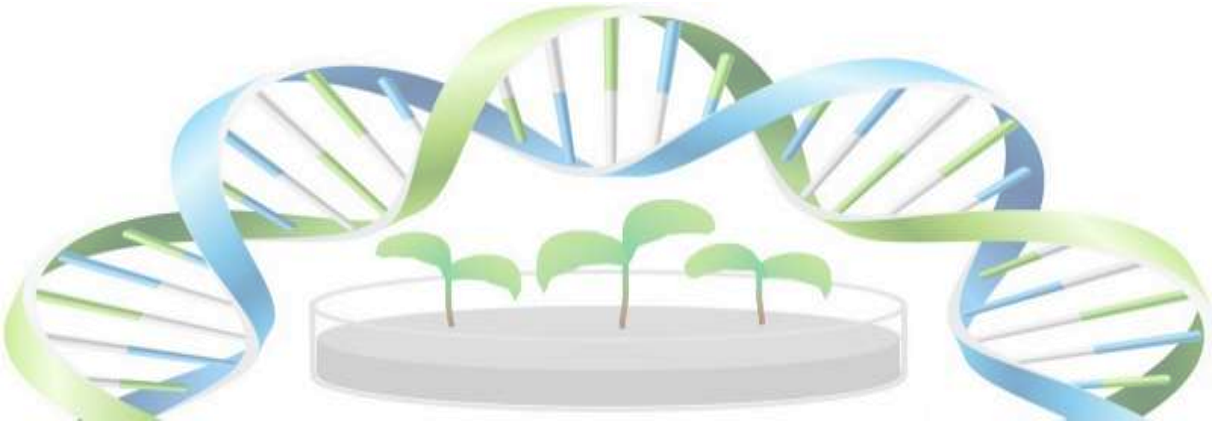
LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK (LOCF) FOR UNDERGRADUATE EDUCATION



BSc BIOTECHNOLOGY

DEPARTMENT OF BIOTECHNOLOGY

EMEA COLLEGE OF ARTS AND SCIENCE

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Aided by Govt. of Kerala & Affiliated to the University of Calicut,
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INTRODUCTION

EMEA College of Arts and Science, Kondotty, is fast emerging as a resourceful destination for higher studies in Malabar, spreading the fragrance of education in the society. The college offers up-to-date, advanced, and job-oriented programmes in the vast expanding horizon of humanities, commerece, and science and technology. The college – affiliated to the University of Calicut, is dedicated to nurturing academic excellence, fostering a culture of research and innovation, and promoting community engagement. Established with a commitment to high-quality education and holistic development, the College aligns its programs with the Learning Outcomes-Based Curriculum Framework (LOCF), ensuring that students acquire not only subject expertise but also skills relevant to real-world applications.

From an LOCF perspective, EMEA College's curriculum prioritizes outcome-based learning, aiming to produce graduates equipped with critical thinking, effective communication, cultural sensitivity, and social responsibility. The College's pedagogical approach integrates both theoretical knowledge and practical experience, creating a learning environment that responds to the dynamic needs of today's society. By mapping program outcomes (POs) and course outcomes (COs) in alignment with UGC's LOCF guidelines, EMEA College ensures that each course contributes to a cohesive learning journey that enhances employability, research capability, and lifelong learning.

In its pursuit of excellence, EMEA College fosters a supportive academic community that encourages students to engage deeply with their disciplines, appreciate diverse perspectives, and contribute meaningfully to their communities. Through this LOCF-aligned curriculum, the College aims to prepare its graduates to meet global challenges while remaining rooted in local values and responsibilities.

VISION AND MISSION OF THE COLLEGE

Vision

EMEA College envisions creating a transformative educational environment that inspires personal growth, social responsibility, and academic excellence. The College aims to become a beacon of higher learning that empowers students to lead meaningful lives, equipped with the knowledge and skills to contribute positively to society.

Mission

Identifying and developing the talent of the youth and moulding them into useful citizens with due emphasize on right character formation is the avowed mission of EMEA College. The fulfilment of this lofty goal is the basis of educational programes formulated and pursued by the institution. The mission of EMEA College of Arts and Science includes the following core objectives:

1. **Quality Education**: To provide high-quality, inclusive education that fosters intellectual and personal growth, enabling students to reach their fullest potential.
2. **Social Responsibility**: To cultivate a sense of responsibility toward the community, encouraging students to engage in social initiatives and contribute to societal well-being.
3. **Research and Innovation**: To promote a culture of research and innovation, encouraging critical inquiry, creative problem-solving, and continuous learning.
4. **Skill Development**: To equip students with essential life skills and competencies that enhance their employability and adaptability in a dynamic global environment.
5. **Community Empowerment**: To support the development of the local community through outreach and extension activities, addressing social and economic challenges.
6. **Sustainable Practices**: To foster sustainability and inclusivity within the College, embracing practices that promote environmental consciousness and ethical responsibility.

VISION AND MISSION OF THE DEPARTMENT OF BIOTECHNOLOGY

Vision

To pass on value and skill-based education and focus on research and innovation to gratify to the need of the country.

Mission

To convey quality technical and scientific education and produce Biologists, Biotechnologists, Environmental Engineers, Genetic Engineers, Molecular specialists, scientists and citizens who will contribute significantly to the growth and development of the country and outrival in various disciplