope and significance of research in life sciences and biotechnology industry.	6
II	**Literature Review**: Importance and purpose of literature review; Sources of literature: primary, secondary and tertiary sources; **Scientific databases**: PubMed, Scopus, Web of Science, Google Scholar, Science Direct; Reference management tools: Mendeley, Zotero, EndNote. **Hypothesis**: meaning, characteristics, types and formulation. **Variables**: Independent, Dependent, Extraneous and Confounding variables; **Sampling**: meaning, need, and methods of sampling (probability and non-probability); Sample size determination.	6
III	**Experimental design in biological sciences**: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design and Factorial design; Field and pot experiments in agricultural biotechnology. **Primary data collection**: observation, interview, questionnaire and schedule. Secondary data sources and their evaluation. Laboratory notebook maintenance and Good Laboratory Practices (GLP). Standard Operating Procedures (SOPs) in a research laboratory. Data recording, validation and quality control.	6
IV	**Biostatistics & Data Analysis**: Measures of central tendency: mean, median and mode. Measures of dispersion: range, standard deviation, variance and coefficient of variation. Probability: basic concepts and distributions (Normal, Binomial, Poisson). Tests of significance: Student's t-test, Chi-square test and Analysis of Variance (ANOVA). Correlation and regression analysis. **Introduction to statistical software**: SPSS, GraphPad Prism, R and MS-Excel data analysis tools. Interpretation and presentation of statistical results (tables, graphs and charts).	
V	**Scientific writing, Publications Ethics & IPR**: Structure of a research report/thesis: title, abstract, introduction, review of literature, materials and methods, results, discussion, summary and conclusion (IMRaD format). Writing a research paper for publication; selection of an appropriate journal; Citation styles: APA, MLA and Vancouver; in-text citation and bibliography; Plagiarism: meaning, types and detection tools (Turnitin, iThenticate, Urkund); Research and publication ethics (UGC-CARE, predatory journals, authorship criteria); Intellectual Property Rights (IPR): patents, copyrights,	

	trademarks and geographical indications relevant to biotechnology. Research funding agencies: DBT, DST-SERB, ICMR, CSIR — overview of proposal writing. Research metrics: impact factor, citation index, h-index and ORCID.	
Total		**30**

Text Books	
1	Kothari C.R. (2004). *Research Methodology: Methods and Techniques* (2nd Edition). New Age International, New Delhi..
2	Trivedi P.K. & Bagai R. (2009). *Research Methodology* (1st Edition). S. Chand, New Delhi.
3	Zar, J.H. (2014). Biostatistical Analysis (5th ed.). Pearson Education, New Delhi..
4	Kumar R. (2019). *Research Methodology: A Step-by-Step Guide for Beginners* (5th Edition). SAGE Publications, London.
5	Bryman, A. (2016). *Social Research Methods (5th ed.)*. Oxford University Press.
Reference Books	
1	Day, R.A., & Gastel, B. (2016). *How to Write and Publish a Scientific Paper* (8th ed.). Cambridge University Press, Cambridge.
2	Sokal, R.R., & Rohlf, F.J. (2012). *Biometry: The Principles and Practice of Statistics in Biological Research* (4th ed.). W.H. Freeman & Co., New York.
3	Panneerselvam R. (2014). *Research Methodology* (2nd Edition). PHI Learning, New Delhi.
4	Creswell J.W. & Creswell J.D. (2023). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (6th Edition). SAGE Publications, Los Angeles.
5	Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., & Fitzgerald, W. T. (2016). *The Craft of Research (4th ed.)*. University of Chicago Press.
6	Trochim, W. M. K., Donnelly, J. P., & Arora, K. (2015). *Research Methods: The Essential Knowledge Base (2nd ed.)*. Cengage Learning.
Web Resources	
1	NPTEL - Research Methodology: https://nptel.ac.in
2	DBT India — https://dbtindia.gov.in
3	NPTEL — Research Methodology courses — https://nptel.ac.in
4	PubMed (National Library of Medicine) — https://pubmed.ncbi.nlm.nih.gov
5	Google Scholar — https://scholar.google.com
6	UGC-CARE List and Research Ethics Guidelines: https://ugccare.unipune.ac.in
7	Committee on Publication Ethics (COPE): https://publicationethics.org
8	Scopus — https://www.scopus.com

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3
CLO1	3	2	1	1	2	3	2	1
CLO2	2	3	2	1	2	2	3	2
CLO3	2	2	3	2	1	3	2	3
CLO4	1	3	3	3	2	2	3	3
CLO5	2	2	2	3	3	3	3	2
TOTAL	**10**	**12**	**11**	**10**	**10**	**13**	**13**	**11**
AVERAGE	**2.0**	**2.4**	**2.2**	**2.0**	**2.0**	**2.6**	**1.8**	**2.2**

Semester - V
Part - IV
Internship: Summer Internship/ Industrial Training

COURSE OBJECTIVE

To provide students with practical industry exposure and hands-on experience in a professional biotechnology work environment.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To provide students with first-hand exposure to the actual working environment of biotechnology-related industries, research institutes, hospitals, or start-ups.	
LO2	To enable students to apply theoretical and laboratory knowledge gained during the programme to real-world organizational tasks and problems.	
LO3	To familiarize students with industrial/institutional protocols, quality systems, safety practices, and professional work culture.	
LO4	To develop workplace-relevant skills such as teamwork, communication, documentation, time management, and professional ethics.	
LO5	To expose students to current technologies, instrumentation, and processes used in the biotechnology and allied sectors.	
LO6	To help students explore potential career pathways and strengthen employability/entrepreneurial readiness through mentored, on-site learning	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the organizational structure, functions, and work culture of the host organization.	Understand
CO2	Apply theoretical and practical knowledge of biotechnology to assigned tasks/projects at the host organization.	Apply
CO3	Demonstrate familiarity with relevant instruments, techniques, SOPs, safety, and quality practices followed at the workplace.	Apply
CO4	Analyze and document work carried out through a daily log/diary and derive meaningful observations or outcomes.	Analyze
CO5	Prepare a comprehensive internship report and communicate the work undertaken through a formal presentation/viva-voce.	Create
CO6	Exhibit professional ethics, teamwork, discipline, and effective workplace communication.	Apply

Internship Process & Time line

Note: Students must undergo a minimum of 15 days (approx. 90-100 hours) of full-time internship at an institution-approved organization, typically during the semester break/vacation period, equivalent to 2 credits as per university norms.

Phase	Key Activities
Pre-Internship	Identification and approval of host organization, MoU/consent letter, orientation on objectives, safety, and reporting formats
During Internship (Min. 2 Weeks / 90-100 hrs)	On-site training, hands-on work on assigned tasks/mini-project, daily log maintenance, periodic mentor interaction
Post-Internship	Submission of certificate from host organization, compilation and submission of internship report, seminar presentation and viva-voce

Teaching – Learning Methods

- Full-time, on-site placement and workplace-based experiential learning at an approved host organization
- Guidance and supervision by an external (industry/institution) mentor and an internal faculty mentor
- Hands-on training on instruments, techniques, protocols, and processes followed at the host organization
- Orientation/induction session on internship guidelines, safety, and reporting formats prior to placement
- Maintenance of a daily activity log/diary duly signed by the external mentor
- Periodic monitoring through telephonic/online/on-site visits by the internal faculty mentor, wherever feasible
- Structured mentoring for compilation of the internship report
- Post-internship seminar/viva-voce presentation before a departmental evaluation committee

General Guidelines

- The internship must be undertaken at an organization approved by the Department/ Institution.
- Students must obtain a certificate of completion (with performance remarks) from the host organization.
- A duly filled and signed internship diary/log must be maintained and submitted along with the report.
- The internship report must follow the format prescribed by the Department and be submitted within the stipulated time after completion.
- In case of any safety, ethical, or biosafety concerns at the host site, the matter must be reported immediately to the internal faculty mentor.

Suggested types of host organization for internship

- Biotechnology, pharmaceutical, or biopharmaceutical manufacturing industries
- Diagnostic laboratories, hospitals, and clinical research organizations
- Government/private R&D institutes and university research laboratories
- Agricultural biotechnology, seed, and agro-industry companies
- Food processing, dairy, and fermentation-based industries
- Bioinformatics, genomics, and biotech start-up/incubation centres
- Environmental biotechnology and bioremediation service providers

5. Evaluation Scheme

Component	Basis of Assessment	Weightage
Host Organization Evaluation / Certificate	Feedback and grading by external/industry mentor on discipline, skill, and performance	30%
Internship Diary / Daily Log	Regularity, quality, and authenticity of day-to-day documentation duly countersigned	20%
Internship Report	Technical content, organization description, work undertaken, learning outcomes, and presentation quality	30%
Seminar Presentation & Viva-Voce	Oral communication, depth of understanding, and responses to questions before evaluation committee	20%
Total		**100%**

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CLO1	2	1	1	-	2	1	1	1	1	1	2	2
CLO2	3	3	2	1	2	-	1	-	1	1	3	3
CLO3	3	2	3	1	1	-	-	-	1	1	3	2
CLO4	2	3	2	1	2	-	1	-	2	2	2	2
CLO5	1	1	1	-	2	1	3	2	2	3	1	2
CLO6	1	1	-	-	3	3	3	3	3	2	1	1
TOTAL	12	11	9	3	12	5	9	6	10	10	12	12
AVERAGE	2	1.8	1.5	0.5	2	0.8	1.5	1	1.7	1.7	2	2

Semester - VI
Part - III
Core – IX: Stem Cell and Tissue Engineering

COURSE OBJECTIVE

To provide students with a comprehensive understanding of stem cell biology, tissue engineering principles and their applications in regenerative medicine.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**	
LO1	To provide a comprehensive understanding of stem cell biology and classification.
LO2	To explain techniques of stem cell isolation, culture and characterisation.
LO3	To introduce the principles of tissue engineering and biomaterials.
LO4	To highlight applications of stem cells and tissue engineering in regenerative medicine.
LO5	To develop an understanding of scaffold design and biomaterial selection in tissue engineering.
LO6	To create awareness of the regulatory framework and bioethical considerations governing stem cell research.

COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the types and properties of stem cells.	K1 - Remember
CO2	Explain methods of isolation, culture and characterisation of stem cells.	K2 - Understand
CO3	Apply reprogramming techniques to generate induced pluripotent stem cells.	K3 - Apply
CO4	Analyse principles of scaffold design and biomaterials in tissue engineering.	K4 - Analyze
CO5	Evaluate applications and ethical issues of stem cells in regenerative medicine.	K5 - Evaluate
CO6	Design regenerative medicine strategies in compliance with ethical and regulatory frameworks.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Introduction to Stem Cell Biology:** Definition and properties of stem cells - self-renewal, potency; Classification - totipotent, pluripotent, multipotent, unipotent; Embryonic stem cells - source and derivation. Adult/somatic stem cells and their niches. Stem cell markers and identification.	15

II	**Isolation, Culture and Characterization:** Concept of the stem cell niche, molecular mechanisms of self-renewal and differentiation Isolation of stem cells from bone marrow, umbilical cord, adipose tissue; Culture conditions and feeder layers; Maintenance of pluripotency; Characterization - flow cytometry, immunostaining; Differentiation assays.	15
III	**Induced Pluripotent Stem Cells (iPSCs):** Concept of cellular reprogramming; Yamanaka factors and methods of reprogramming; Characterization of iPSCs; Disease modelling using iPSCs; Applications in drug screening.	15
IV	**Principles of Tissue Engineering:** Concept and scope of tissue engineering; types and properties of scaffolds, Scaffold materials - natural and synthetic biomaterials; Scaffold fabrication techniques: - electrospinning, freeze-drying and 3D bioprinting, cell-scaffold interactions. Bioreactors for tissue engineering; Cell-scaffold interactions.	15
V	**Applications in Regenerative Medicine:** Skin tissue engineering and wound healing, bone and cartilage tissue engineering, cardiac and vascular tissue engineering, organ-on-chip technology, design and function of bioreactors in tissue engineering.Stem cell therapy for degenerative and hematological diseases, umbilical cord blood banking, stem cell-based regenerative medicine and organ transplantation, ethical, legal and social issues (ELSI) in stem cell technology; Stem cell research regulations in India.	15
Total		**75**

Text Books

1	Lanza R. et al. (2014). Essentials of Stem Cell Biology (3rd Edition). Academic Press, San Diego.
2	Bongso A. & Lee E.H. (2005). Stem Cells: From Bench to Bedside (1st Edition). World Scientific, Singapore.
3	Palsson B. & Bhatia S.N. (2003). Tissue Engineering (1st Edition). Pearson Prentice Hall, Upper Saddle River.
4	Lanza R., Langer R. & Vacanti J. (Eds.) (2020). Principles of Tissue Engineering (5th Edition). Academic Press, San Diego.
5	Slack J.M.W. (2012). Stem Cells: A Very Short Introduction (1st Edition). Oxford University Press, Oxford.
6	Klimanskaya I. & Lanza R. (Eds.) (2013). Handbook of Stem Cells (2nd Edition). Academic Press, San Diego.

Reference Books

1	Vunjak-Novakovic G. & Freshney R.I. (2006). Culture of Cells for Tissue Engineering (1st Edition). Wiley, Hoboken.
2	Atala A. (2011). Principles of Regenerative Medicine (2nd Edition). Academic Press, San Diego.
3	Wobus A.M. & Boheler K.R. (2006). Stem Cells (1st Edition). Springer, Berlin.
4	Ratner B.D., Hoffman A.S., Schoen F.J. & Lemons J.E. (Eds.) (2012). Biomaterials Science: An Introduction to Materials in Medicine (3rd Edition). Academic Press, San Diego.
5	Meyers R.A. (Ed.) (2013). Stem Cell Research and Therapeutics (1st Edition). Wiley-VCH, Weinheim.
6	Fisher J.P., Mikos A.G. & Bronzino J.D. (Eds.) (2007). Tissue Engineering (1st Edition). CRC Press, Boca Raton.
Web Resources	
1	NPTEL - Stem Cell Biology and Engineering: https://nptel.ac.in
2	International Society for Stem Cell Research (ISSCR): https://www.isscr.org
3	NIH Stem Cell Information: https://stemcells.nih.gov
4	EuroStemCell - Stem Cell Information Resource: https://www.eurostemcell.org
5	California Institute for Regenerative Medicine (CIRM): https://www.cirm.ca.gov
6	Indian Council of Medical Research - Stem Cell Research Guidelines: https://main.icmr.nic.in
7	Nature Reviews - Regenerative Medicine Resources: https://www.nature.com
8	Tissue Engineering and Regenerative Medicine International Society (TERMIS): https://www.termis.org

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	2	2	1	1	2	1	1	1	1	1
TOTAL	**15**	**11**	**12**	**10**	**10**	**10**	**14**	**10**	**10**	**10**
AVERAGE	**2.5**	**1.8**	**2.0**	**1.6**	**1.6**	**1.6**	**2.6**	**1.6**	**1.6**	**1.6**

Semester - VI
Part - III
Core – X: Industrial Bioprocess Technology

COURSE OBJECTIVE

This core course provides students with a thorough understanding of the principles and practices of industrial bioprocess technology, from microbial strain selection through fermentation, downstream processing and commercial-scale production. The course covers fermenter design, industrial production of antibiotics, organic acids, enzymes and beverages, as well as bioprocess economics, scale-up and waste management, preparing students for careers in the fermentation and bioprocess industries.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To explain the principles underlying industrial fermentation processes.	
LO2	To describe the design and operation of bioreactors.	
LO3	To provide knowledge of upstream and downstream processing in bioprocess technology.	
LO4	To familiarize students with industrially important microbial products.	
LO5	To develop competence in interpreting fermentation kinetics and process optimisation data.	
LO6	To create awareness of process economics and scale-up considerations in industrial bioprocessing.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	State the principles of fermentation and microbial growth kinetics.	K1 - Remember
CO2	Explain the design, types and sterilisation of bioreactors.	K2 - Understand
CO3	Apply strain improvement and media optimisation strategies.	K3 - Apply
CO4	Analyse downstream processing techniques for product recovery and purification.	K4 - Analyze
CO5	Evaluate industrial production processes for antibiotics, enzymes and biofuels.	K5 - Evaluate
CO6	Design economically viable and environmentally compliant bioprocess systems.	K6 – Create

COURSE CONTENT

Unit	**Content**	**No. of Hours**

I	**Principles of Fermentation Technology:** Scope and significance of industrial biotechnology, Isolation and screening of industrially important microorganisms, culture preservation methods. Microbial growth kinetics.	15
II	**Bioreactor Design and Operation:** Design of a stirred-tank bioreactor, Types of bioreactors - airlift, packed-bed, membrane, Sterilization of media and equipment, Aeration and agitation systems, Instrumentation and process control. Types of fermentation processes - batch, fed-batch and continuous, fermenter design and components, media formulation, sterilization of media and air, principles of aeration and agitation.	15
III	**Upstream Processing:** Strain improvement - mutation and selection, Media formulation and optimization, Scale-up principles, Immobilization of cells and enzymes, Process economics.	15
IV	**Downstream Processing:** Cell disruption methods, Solid-liquid separation - filtration, centrifugation, Product recovery and concentration, Purification techniques – chromatography, Product formulation and drying.	15
V	**Industrial Products:** Production of antibiotics - penicillin, streptomycin. Production of industrial enzymes; Organic acid production - citric acid, production of alcohol and fermented beverages, Single-cell protein production, Biofuel production – bioethanol.	15
Total		**75**

Text Books

1	Stanbury P.F., Whitaker A. & Hall S.J. (2016). Principles of Fermentation Technology (3rd Edition). Elsevier, Amsterdam.
2	Casida L.E. (2007). Industrial Microbiology (1st Edition). New Age International, New Delhi..
3	Crueger W. & Crueger A. (2000). Biotechnology: A Textbook of Industrial Microbiology (2nd Edition). Panima Publishing, New Delhi.
4	Shuler M.L. & Kargi F. (2017). Bioprocess Engineering: Basic Concepts (3rd Edition). Prentice Hall, Upper Saddle River.
5	Doran P.M. (2013). Bioprocess Engineering Principles (2nd Edition). Academic Press, London.
6	Najafpour G.D. (2015). Biochemical Engineering and Biotechnology (2nd Edition). Elsevier, Amsterdam.

Reference Books

1	Waites M.J., Morgan N.L., Rockey J.S. & Higton G. (2001). Industrial Microbiology: An Introduction (1st Edition). Wiley-Blackwell, Oxford.
2	Prescott L.M. (2002). Prescott's Microbiology (5th Edition). McGraw-Hill, New York.
3	El-Mansi E.M.T. et al. (2011). Fermentation Microbiology and Biotechnology (3rd Edition). CRC Press, Boca Raton

4	Bailey J.E. & Ollis D.F. (1986). Biochemical Engineering Fundamentals (2nd Edition). McGraw-Hill, New York.
5	Vogel H.C. & Todaro C.L. (Eds.) (2014). Fermentation and Biochemical Engineering Handbook (3rd Edition). William Andrew/Elsevier, Oxford.
6	Demain A.L. & Davies J.E. (Eds.) (1999). Manual of Industrial Microbiology and Biotechnology (2nd Edition). ASM Press, Washington D.C.
Web Resources	
1	Waites M.J. et al., Industrial Microbiology: An Introduction, Wiley-Blackwell.
2	Prescott L.M., Prescott's Microbiology, McGraw-Hill.
3	El-Mansi E.M.T. et al., Fermentation Microbiology and Biotechnology, CRC Press.
4	Bailey J.E. & Ollis D.F. (1986). Biochemical Engineering Fundamentals (2nd Edition). McGraw-Hill, New York.
5	Vogel H.C. & Todaro C.L. (Eds.) (2014). Fermentation and Biochemical Engineering Handbook (3rd Edition). William Andrew/Elsevier, Oxford.
6	Demain A.L. & Davies J.E. (Eds.) (1999). Manual of Industrial Microbiology and Biotechnology (2nd Edition). ASM Press, Washington D.C.
7	Waites M.J. et al., Industrial Microbiology: An Introduction, Wiley-Blackwell.
8	Prescott L.M., Prescott's Microbiology, McGraw-Hill.

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	2	2	1	1	2	2	1	1	1	1
TOTAL	**15**	**11**	**12**	**10**	**10**	**11**	**14**	**10**	**10**	**10**
AVERAGE	**2.5**	**2.2**	**2.0**	**1.8**	**1.6**	**1.8**	**2.3**	**1.6**	**1.6**	**1.6**

Semester - VI
Part - III
Core – XI: Food Biotechnology

COURSE OBJECTIVE

This core course introduces students to the application of biotechnological principles in food production, processing, preservation and safety. The syllabus covers the role of microorganisms in food fermentation, production of food enzymes and additives, genetically modified foods, and food quality and safety management systems. The course equips students with the scientific and technical foundation required for careers in the food biotechnology and food processing industry.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**	
LO1	To introduce the microbiological and biochemical basis of food biotechnology.
LO2	To explain the production processes of fermented foods and beverages.
LO3	To describe modern methods of food preservation and quality control.
LO4	To create awareness of functional foods, nutraceuticals and food safety regulations.
LO5	To develop skills in identifying and applying quality control measures in food processing industries.
LO6	To create awareness of emerging trends and biotechnological innovations in functional food development.

COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the scope of food biotechnology and food microbiology.	K1 - Remember
CO2	Explain the production of fermented foods and beverages.	K2 - Understand
CO3	Apply food preservation techniques and the use of enzymes in food processing.	K3 - Apply
CO4	Analyse food safety and quality control systems including HACCP.	K4 - Analyze
CO5	Evaluate the role of functional foods, probiotics and nutraceuticals in health.	K5 - Evaluate
CO6	Develop food safety and quality assurance strategies for the food biotechnology industry.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Introduction to Food Biotechnology:** History and scope of food biotechnology; Microorganisms associated with food - beneficial and	15

	spoilage; causes and types of food spoilage, principles and methods of food preservation. Regulatory bodies - FSSAI, Codex Alimentarius.	
II	**Fermented Foods and Beverages:** Fermented dairy products - yogurt, cheese; Fermented vegetables - sauerkraut, pickles; Alcoholic beverages - beer, wine. Traditional Indian fermented foods - idli, dosa batter. Bread and bakery product fermentation.	15
III	**Food Preservation and Processing:** Thermal processing - Pasteurization, sterilization; Non-thermal preservation - irradiation, high pressure processing; Role of enzymes in food processing; Production of food enzymes – amylase, protease and pectinase. Food additives and preservatives; Packaging technologies. Classification and function of food additives - preservatives, colorants and flavor enhancers, single cell protein as a food source.	15
IV	**Food Safety and Quality Control:** GM foods and labelling regulations; Food-borne pathogens and toxins; Methods of food quality control, Hazard Analysis and Critical Control Points (HACCP) and quality management system; Food safety standards - FSSAI and ISO standards in the food industry (ISO 22000), principles of food packaging technology, application of biosensors in food safety monitoring. Microbiological testing of food;	15
V	**Functional Foods, Nutraceuticals & GM foods:** Concept of functional foods and nutraceuticals; Probiotics and prebiotics; Dietary fibre and its health benefits; Fortification and biofortification of foods; Emerging trends in food biotechnology. Overview of GM crops and their benefits, case studies - Bt cotton and golden rice, food safety assessment of GM foods, labelling and regulatory frameworks, functional foods and nutraceuticals.	15
Total		**75**

Text Books

1	Purohit S.S. (2005). Food Biotechnology: Principles and Practices (1st Edition). Agrobios, Jodhpur.
2	Reed G. & Nagodawithana T.W. (1991). Prescott and Dunn's Industrial Microbiology (4th Edition). CBS Publishers, New Delhi.
3	Frazier W.C. & Westhoff D.C. (2017). Food Microbiology (5th Edition). McGraw-Hill, New York.
4	Chandrasekhar U. (2013). Food Science and Applications (1st Edition). Elsevier, New Delhi.
5	Ray B. & Bhunia A. (2013). Fundamental Food Microbiology (5th Edition). CRC Press, Boca Raton.
6	Srivastava R.P. & Kumar S. (2015). Fruit and Vegetable Preservation: Principles and Practices (4th Edition). International Book Distributing Co., Lucknow.

Reference Books	
1	Joshi V.K. & Singh R.S. (2012). Food Biotechnology: Principles and Practices (1st Edition). I.K. International, New Delhi.
2	Fellows P.J. (2016). Food Processing Technology: Principles and Practice (4th Edition). Woodhead Publishing, Cambridge.
3	Vasanthi Nachiyar C. et al. (2019). Food Microbiology and Biotechnology (1st Edition). MJP Publishers, Chennai.
4	Doyle M.P. & Buchanan R.L. (Eds.) (2012). Food Microbiology: Fundamentals and Frontiers (4th Edition). ASM Press, Washington D.C.
5	Potter N.N. & Hotchkiss J.H. (1998). Food Science (5th Edition). Springer, New York.
6	Shetty K., Paliyath G., Pometto A. & Levin R.E. (Eds.) (2005). Food Biotechnology (2nd Edition). CRC Press, Boca Raton.
Web Resources	
1	NPTEL - Food Biotechnology: https://nptel.ac.in
2	FSSAI - Food Safety and Standards Authority of India: https://www.fssai.gov.in
3	FAO - Food Biotechnology resources: https://www.fao.org
4	Codex Alimentarius Commission: https://www.fao.org/fao-who-codexalimentarius
5	Institute of Food Technologists (IFT): https://www.ift.org
6	US FDA - Food Safety Resources: https://www.fda.gov/food
7	International Food Information Council (IFIC): https://foodinsight.org
8	Central Food Technological Research Institute (CFTRI), India: https://cftri.res.in

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	13	9	11	9	8	9	13	9	9	9
AVERAGE	2.6	1.8	2.2	1.8	1.8	1.8	2.6	1.8	1.8	1.8

Semester - VI
Part - III
Core Practical – VII: Lab in Industrial Bioprocess and Food Biotechnology

COURSE OBJECTIVE

To provide hands-on experience in fermentation, enzyme assays and food quality testing techniques used in industrial and food biotechnology

LEARNING OBJECTIVE:	
On successful completion of the course, students will be able to	
LO1	To train students in aseptic techniques for the isolation, screening, and maintenance of industrially important microorganisms.
LO2	To provide hands-on experience in microbial growth kinetics and fermentation-based production of industrial products such as ethanol and citric acid.
LO3	To develop practical skills in enzyme production, quantitative assay, immobilization techniques, and bioreactor operation used in bioprocess industries.
LO4	To familiarize students with downstream processing techniques for the recovery and purification of fermentation products.
LO5	To impart practical knowledge of fermented food production and standard microbiological quality-control analysis of food products.
LO6	To develop competency in the detection of food adulterants and in proximate analysis techniques relevant to the food industry.

COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Demonstrate the operation of a laboratory-scale fermenter.	K3 - Apply
CO2	Perform enzyme assays relevant to industrial bioprocesses.	K3 - Apply
CO3	Prepare fermented food and beverage products under aseptic conditions.	K3 - Apply
CO4	Analyze microbial load and quality parameters of food samples.	K4 - Analyze
CO5	Evaluate the results of bioprocess and food quality experiments.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	1. Isolation and screening of industrially important microorganisms from soil samples 2. Demonstration and study of the design, parts, and working of a laboratory-scale fermenter/bioreactor	12

II	3. Preparation of wine from fruit juice by fermentation and estimation of alcohol content 4. Production of citric acid using *Aspergillus niger* by submerged fermentation and estimation of citric acid content	12
III	5. Production and quantitative assay of amylase enzyme from *Bacillus sp.* 6. Preparation of vinegar by acetic acid fermentation. 7. Immobilization of yeast cells in calcium alginate beads and study of ethanol production.	12
IV	8. Downstream processing: recovery of a fermentation product by precipitation and centrifugation 9. Quality control test for milk — Methylene Blue Reduction Test (MBRT) / phosphatase test. 10. Microbial quality analysis of a food sample (Standard Plate Count)	12
V	11. Detection of common adulterants in food samples (milk, oil, spices). 12. Proximate analysis of a food sample — estimation of moisture and ash content.	12
Total		**60**

Text Books	
1	Stanbury P.F., Whitaker A. & Hall S.J. (2016). Principles of Fermentation Technology (3rd Edition). Elsevier, Amsterdam.
2	Frazier W.C. & Westhoff D.C. (2017). Food Microbiology (5th Edition). McGraw-Hill, New York.
3	Cappuccino J.G. & Sherman N. (2013). Microbiology: A Laboratory Manual (10th Edition). Pearson, San Francisco.
4	Vasanthi Nachiyar C., Sunkar S. & Prakash P. (2019). Industrial Biotechnology (1st Edition). MJP Publishers, Chennai.
5	Waites M.J., Morgan N.L., Rockey J.S. & Higton G. (2001). Industrial Microbiology: An Introduction (1st Edition). Wiley-Blackwell, Oxford.
6	Joshi V.K. & Singh R.S. (2012). Food Biotechnology: Principles and Practices (1st Edition). I.K. International, New Delhi.
Reference Books	
1	Reed G. & Nagodawithana T.W. (1991). Prescott and Dunn's Industrial Microbiology (4th Edition). CBS Publishers, New Delhi.
2	Purohit S.S. (2005). Food Biotechnology: Principles and Practices (1st Edition). Agrobios, Jodhpur.
3	Aneja K.R. (2007). Experiments in Microbiology, Plant Pathology and Biotechnology (4th Edition). New Age International, New Delhi.
4	Crueger W. & Crueger A. (2000). Biotechnology: A Textbook of Industrial Microbiology (2nd Edition). Panima Publishing, New Delhi.

5	Ray B. (2004). Fundamentals of Food Microbiology (3rd Edition). CRC Press, Boca Raton.
6	Prescott L.M., Harley J.P. & Klein D.A. (2002). Microbiology (5th Edition). McGraw-Hill, New York.
Web Resources	
1	NPTEL - Fermentation Technology: https://nptel.ac.in
2	FSSAI Food Testing Manuals: https://www.fssai.gov.in
3	Bio-protocol - Microbiology protocols: https://bio-protocol.org
4	Society for Industrial Microbiology and Biotechnology (SIMB): https://www.simbhq.org
5	Central Food Technological Research Institute (CFTRI), India: https://cftri.res.in
6	JoVE - Fermentation and Food Science Video Protocols: https://www.jove.com
7	American Society for Microbiology (ASM) Resources: https://asm.org
8	BioProcess International - Industry Resource: https://www.bioprocessintl.com

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Pre-lab briefing, Demonstration by faculty, Hands-on individual practice, Supervised bench work	Lab manual, Charts, Models, Lab equipment, Reagents, Glassware, cultures & samples
Unit 2	Group experimentation/ Demonstration, Peer-checking of results	Instruments, Specimens, reagents, glassware, Observation records, Sample reports
Unit 3	Group experimentation/ Demonstration, Peer-checking of results	Instruments, Specimens, reagents, glassware, Observation records, Sample reports
Unit 4	Group experimentation, Peer-checking of results	Instruments, Specimens, reagents, glassware, Observation records, Sample reports
Unit 5	Hands-on individual practice, Supervised bench work	Lab equipment, Reagents, Glassware

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	3	2	2	2	2	2	3	2	2	2
CLO2	3	2	2	2	2	2	3	2	2	2
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	**15**	**11**	**11**	**11**	**10**	**11**	**15**	**11**	**11**	**11**
AVERAGE	3	2.2	2.2	2.2	2	2.2	3	2.2	2.2	2.2

Semester - VI
Part - VI
Mini project: Mini project/ Entrepreneurship Start up Project

COURSE OBJECTIVE

To develop research, innovation and entrepreneurial skills through the execution of an independent biotechnology-based project.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To enable students to identify a real-world biotechnology-related problem, gap, or opportunity and translate it into a viable mini project or start-up idea.	
LO2	To provide hands-on experience in planning, executing, troubleshooting, and documenting a scientific/technical project independently or in small teams.	
LO3	To develop entrepreneurial thinking, including business model development, costing, and basic financial planning relevant to biotechnology-based ventures.	
LO4	To train students in market research, intellectual property rights (IPR) awareness, regulatory and biosafety requirements, and prototype / proof-of-concept development.	
LO5	To strengthen skills in scientific writing, data analysis, and the presentation and pitching of ideas to faculty, industry mentors, and potential investors.	
LO6	To foster innovation, teamwork, time management, ethical practice, and problem-solving abilities among students through experiential learning.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Identify and formulate a biotechnology-based problem or opportunity suitable for a mini project or start-up venture.	K3 - Apply
CO2	Design an appropriate methodology / experimental protocol / prototype plan and execute it systematically.	K3, K4 -Apply / Analyze
CO3	Analyze and interpret experimental data or market data and evaluate the technical and commercial feasibility of the project.	K4, K5 - Analyze / Evaluate
CO4	Develop a start-up/business model, including cost estimation, market analysis, and IP considerations.	K6 - Create
CO5	Prepare a comprehensive project report / business plan and demonstrate effective written, oral, and pitch communication skills.	K6 - Create
Web Resources		
1	Startup India portal and DPIIT guidelines (www.startupindia.gov.in)	

2	Osterwalder, A. & Pigneur, Y. — Business Model Generation, Wiley
3	National Biotechnology Development Strategy documents, DBT, Govt. of India
4	BIRAC (Biotechnology Industry Research Assistance Council) schemes and resources
5	Relevant peer-reviewed journals and patent databases (Google Patents, IPINDIA) related to the chosen project domain

Teaching – Learning Methods

S. No	Teaching & Learning methods
1	Mentor-guided independent/team project work (faculty mentor + optional industry mentor)
2	Hands-on laboratory, greenhouse, or field-based experimentation as applicable to the chosen project
3	Workshops and hands-on sessions on entrepreneurship, Business Model Canvas, and start-up ideation
4	Guest lectures / interactive sessions by biotech entrepreneurs, incubation managers, and industry experts
5	Case-study discussions of successful and failed biotechnology start-ups
6	Periodic project review meetings, progress seminars, and milestone-based mentoring
7	Literature survey and patent/IP landscaping using databases and ICT tools
8	Flipped-classroom modules for business-plan and financial-modelling components
9	Peer review, group discussion, and structured feedback sessions
10	Exposure/field visits to incubation centres, start-ups, biotech industries, or agri-business units
11	Final project exhibition / start-up pitch event (Shark-Tank style) before an evaluation panel

4. Weekly Break-up of Activities (5 Hrs/Week; 15 Weeks)

Week	Phase / Milestone	Activities	Hrs/Wk
1	Idea Generation/ Problem Identification	Brainstorming, need assessment, literature/patent survey, mentor allotment	1
2–4	Project Proposal / Business Plan Formulation	Objective setting, methodology design, Business Model Canvas, feasibility study	3
5–10	Execution Phase I	Laboratory/field work, prototype development, data/market data collection, regular mentor review	6

11–13	Execution Phase II	Troubleshooting, optimization, costing, IP filing awareness/documentation	3
14	Data Analysis & Interpretation	Statistical/experimental result/ financial analysis, results compilation	1
15	Report Writing & Documentation	Draft project report / business plan preparation	1
16	Final Submission & Evaluation	Final report/business plan submission, poster presentation, viva-voce and start-up pitch before evaluation panel	—

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CLO1	3	3	1	-	2	-	-	-	1	1
CLO2	3	3	2	1	3	-	1	-	1	1
CLO3	2	3	2	1	2	-	-	-	1	1
CLO4	1	2	1	-	2	3	2	1	2	2
CLO5	1	1	1	-	2	1	3	2	2	3
TOTAL	**10**	**12**	**7**	**2**	**11**	**4**	**6**	**3**	**7**	**8**
AVERAGE	2	2.4	1.4	0.4	2.2	0.8	1.2	0.6	1.4	1.6

Semester – I
Part - IV
Non Major Elective (NME) – I: A. Mushroom Cultivation

COURSE OBJECTIVE

To acquaint students with the biology of edible mushrooms and to impart practical knowledge of spawn production, cultivation techniques, and post-harvest processing for self-employment opportunities.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	Introduce students to the biology and importance of edible mushrooms.	
LO2	Provide knowledge on cultivation methods of commercially important mushrooms.	
LO3	Familiarize students with spawn production and cultivation techniques.	
LO4	Develop awareness on mushroom harvesting, storage and marketing.	
LO5	Encourage entrepreneurship through mushroom farming and value-added products.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Recall the basic concepts, classification and importance of mushrooms.	K1 - Remember
CO2	Explain the nutritional and medicinal value of mushrooms.	K2 - Understand
CO3	Apply basic techniques involved in mushroom cultivation and spawn production.	K3 - Apply
CO4	Analyze factors affecting mushroom growth, yield and disease management.	K4 - Analyze
CO5	Evaluate the economic potential and marketing strategies of mushroom farming.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	Definition, classification and morphology of mushrooms. Edible and poisonous mushrooms. Economic importance of mushrooms. Nutritional and medicinal value of mushrooms.	6
II	Oyster mushroom (*Pleurotus*), Button mushroom (*Agaricus bisporus*), Milky mushroom (*Calocybe indica*) and Paddy straw mushroom (*Volvariella volvacea*). Identification and characteristics of different mushrooms	6

III	Selection of substrate, substrate preparation, spawning methods, cropping room management, environmental factors affecting cultivation**.**	6
IV	Harvesting methods, storage, and packaging, preservation, drying and processing of mushrooms. Mushroom diseases and pest management.	6
V	Small-scale mushroom farming, economics of mushroom cultivation, marketing strategies, value-added mushroom products and self-employment opportunities.	6
Total		**30**

Text Books	
1	Bahl, N. (2006). *Handbook on Mushrooms* (4th ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
2	Pathak, S., & Yadav, N. (2020). *Handbook of Mushrooms*. Agrobios (India), Jodhpur.
3	Lakhanpal, T. N. (1996). *Mushroom Cultivation*. Directorate of Mushroom Research, Solan.
4	Pathak, V. N. (2010). *Mushroom Production and Processing Technology*. Agrobios (India), Jodhpur.
5	Miles, P. G., & Chang, S. T. (2004). *Mushrooms: Cultivation, Nutritional Value and Medicinal Effect* (2nd ed.). CRC Press, Boca Raton, Florida.
Reference Books	
1	Stamets, P. (2000). *Growing Gourmet and Medicinal Mushrooms* (3rd ed.). Ten Speed Press, Berkeley, California.
2	Chang, S. T., & Hayes, W. A. (1978). *The Biology and Cultivation of Edible Mushrooms* (1st ed.). Academic Press, New York.
3	Nair, M. C. (1995). *Mushroom Production and Processing Technology* (1st ed.). Daya Publishing House, New Delhi.
4	Ahlawat, O. P., & Singh, M. (2006). *Mushroom Cultivation Technology* (1st ed.). Directorate of Mushroom Research (DMR), Solan, Himachal Pradesh.
5	Reddy, A. P. K. (2011). *Handbook of Mushroom Cultivation, Processing and Packaging* (1st ed.). Astral International Pvt. Ltd., New Delhi.
Web Resources	
1	https://dmr.icar.gov.in. Information on mushroom cultivation technologies, training and research.
2	https://dmr.icar.gov.in. Online learning resources for mushroom cultivation and agriculture.
3	https://dmr.icar.gov.in. Courses on agricultural biotechnology and mushroom cultivation.
4	https://dmr.icar.gov.in. Training and extension activities related to mushroom farming.
5	https://dmr.icar.gov.in. Resources on commercial mushroom production and marketing.
6	https://kvk.icar.gov.in. Online agricultural courses including mushroom cultivation.
7	https://www.manage.gov.in. Sustainable farming and mushroom production resources.

8	https://nios.ac.in. Practical cultivation guidelines and extension materials.
9	https://www.fao.org. Learning materials related to fungi and mushroom biology.
10	https://nptel.ac.in. Information on entrepreneurship and value-added mushroom products.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CLO1	3	1	1	–	1	1	3	1	1
CLO2	3	2	2	–	1	1	3	2	2
CLO3	3	3	2	2	1	1	3	3	2
CLO4	2	3	3	2	2	2	2	3	2
CLO5	2	2	3	2	3	3	2	2	3
TOTAL	13	11	11	6	8	8	13	11	10
AVERAGE	2.6	2.2	2.2	1.2	1.6	1.6	2.6	2.2	2

Semester - I
Part - IV
Non Major Elective (NME) – I: B. Public Health & Hygiene

COURSE OBJECTIVE

To create awareness among students about the principles of public health, personal and community hygiene, sanitation, and prevention of communicable diseases.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To understand the principles of public health and hygiene.	
LO2	To create awareness about communicable and non-communicable diseases.	
LO3	To promote healthy lifestyle practices and sanitation.	
LO4	To understand environmental and social health problems.	
LO5	To develop knowledge about nutrition, hygiene, and disease prevention.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Explain the basic concepts, scope, and importance of public health and hygiene.	K1 - Remember
CO2	Describe the structure and functions of the human body in relation to health and disease.	K2 - Understand
CO3	Apply principles of personal hygiene, environmental sanitation, and safe living practices in daily life.	K3 - Apply
CO4	Identify common communicable and non-communicable diseases along with their causes and preventive measures.	K4 - Analyze
CO5	Evaluate national immunisation and health programmes.	K5 - Evaluate
CO6	Design a community health awareness activity.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	Hygiene: Definition. Personal, Community, Medical and Culinary hygiene; WASH (WAter, Sanitation and Hygiene) programme. Rural Community Health: Village health sanitation & Nutritional committee (Roles & Responsibilities); About Accredited Social Health Activist (ASHA); Village Health Nutrition Day, Rogi Kalyan Samitis. Community & Personal Hygiene: Environmental Sanitation and Sanitation in Public places.	6

II	Nutrition and Health Education: Principles of a balanced diet and malnutrition, Nutritional deficiencies and associated disorders, Role of health education in schools and communities, Health appraisal, personal health records, and emergency care.	6
III	Adulteration of food: food hygiene – hygiene of milk, meat, fish, eggs, fruits and vegetables, common food adulterants – harmful effects and their detection, food additives, fortification of food; Food Adulteration Act and its stringent implementation.	6
IV	Health Care: Concepts, health care services, Primary Health Care, present level of health care; Health Education: principles and means; National Health Programmes: ICDS, Expanded Programme of Immunization, STD control programme, National AIDS control programme.	6
V	Public Awareness through Digital Media - An Introduction to Mobile Apps of Government of India: NHP, Swasth Bharat, No More Tension, Pradhan Mantri Surakshit Mantritva Abhiyan (PM Suman Yojana), My Hospital (Mera aspataal), India fights Dengue, JSK Helpline, Ayushman Bhava, Arogya Setu, Covid 19AP.	6
Total		**30**

Text Books

1	Park, K. (2023). *Park's Textbook of Preventive and Social Medicine* (27th Ed.). Banarsidas Bhanot Publishers, Jabalpur.
2	Mahajan, B.K., & Gupta, M.C. (2013). *Textbook of Preventive and Social Medicine* (4th Ed.). Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
3	Suryakantha, A.H. (2022). *Community Medicine with Recent Advances* (6th Ed.). Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
4	Gupta, S. (2022). *The Short Textbook of Preventive and Social Medicine* (13th Ed.). Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.

Reference Books

1	Bhalwar, R. (Ed.). (2022). *Textbook of Public Health and Community Medicine* (2nd Ed.). Wolters Kluwer India Pvt. Ltd., New Delhi.
2	Srinivasa, D.K. (2017). *Principles of Community Medicine* (4th Ed.). CBS Publishers & Distributors Pvt. Ltd., New Delhi.
3	Detels, R., Gulliford, M., Karim, Q.A., & Tan, C.C. (Eds.). (2021). *Oxford Textbook of Public Health* (7th Ed.). Oxford University Press.
4	Heymann, D.L. (Ed.). (2022). *Control of Communicable Diseases Manual* (21st Ed.). American Public Health Association (APHA), Washington, DC.
5	Gordis, L. (2018). *Epidemiology* (6th Ed.). Elsevier.

Web Resources

1	https://www.who.int. Global guidelines on public health, disease prevention, vaccination, and health emergencies.
2	https://www.mohfw.gov.in. Information on national health programmes, policies, and public health initiatives.
3	https://nhm.gov.in. Details on maternal health, child health, immunization, and rural health services
4	https://www.icmr.gov.in. Research updates on diseases, epidemiology, and public health studies
5	https://www.cdc.gov. Guidelines on disease control, outbreak management, and health safety practices.
6	https://www.who.int. Global guidelines on public health, disease prevention, vaccination, and health emergencies.
7	https://swayam.gov.in. Online courses on public health, hygiene, biology, and environmental health.
8	https://epathshala.nic.in. Digital learning materials for health education and science subjects.
9	https://nptel.ac.in. Video lectures on life sciences, microbiology, and environmental studies.
10	https://www.edx.org. University-level courses on public health and disease prevention.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	**Teaching Methodology**	**Teaching Aids**
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CLO1	3	2	1	1	2	1	2	-	-
CLO2	3	2	1	1	2	1	2	-	-
CLO3	3	3	1	2	3	1	2	1	-
CLO4	2	3	2	2	3	2	1	1	-
CLO5	2	3	2	2	3	2	1	1	1
CLO6	2	2	1	1	1	2	1	1	**1**
TOTAL	**15**	**15**	**8**	**9**	**14**	**9**	**9**	**4**	**2**
AVERAGE	**2.5**	**2.5**	**1.3**	**1.5**	**2.3**	**1.5**	**1.5**	**0.6**	**0.3**

Semester - II
Part - IV
Non Major Elective (NME) – II: A. Organic Farming & Vermicomposting Technology

COURSE OBJECTIVE

To introduce students to the principles of organic farming and to impart practical knowledge of vermicomposting and biofertilizer use for sustainable agriculture

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Introduce students to the basic concepts and importance of organic farming.	
LO2	Explain the difference between organic and conventional (chemical-based) farming.	
LO3	Familiarise students with the principles of soil health and natural nutrient cycling.	
LO4	Provide a clear understanding of vermicomposting — what it is, how it works, and its benefits.	
LO5	Help students appreciate the role of organic practices in sustainable development and environmental protection.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Recall the meaning of organic farming, vermicomposting, and related key terms.	K1 - Remember
CO2	Explain the principles of organic farming, soil health, and the role of earthworms in composting.	K2 - Understand
CO3	Apply basic knowledge to identify organic farming practices and vermicompost preparation steps.	K3 - Apply
CO4	Compare organic and conventional farming in terms of environmental impact, cost, and soil quality.	K4 - Analyze
CO5	Assess the advantages and limitations of organic farming and vermicomposting for farmers and society.	K5 - Evaluate
CO6	Design a small-scale vermicompost/organic input production unit.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	Introduction to Organic farming: Concept, principles, and objectives of organic farming; Difference between organic farming and conventional	6

	farming; Scope and importance of organic farming in sustainable agriculture; Advantages and limitations of organic farming; National and international organic farming programs.	
II	Organic inputs and soil fertility management: Importance of Soil health, soil layers and soil fertility in plant growth; Organic manures: Farmyard manure (FYM), compost, green manure, and natural biofertilizers; Integrated nutrient management. Organic pest and disease management. Biopesticides — natural alternatives to chemical pesticides. Crop rotation and mixed cropping. Water conservation in organic farms.	6
III	Fundamentals of Vermi composting: Definition and Overview of Vermicomposting. Biology and ecology of earthworms. Types of earthworms used in vermicomposting. Conversion of suitable organic waste into rich compost (kitchen waste, crop residues, animal dung). Materials to be avoided in compost waste.	6
IV	Vermicomposting technology: Raw materials for vermicomposting, Stepwise process and methods in vermicompost production: Pit method, Bed method and Tank method; Environmental factors affecting vermicomposting (moisture, temperature, aeration, pH); Harvesting, processing, storage, and packaging of vermicompost; Quality parameters and nutrient composition of vermicompost; Vermiwash production and applications. Properties of good vermicompost. Method of application of vermicompost in garden or field.	6
V	Applications and Entrepreneurship: Benefits of organic farming and vermicompost. Challenges faced by organic farmers (cost, time, awareness, market access). Scope of organic farming and vermicomposting as a livelihood option and entrepreneurship opportunities. Success stories of organic farming. Role of organic farming in achieving Sustainable Development Goals (SDGs). Government schemes and support programs for organic agriculture	6
Total		**30**

Text Books

1	Palaniappan, S.P. & Annadurai, K. (2018). *Organic Farming: Theory and Practice* (3rd Ed.). Scientific Publishers, Jodhpur.
2	Reddy, S.R. (2017). *Principles of Organic Farming*. Kalyani Publishers, New Delhi.
3	Dahama, A.K. (2015). *Organic Farming for Sustainable Agriculture*. Agrobios (India), Jodhpur.
4	Sathe, T.V. (2014). *Vermiculture and Organic Farming*. Daya Publishing House, New Delhi.
5	Edwards, C.A., Arancon, N.Q. & Sherman, R.L. (2011). *Vermiculture Technology: Earthworms, Organic Wastes and Environmental Management*. CRC Press.

6	Walia, S.S. & Dhaliwal, G.S. (2010). *Fundamentals of Organic Farming and Gardening*. 1st Edition. Kalyani Publishers, New Delhi, India.
7	Kuhad, M.S. (2019). *Organic Farming: Principles and Practices*. 1st Edition. New India Publishing Agency (NIPA), New Delhi, India.
8.	Ghosh, P.K., Bandyopadhyay, K.K., Manna, M.C. & Misra, A.K. (2015). *Organic Farming for Sustainable Agriculture*. 1st Edition. Agrotech Publishing Academy, Udaipur, India.
Reference Books	
1	International Federation of Organic Agriculture Movements (IFOAM). (2017). *Principles of Organic Agriculture*. Revised Edition. IFOAM – Organics International, Bonn, Germany.
2	Manyuchi, M.M. (2013). *Vermicomposting of Organic Wastes: A Sustainable Approach to Waste Management*. 1st Edition. LAP Lambert Academic Publishing, Saarbrücken, Germany.
3	National Institute of Open Schooling (NIOS). (2020). *Organic Farming and Soil Conservation*. Revised Edition. National Institute of Open Schooling, Noida, India.
4	National Council of Educational Research and Training (NCERT). (2022). *Sustainable Management of Natural Resources and Soil Conservation* (Supplementary Resource Material). Latest Edition. NCERT, New Delhi, India.
5	Edwards, C.A., Arancon, N.Q. & Sherman, R.L. (2011). *Vermiculture Technology: Earthworms, Organic Wastes and Environmental Management*. 2nd Edition. CRC Press, Boca Raton, Florida, USA.
Web Resources	
1	https://ncof.dacnet.nic.in. National Centre of Organic and Natural Farming (NCONF) (Government of India resource on organic farming, certification, and organic inputs)
2	https://pgsindia-ncof.gov.in/PKVY. Paramparagat Krishi Vikas Yojana (PKVY) (Government scheme promoting organic farming in India)
3	https://icar.org.in Indian Council of Agricultural Research (ICAR) (Research publications and technologies related to organic agriculture)
4	https://www.fao.org/organicag. Food and Agriculture Organization (FAO) – Organic Agriculture (Global information on organic farming practices and sustainability)
5	https://www.fibl.org/en. Research Institute of Organic Agriculture (FiBL) (International research reports and statistics on organic farming)
6	https://www.ifoam.bio. International Federation of Organic Agriculture Movements (IFOAM Organics International) (Global standards, policies, and organic agriculture resources)

7	https://www.ifoam.bio. National Bank for Agriculture and Rural Development (NABARD) (Entrepreneurship, vermicomposting units, and agricultural development programs)
8	https://vigyanprasar.gov.in. Vigyan Prasar – Organic Farming Resources (Educational materials on sustainable and organic farming practices)

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - II
Part - IV
Non Major Elective (NME) – II: B. Herbal Biotechnology in Alternative medicine

COURSE OBJECTIVE

To introduce students to the principles of herbal biotechnology and the role of medicinal plants and their bioactive compounds in traditional and alternative systems of medicine.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Provide fundamental knowledge on herbal biotechnology and alternative systems of medicine.	
LO2	Develop understanding of medicinal plants, phytochemicals, and their therapeutic significance.	
LO3	Introduce biotechnological approaches for conservation and enhancement of medicinal plants.	
LO4	Familiarize students with herbal drug preparation, quality control, and standardization procedures.	
LO5	Explore the role of herbal and alternative medicines in modern healthcare and wellness industries.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Recall the concepts, terminology, history, and scope of herbal biotechnology and alternative medicine systems.	K1 - Remember
CO2	Explain the classification, properties, and therapeutic importance of medicinal plants and phytochemicals.	K2 - Understand
CO3	Apply plant tissue culture and biotechnology techniques for conservation and propagation of medicinal plants.	K3 - Apply
CO4	Analyze methods of extraction, quality control, standardization, and safety assessment of herbal products.	K4 - Analyze
CO5	Evaluate the effectiveness and applications of herbal and alternative medicines in healthcare and wellness management.	K5 - Evaluate
CO6	Develop innovative ideas and sustainable strategies for herbal product development and medicinal plant resource management.	K6 - Create
COURSE CONTENT		

Unit	Content	No. of Hours
I	Definition, scope and importance of herbal biotechnology. History and development of herbal medicine. Ethnobotany and ethnomedicine. Traditional systems of medicine – Ayurveda, Siddha, Unani, Homeopathy and Folk medicine.	6
II	Classification of medicinal plants. Secondary metabolites and their significance. Alkaloids, flavonoids, tannins, terpenoids, glycosides and phenolic compounds. Therapeutic applications of medicinal plants. Important medicinal plants: *Ocimum sanctum, Aloe vera, Withania somnifera, Curcuma longa, Azadirachta indica and Phyllanthus amarus.*	6
III	Plant tissue culture techniques. Micropropagation of medicinal plants. Germplasm conservation. Production of secondary metabolites through cell and tissue culture. Genetic improvement of medicinal plants and cryopreservation.	6
IV	Collection and processing of medicinal plants. Extraction and isolation of herbal products. Standardization and quality control of herbal medicines. WHO guidelines for herbal drugs. Safety evaluation, toxicity studies and quality assurance practices.	6
V	Nutraceuticals and herbal supplements. Aromatherapy, naturopathy and complementary therapies. Herbal formulations and traditional healthcare products. Regulatory aspects, commercialization, entrepreneurship opportunities and future prospects of herbal biotechnology**.**	6
Total		**30**

Text Books

1	Chevallier, A. (2016). *Encyclopedia of Herbal Medicine* (3rd ed.). DK Publishing, London.
2	Malviya, N., & Malviya, S. (2017). *Herbal Drug Technology* (1st ed.). CBS Publishers & Distributors Pvt. Ltd., New Delhi.
3	Joshi, M.C. (Latest ed.). *Handbook of Indian Medicinal Plants*. Scientific Publishers, Jodhpur.
4	Jain, S.K. (2016). *Contribution to Indian Ethnobotany* (3rd ed.). Scientific Publishers, Jodhpur.
5	Sinha, R.K., & Sinha, S. (2018). *Ethnobiology* (1st ed.). Surabhi Publications, Jaipur.
6	Green, J. (2000). *The Herbal Medicine-Maker's Handbook: A Home Manual* (Revised ed.). Crossing Press, California.
7	Newall, C.A., Anderson, L.A., & Phillipson, J.D. (Latest ed.). *Herbal Medicines: A Guide for Health-Care Professionals*. Pharmaceutical Press, London.

Reference Books	
1	Horne, S., & Easley, T. (2016). *Modern Herbal Dispensatory: A Medicine-Making Guide*. North Atlantic Books, California.
2	Malviya, N., & Malviya, S. (2017). *Herbal Drug Technology* (1st ed.). CBS Publishers & Distributors Pvt. Ltd., New Delhi.
3	Usman, R.M., Darvhekar, V.M., Kumar, V.D., & Akhila, S.A. (2021). *Practical Book of Herbal Drug Technology*. Nirali Prakashan, Pune.
4	Joshi, M.C. (Latest ed.). *Handbook of Indian Medicinal Plants*. Scientific Publishers, Jodhpur.
5	Jain, S.K. (2016). *Contribution to Indian Ethnobotany* (3rd ed.). Scientific Publishers, Jodhpur.
	Pal, D.C., & Jain, S.K. (1998). *Tribal Medicine*. Naya Prakash Publishers, Kolkata.
Web Resources	
1	https://ayush.gov.in. Official portal providing information on Ayurveda, Siddha, Unani, Yoga, Naturopathy and Homeopathy systems of medicine.
2	https://nmpb.nic.in. Resource on medicinal plant conservation, cultivation, marketing and sustainable utilization of medicinal plants.
3	https://www.who.int/health-topics/traditional-complementary-and-integrative-medicine. Global guidelines, policies and reports on herbal and traditional medicine practices.
4	https://archive.org. Access to textbooks, medicinal plant biotechnology resources, pharmacognosy references and scientific literature.
5	https://nptel.ac.in. IIT and IISc online lectures on Biotechnology, Plant Biotechnology, Medicinal Plants and Herbal Drug Technology.
6	https://epgp.inflibnet.ac.in. UGC e-learning platform providing study materials on Ethnobotany, Pharmacognosy and Medicinal Plant Sciences.
7	https://epgp.inflibnet.ac.in. Information on medicinal and aromatic plants, cultivation technologies and herbal product development.
8	https://pubmed.ncbi.nlm.nih.gov. International database of peer-reviewed research articles on herbal medicine, phytochemistry and medicinal plant biotechnology.
9	https://www.who.int/publications. Research publications, healthcare guidelines and evidence-based studies on traditional medicine.
10	https://www.bgci.org. Resources on conservation, sustainable utilization and cultivation of medicinal plant resources worldwide.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
CLO6	3	3	3	3	3	3	3	3	3	3
Total	**16**	**12**	**14**	**12**	**11**	**12**	**16**	**12**	**12**	**12**
Average	**2.7**	**2.0**	**2.3**	**2.0**	**1.8**	**2.0**	**2.7**	**2.0**	**2.0**	**2.0**

Semester - II
Part - IV
SEC alternative to "Naan Mudhalvan" – 1: Mushroom Cultivation

COURSE OBJECTIVE

To acquaint students with the biology of edible mushrooms and to impart practical knowledge of spawn production, cultivation techniques, and post-harvest processing for self-employment opportunities.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	Provide fundamental knowledge of mushroom biology, classification, nutritional value, and economic importance.	
LO2	Develop skills in the selection of mushroom species, substrate preparation, spawn handling, and cultivation techniques.	
LO3	Train learners in managing environmental conditions required for successful mushroom production.	
LO4	Equip learners with the knowledge to identify and manage pests, diseases, and contamination in mushroom cultivation.	
LO5	Develop competencies in planning, record-keeping, cost analysis, marketing, and entrepreneurship related to mushroom production.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Describe the biology, classification, nutritional value, and economic significance of mushrooms.	K1 - Remember
CO2	Recognize the commercially important mushroom species and select suitable cultivation methods.	K2 - Understand
CO3	Prepare substrates, spawn, and cultivation beds using standard procedures and hygienic practices.	K3 - Apply
CO4	Study the appropriate environmental management techniques for successful mushroom growth and production.	K4 - Analyze
CO5	Assess the basic business plans, maintain production records, and evaluate the economic feasibility of mushroom enterprises.	K5 - Evaluate
CO6	Formulate experimental approaches to investigate gene structure, expression, and regulatory mechanisms.	K6 - Create

COURSE CONTENT

Unit	**Content**	**No. of Hours**

I	Definition and characteristics of mushrooms, History of mushroom cultivation, Scope and importance of mushroom cultivation, Nutritional and medicinal value of mushrooms, Types of mushrooms – edible and poisonous, Morphology and life cycle of mushrooms.	6
II	Common cultivated mushrooms: Oyster mushroom (*Pleurotus*), Button mushroom (*Agaricus bisporus*), Milky mushroom, Paddy straw mushroom. Environmental conditions required: Temperature, Humidity, Light, Ventilation, Infrastructure and equipment for mushroom cultivation, Selection of substrates and growth media.	6
III	Pure culture techniques, Spawn preparation and multiplication, Sterilization and sanitation methods, Compost preparation, Bed preparation and spawning, Spawn running and crop management, Fruiting and cropping conditions.	6
IV	Harvesting methods, Grading and packaging, Short-term and long-term storage, Preservation techniques, Value added products / recipes, Quality assurance, Packing and packaging, Market opportunities.	6
V	Common diseases in mushrooms: Fungal diseases, Bacterial diseases, Viral diseases, Insect pests, mites, and nematodes, Contamination and competitor molds, Prevention and control measures, Integrated Pest Management (IPM).	6
Total		**30**

Text Books

1	Pandey, R.K., & Ghosh, S.K. (2018). *A Handbook of Mushroom Cultivation* (7th Ed.). Emkay Publications, New Delhi.
2	Pathak, V.N., & Yadav, N. (2013). *Mushroom Production and Processing Technology* (9th Ed.). Agrobios (India), Jodhpur.
3	Bahl, N. (2000). *Handbook of Mushrooms* (Vols. I & II, 6th Ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
4	Tewari, P., & Kapoor, S.C. (1988). *Mushroom Cultivation* (3rd Ed.). Mittal Publications, New Delhi.
5	Suman, B.C., & Sharma, V.P. (2007). *Mushroom Cultivation, Processing and Uses* (6th Ed.). IBDC Publishers, India.

Reference Books

1	Tewari, P.K. (1986). *Mushroom Cultivation in India* (1st Ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
2	Chang, S.T., & Miles, P.G. (2004). *Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact* (2nd Ed.). CRC Press, Taylor & Francis Group.
3	Quimio, T.H., Chang, S.T., & Royse, D.J. (1990). *Technical Guidelines for Mushroom Growing in the Tropics* (1st Ed.). FAO, Rome.

4	Singh, R.P., & Kamal, S. (2005). *Mushroom Production and Management* (1st Ed.). Book Distributing Company, Lucknow.
5	Pathak, V.N., Yadav, N., & Gaur, M. (2000). *Mushroom Production and Processing Technology* (1st Ed.). Agrobios (India), Jodhpur.
Web Resources	
1	https://www.fao.org. Provides technical manuals, cultivation guidelines, and sustainable agriculture resources.
2	https://www.icar.org.in. Offers research updates, training materials, and extension resources on mushroom production.
3	https://nhb.gov.in. Information on horticulture schemes, subsidies, and mushroom cultivation support.
4	https://kvk.icar.gov.in. Practical training materials, demonstrations, and farmer-friendly technologies.
5	https://www.mushroomcouncil.org. Nutritional information, industry trends, and global mushroom consumption data
6	https://swayam.gov.in. Offers agricultural and horticulture-related courses including mushroom cultivation modules.
7	https://ecourses.icar.gov.in. Free agricultural e-learning courses with practical and theoretical content.
8	https://nptel.ac.in. Video lectures on biology, microbiology, and agricultural sciences.
9	https://agmoocs.in. Specialized agricultural training modules including mushroom production technologies.
10	https://www.coursera.org, https://www.edx.org. International courses on food production, agribusiness, and sustainable farming.

TEACHING METHODOLOGY AND TEACHING AIDS

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar/assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CLO1	3	2	1	1	2	1	2	-	1
CLO2	3	3	1	2	2	1	3	1	2
CLO3	2	3	1	3	2	1	3	2	2
CLO4	2	3	1	3	3	2	2	2	2
CLO5	2	3	2	2	2	3	1	1	3
CLO6	2	2	2	2	2	1	1	-	1
TOTAL	**12**	**16**	**8**	**13**	**13**	**9**	**12**	**6**	**11**
AVERAGE	**2.3**	**2.6**	**1.3**	**2.1**	**2.1**	**1.5**	**2.0**	**1.0**	**1.8**

Semester - III
Part - IV
SEC alternative to "Naan Mudhalvan" – 2: Agri-Biotechnology

COURSE OBJECTIVE

To introduces students to the principles and hands-on practices of agribiotechnology applicable to sustainable food production. It covers organic farming, vermicomposting, hydroponics, and urban farming, equipping students with employable, entrepreneurship-oriented skills that connect biotechnology with modern, resource-efficient and environmentally sustainable agricultural systems.

LEARNING OBJECTIVE: **On successful completion of the course, students will be able to**		
LO1	To introduce the fundamental concepts, principles, and scope of organic farming as a sustainable alternative to conventional agriculture.	
LO2	To familiarize students with the biology of earthworms and the scientific process of vermicomposting for organic waste management and soil enrichment.	
LO3	To impart knowledge of hydroponic systems, nutrient solution management, and soilless crop production technologies.	
LO4	To develop an understanding of urban farming models, space-efficient cultivation techniques, and their role in urban food security.	
LO5	To enable students to design and set up small-scale organic farming, vermicomposting, and hydroponic units through practical exposure.	
LO6	To cultivate skills for self-employment and entrepreneurship in sustainable agribiotechnology-based enterprises.	
COURSE OUTCOME: **Upon successful completion, students will have the knowledge and skills to**		
CO1	Explain the principles of organic farming and differentiate it from conventional agricultural practices.	K2, K4 – Understand, Analyze
CO2	Demonstrate the process of vermicomposting, including earthworm handling and vermibed maintenance.	K3 - Apply
CO3	Set up and manage a basic hydroponic system for soilless crop cultivation.	K3- Apply
CO4	Apply space-efficient urban farming techniques suited to limited urban environments.	K3 - Apply

CO5	Design a small-scale, sustainable agribiotechnology-based enterprise integrating organic farming, vermicomposting, hydroponics, or urban farming	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Organic farming and Vermicomposting:** Organic farming: definition, principles, scope, and importance. Difference between organic and conventional farming. Organic manures - farmyard manure, green manure, compost. Vermicomposting: definition, process, and biochemical changes. Earthworm biology and ecological classification. Selection of suitable earthworm species. Vermibed construction, feed materials, and maintenance. Vermiwash preparation and applications.	6
II	**Biofertilizers**: Definition, scope, and importance in sustainable agriculture. Types of biofertilizers - nitrogen-fixing (*Rhizobium*, *Azotobacter*, *Azospirillum*, blue-green algae/*Anabaena-Azolla*), phosphate-solubilizing bacteria (PSB), potassium-mobilizing biofertilizers, and mycorrhizal (VAM) biofertilizers. Mass production technology of biofertilizers. Vermicompost as an organic fertilizer- nutrient value and impact on soil health.	6
III	**Biopesticides**: definition, classification, and role in integrated pest management (IPM). Microbial biopesticides — bacterial (*Bacillus thuringiensis*), fungal (*Trichoderma viride*, *Trichoderma harzianum*), and bacterial biocontrol agents (*Pseudomonas fluorescens*). Viral biopesticides Nuclear Polyhedrosis Virus (NPV). Botanical biopesticides — neem-based formulations (azadirachtin) and other plant-derived pesticides. Mass production and fermentation technology of microbial biopesticides. Formulation types — wettable powder, liquid concentrate, and granules. Quality standards, shelf-life determination, and safety/toxicity considerations	6
IV	**Hydrophonics:** Hydroponics: principles and history of soilless cultivation. Types of hydroponic systems — Nutrient Film Technique (NFT), Deep Water Culture (DWC), wick system, drip system, ebb and flow. Growing media (cocopeat, perlite, rockwool). Nutrient solution preparation, pH and EC management. Advantages and limitations of hydroponics over soil-based cultivation. Crops suited for hydroponic production.	6
V	**Urban farming:** Urban farming: concept, scope, and relevance to food security in cities. Space-efficient methods: terrace/rooftop gardening, vertical farming, container gardening, community gardens. Urban composting and waste recycling for city agriculture. Policy support and case	6

	studies of successful urban farming initiatives. Challenges of urban agriculture - space, zoning, and resource constraints.	
Total		**30**
Text Books		
1	Singh, A. K. (2022). Textbook of Organic Farming (1st ed.). Astral International Pvt. Ltd.	
2	Das, S. K. (Ed.). (2020). Organic Agriculture (1st ed.). IntechOpen.	
3	Badwaik, V. (2025). Textbook of Vermiculture and Vermicomposting (1st ed.). Bhumi Publishing.	
4	Jones, J. B., Jr. (2005). Hydroponics: A Practical Guide for the Soilless Grower (2nd ed.). CRC Press.	
5	Morgan, L. (2021). Hydroponics and Protected Cultivation: A Practical Guide (1st ed.). CABI.	
6	Fox, T. J. (2018). Urban Farming: Sustainable City Living in Your Backyard, in Your Community, and in the World (2nd ed.). CompanionHouse Books.	
Reference Books		
1	Raviv, M., & Lieth, J. H. (Eds.). (2008). Soilless Culture: Theory and Practice (1st ed.). Elsevier.	
2	Turan, M., & Yildirim, E. (Eds.). (2022). New Generation of Organic Fertilizers (1st ed.). IntechOpen.	
3	Samer, M. (Ed.). (2016). Urban Agriculture (1st ed.). IntechOpen.	
4	Kumari, V., Junuthula, S., & Mandapaka, R. T. (2021). Urban Farming: An Alternative Strategy for Food and Nutritional Security (1st ed.). National Institute of Agricultural Extension Management (MANAGE).	
5	Singh, B., Singh, B., Sabir, N., & Hasan, M. (Eds.). (2014). Advances in Protected Cultivation (1st ed.). New India Publishing Agency.	
6	Awasthi, L. P. (Ed.). (2024). Advances in Organic Farming (1st ed.). CABI.	
Web Resources		
1	National Centre for Organic and Natural Farming (NCONF), Ministry of Agriculture & Farmers Welfare, Government of India: https://nconf.dac.gov.in/	
2	PGS-India — Participatory Guarantee System for Organic Certification: https://pgsindia-ncof.gov.in/	
3	TNAU Agritech Portal — Organic Farming, Tamil Nadu Agricultural University: https://agritech.tnau.ac.in/org_farm/index.html	
4	FAO — Urban and Peri-urban Agriculture, Food and Agriculture Organization of the United Nations: https://www.fao.org/urban-peri-urban-agriculture/en	

5	ICAR—Indian Institute of Horticultural Research — Hydroponics and Soilless Cultivation Technologies: https://iihr.res.in/technologies
6	ICAR—National Rice Research Institute — Vermicompost Technology: https://icar-nrri.in/
7	Council on Energy, Environment and Water (CEEW) — State of Vermicomposting in India: https://www.ceew.in/publications/sustainable-agriculture-india/vermicomposting
8	IntechOpen — Open Access Repository on Organic Agriculture and Soilless Cultivation: https://www.intechopen.com

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	2	1	2	1	1	1	2	1	1	1
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	**12**	**8**	**11**	**8**	**7**	**8**	**12**	**8**	**8**	**8**
AVERAGE	2.4	1.6	2.2	1.6	1.4	1.6	2.4	1.6	1.6	1.6

Semester - IV
Part - IV
SEC alternative to Naan "Mudhalvan" – 3: Sericulture & Apiculture

COURSE OBJECTIVE

To provide students with knowledge of silkworm rearing, silk production and beekeeping practices and their economic significance.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To introduce the biology and rearing practices of silkworms.	
LO2	To explain the process of silk production from cocoon to reeling.	
LO3	To familiarise students with honeybee biology and beekeeping practices.	
LO4	To create awareness of the economic importance of sericulture and apiculture.	
LO5	To develop practical awareness of pest and disease management strategies in silkworm rearing and beekeeping.	
LO6	To create an understanding of value-added products and entrepreneurship opportunities in sericulture and apiculture.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Describe the life cycle and biology of the silkworm.	K1 - Remember
CO2	Explain mulberry cultivation and silkworm rearing practices.	K2 - Understand
CO3	Identify common diseases of silkworm and their management.	K3 - Apply
CO4	Describe honeybee biology, castes and colony organisation.	K2 - Understand
CO5	Evaluate beekeeping practices and products of apiculture.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	**Introduction to Sericulture:** History and scope of sericulture in India; Types of silk and silkworms; Life cycle of *Bombyx mori*; Mulberry varieties and cultivation practices; Sericulture as a cottage industry	6
II	**Silkworm Rearing and Silk Production:** Rearing house and equipment; Rearing techniques - chawki and late-age rearing; Mounting and cocoon harvesting; Silk reeling and processing; Grading and marketing of silk	6
III	**Silkworm Diseases and Management:** Common diseases - grasserie, flacherie, muscardine; Pebrine disease and its control; Pests of silkworm; Disinfection and hygienic rearing practices; Integrated disease management	6

IV	**Introduction to Apiculture:** Species of honeybees and their distribution; Honeybee colony organization - queen, worker, drone; Life cycle of honeybee; Bee foraging behaviour and communication (dance language) Economic importance of bees – pollination.	6
V	**Beekeeping Practices and Products:** Beehive types and apiary management; Bee pasturage and seasonal management; Honey extraction and processing; Products of apiculture - wax, propolis, royal jelly, venom; Marketing and value addition of bee products.	6
Total		**30**

Text Books	
1	Jolly M.S., Sen S.K. & Ahsan M.M. (1979). Appropriate Sericulture Techniques (1st Edition). Central Sericultural Research and Training Institute, Mysore.
2	Gupta P.K. (2010). Beekeeping for Beginners (1st Edition). Agrobios, Jodhpur.
3	Krishnaswami S. (1978). New Technology of Silkworm Rearing (1st Edition). Central Silk Board, Bangalore.
4	Dandin S.B. & Giridhar K. (2014). Handbook of Sericulture Technologies (1st Edition). Central Silk Board, Bangalore.
5	Ruttner F. (1988). Biogeography and Taxonomy of Honeybees (1st Edition). Springer-Verlag, Berlin.
6	Thangavelu K. (1993). Sericulture (1st Edition). Oxford & IBH Publishing, New Delhi.
Reference Books	
1	Sengupta K. (1989). Silkworm Rearing Technology (1st Edition). Oxford & IBH Publishing, New Delhi.
2	Free J.B. (1982). Bees and Mankind (1st Edition). George Allen & Unwin, London.
3	Narayanaswamy K.C. (2003). Sericulture and Silk Production (1st Edition). Kalyani Publishers, New Delhi.
4	Winston M.L. (1987). The Biology of the Honey Bee (1st Edition). Harvard University Press, Cambridge.
5	Morse R.A. & Hooper T. (Eds.) (1985). The Illustrated Encyclopedia of Beekeeping (1st Edition). E.P. Dutton, New York.
6	Tazima Y. (1978). The Silkworm: An Important Laboratory Tool (1st Edition). Kodansha, Tokyo.
Web Resources	
1	Central Silk Board, Government of India: https://csb.gov.in
2	NPTEL - Sericulture and Apiculture resources: https://nptel.ac.in
3	National Bee Board, Government of India: https://nbb.gov.in
4	International Sericultural Commission (ISC): https://inserco.org
5	Food and Agriculture Organization - Beekeeping and Bee Products: https://www.fao.org
6	Bee Informed Partnership: https://beeinformed.org

7	Central Sericultural Research and Training Institute (CSRTI), India: https://csrtimysore.res.in
8	Khadi and Village Industries Commission (KVIC) - Beekeeping: https://www.kviconline.gov.in

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	2	1	2	1	1	1	2	1	1	1
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	**12**	**8**	**11**	**8**	**7**	**8**	**12**	**8**	**8**	**8**
AVERAGE	2.4	1.6	2.2	1.6	1.4	1.6	2.4	1.6	1.6	1.6

Semester - V
Part - IV
SEC alternative to "Naan Mudhalvan" – 4: Forensic Science

COURSE OBJECTIVE

To introduce students to the principles and techniques of forensic science and their applications in criminal investigation.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To introduce the scope and principles of forensic science.	
LO2	To explain methods of crime scene investigation and evidence collection.	
LO3	To provide knowledge of DNA fingerprinting techniques used in forensic analysis.	
LO4	To create awareness of the applications of forensic science in legal investigations.	
LO5	To develop an understanding on forensic toxicology through case study analysis	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Describe the scope and branches of forensic science.	K1 - Remember
CO2	Explain procedures for crime scene investigation and evidence handling.	K2 - Understand
CO3	Identify biological evidence such as blood and body fluids.	K3 - Apply
CO4	Analyse DNA fingerprinting techniques used in forensic identification.	K4 - Analyze
CO5	Evaluate applications of forensic science in paternity and wildlife cases.	K5 - Evaluate

COURSE CONTENT

Unit	Content	No. of Hours
I	**Introduction to Forensic Science:** History, scope and branches of forensic science; Crime scene investigation – protocols; Chain of custody of evidence; Types of physical evidence;Role of forensic laboratories	6
II	**Forensic Biology:** Identification of blood and blood stains; Identification of semen, saliva and other body fluids; Hair and fibre analysis; Forensic serology techniques; Species identification from biological samples	6
III	**DNA Fingerprinting:** Principle of DNA fingerprinting; STR analysis and its applications; PCR-based DNA profiling; DNA databases and analysis CODIS for DNA forensics; Interpretation of DNA profiles	6

IV	**Forensic Toxicology and Entomology:** Common poisons and their detection; Drug and alcohol analysis; Principles of forensic entomology; Estimation of time since death using insect evidence; Case studies in toxicology	6
V	**Applications of Forensic Science:** Paternity testing using DNA analysis; Wildlife forensics - species and product identification; Forensic anthropology - skeletal identification; Introduction to cyber and digital forensics; Forensic science and the legal system	6
Total		**30**

Text Books	
1	Sharma B.R. (2014). Forensic Science in Criminal Investigation and Trials (5th Edition). Universal Law Publishing, New Delhi.
2	Saferstein R. (2017). Criminalistics: An Introduction to Forensic Science (12th Edition). Pearson, Boston.
3	James S.H. & Nordby J.J. (2014). Forensic Science: An Introduction to Scientific and Investigative Techniques (4th Edition). CRC Press, Boca Raton.
4	Kobilinsky L. (Ed.) (2012). Forensic Chemistry Handbook (1st Edition). John Wiley & Sons, Hoboken.
5	Houck M.M. & Siegel J.A. (2015). Fundamentals of Forensic Science (3rd Edition). Academic Press, San Diego.
6	Bell S. (2013). Forensic Chemistry (2nd Edition). Pearson, Boston.

Reference Books	
1	Butler J.M. (2011). Forensic DNA Typing: Biology, Technology and Genetics of STR Markers (2nd Edition). Academic Press, San Diego.
2	Goodman A. & Rathbun T.A. (1984). Forensic Anthropology (1st Edition). Charles C. Thomas, Springfield.
3	Nickell J. & Fischer J.F. (1999). Crime Science: Methods of Forensic Detection (1st Edition). University Press of Kentucky, Lexington.
4	Gaensslen R.E., Harris H.A. & Lee H.C. (2008). Introduction to Forensic Science and Criminalistics (1st Edition). McGraw-Hill, New York.
5	Byrd J.H. & Castner J.L. (Eds.) (2010). Forensic Entomology: The Utility of Arthropods in Legal Investigations (2nd Edition). CRC Press, Boca Raton.
6	Jain V.K. (2015). Forensic Science and Criminology (1st Edition). Selective and Scientific Books, New Delhi.

Web Resources	
1	Directorate of Forensic Science Services, Government of India: https://dfs.gov.in
2	NPTEL - Forensic Science resources: https://nptel.ac.in
3	Interpol Forensic Science resources: https://www.interpol.int
4	Central Forensic Science Laboratory (CFSL), India: https://cfsl.gov.in

5	American Academy of Forensic Sciences (AAFS): https://www.aafs.org
6	National Institute of Justice (NIJ) - Forensic Science Resources: https://nij.ojp.gov
7	Federal Bureau of Investigation (FBI) - Forensic Science Resources: https://www.fbi.gov
8	European Network of Forensic Science Institutes (ENFSI): https://enfsi.eu

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	3	2	2	2	2	2	3	2	2	2
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	3
TOTAL	**13**	**9**	**11**	**9**	**8**	**9**	**13**	**9**	**9**	**9**
AVERAGE	2.6	1.8	2.2	1.8	1.6	1.8	2.6	1.8	1.8	1.8

Semester - VI

Part - IV

SEC alternative to "Naan Mudhalvan" – 5: Pharmaceutical Biotechnology

COURSE OBJECTIVE

This course introduces students to the application of biotechnology in the discovery, development, production and quality control of pharmaceutical products. The syllabus covers recombinant therapeutics, vaccine and monoclonal antibody production, the drug discovery and development pipeline, novel drug delivery systems and regulatory affairs. The course prepares students for careers in the biopharmaceutical and pharmaceutical biotechnology industry.

LEARNING OBJECTIVE:		
On successful completion of the course, students will be able to		
LO1	To introduce the principles and processes involved in pharmaceutical biotechnology.	
LO2	To explain the production of recombinant therapeutic proteins and vaccines.	
LO3	To describe monoclonal antibody technology & biosimilar production and its therapeutic applications.	
LO4	To create awareness of drug delivery systems and regulatory affairs in the pharmaceutical industry	
LO5	To familiarize about gene therapy approaches and their clinical translation in modern pharmaceutical biotechnology.	
COURSE OUTCOME:		
Upon successful completion, students will have the knowledge and skills to		
CO1	Describe the scope and historical development of pharmaceutical biotechnology.	K1 - Remember
CO2	Explain the production processes of recombinant insulin, interferons and monoclonal antibodies.	K2 - Understand
CO3	Apply the stages of drug discovery and clinical trial design in pharmaceutical development.	K3 - Apply
CO4	Analyze novel drug delivery systems for improved therapeutic efficacy.	K4 - Analyze
CO5	Evaluate gene therapy and RNA-based therapeutic approaches.	K5 - Evaluate
CO6	Formulate quality assurance and regulatory strategies compliant with GMP and ICH guidelines.	K6 - Create

COURSE CONTENT

Unit	Content	No. of Hours
I	**Introduction to Pharmaceutical Biotechnology:** Scope of pharmaceutical biotechnology; Overview of the drug discovery and development process; biopharmaceuticals versus conventional drugs, sources of drugs - natural,	6

	synthetic and biotechnological Target identification and validation; High-throughput screening; Basic concepts in Pharmacokinetics and pharmacodynamics	
II	**Recombinant Therapeutics:** Production of recombinant insulin; Production of recombinant growth hormone; Types and Production of Vaccines: Recombinant vaccines (Hepatitis B vaccine) and DNA vaccines. Erythropoietin, Interferons and interleukins as therapeutics; Quality control of biopharmaceuticals. Hybridoma technology - production of monoclonal antibodies; Humanised and chimeric antibodies; Therapeutic applications of monoclonal antibodies; Concept of biosimilars; Antibody-drug conjugates.	6
III	**Drug Discovery and Development** Stages of drug discovery, high throughput screening, combinatorial chemistry, principles of pharmacokinetics and pharmacodynamics, preclinical studies, clinical trial phases (I-IV) and regulatory approval process.	6
IV	**Drug Delivery Systems and Gene Therapy:** Conventional versus novel drug delivery systems; Novel drug delivery systems: Liposomes, nanoparticle-based delivery, transdermal; Controlled release systems and targeted drug delivery. Principles of gene therapy; Viral and non-viral vectors in gene therapy. Antisense therapy and SiRNA- based therapeutics.	6
V	**Quality Control & Regulatory Affairs in Pharma Biotechnology:** Good Manufacturing Practices (GMP) and Good Laboratory Practices, . quality assurance in the pharmaceutical industry Clinical trial phases. Regulatory bodies - CDSCO, USFDA and ICH guidelines. Intellectual property rightsand patenting in biopharmaceuticals. Fundamentals of Pharmacovigilance.	6
Total		**30**

Text Books

1	Vyas S.P. & Dixit V.K. (2013). Pharmaceutical Biotechnology (1st Edition). CBS Publishers, New Delhi.
2	Walsh G. (2013). Pharmaceutical Biotechnology: Concepts and Applications (1st Edition). Wiley, Chichester.
3	Crommelin D.J.A., Sindelar R.D. & Meibohm B. (Eds.) (2019). Pharmaceutical Biotechnology: Fundamentals and Applications (5th Edition). Springer, Cham.
4	Ratledge C. & Kristiansen B. (Eds.) (2006). Basic Biotechnology (3rd Edition). Cambridge University Press, Cambridge.
5	Groves M.J. (2006). Pharmaceutical Biotechnology (2nd Edition). CRC Press, Boca Raton.
6	Walsh, G. 2013. Pharmaceutical Biotechnology: Concepts and Applications. Wiley-Blackwell

Reference Books

1	Kayser O. & Warzecha H. (2012). Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications (2nd Edition). Wiley-VCH, Weinheim.
2	Chirino A.J. & Mire-Sluis A. (2004). Characterization of Protein Therapeutics (1st Edition). Springer, New York.
3	Satyanarayana U. (2016). Biotechnology (4th Edition). Books and Allied, Kolkata.
4	Nair R. & Jacob S. (2016). Concise Textbook of Pharmaceutical Biotechnology (1st Edition). Jaypee Brothers Medical Publishers, New Delhi.
5	Templeton N.S. (Ed.) (2015). Gene and Cell Therapy: Therapeutic Mechanisms and Strategies (4th Edition). CRC Press, Boca Raton.
6	Walsh G. (2018). Biopharmaceuticals: Biochemistry and Biotechnology (3rd Edition). Wiley, Chichester.
Web Resources	
1	NPTEL - Pharmaceutical Biotechnology: https://nptel.ac.in
2	Central Drugs Standard Control Organisation (CDSCO): https://cdsco.gov.in
3	US FDA - Biologics resources: https://www.fda.gov
4	European Medicines Agency (EMA) - Biosimilars Resources: https://www.ema.europa.eu
5	Pharmaceuticals Export Promotion Council of India (Pharmexcil): https://www.pharmexcil.com
6	International Pharmaceutical Federation (FIP): https://www.fip.org
7	BioPharma Reporter - Industry News and Resources: https://www.biopharma-reporter.com
8	World Health Organization - Biologicals and Biosimilars: https://www.who.int

Teaching Methodology and Teaching Aids

Unit	Teaching Methodology	Teaching Aids
Unit 1	Lecture with illustrated examples, Chalk-and-talk, Discussion	Whiteboard, LCD projector, Charts
Unit 2	PowerPoint presentation, Group discussion, Case study	PPT slides, Smart board, Models
Unit 3	Demonstration, Flipped classroom, Peer learning	Laboratory demonstration, Specimens/Videos
Unit 4	Seminar / assignment-based learning, Concept mapping	Journals, Online databases, Handouts
Unit 5	Video demonstration, Problem-based learning, Quiz	Documentary/video clips, Online simulations

MAPPING COURSE LEARNING OUTCOME WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOME

1 = Low correlation, 2 = Medium correlation, 3 = High correlation

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CLO1	2	1	2	1	1	1	2	1	1	1
CLO2	2	1	2	1	1	1	2	1	1	1
CLO3	2	1	2	1	1	1	2	1	1	1
CLO4	3	2	2	2	2	2	3	2	2	2
CLO5	3	3	3	3	2	3	3	3	3	2
CLO6	3	1	2	3	1	2	3	1	1	1
TOTAL	**15**	**9**	**13**	**11**	**8**	**10**	**15**	**9**	**9**	**8**
AVERAGE	**2.5**	**1.5**	**2.1**	**1.8**	**1.3**	**1.6**	**2.5**	**1.5**	**1.5**	**1.3**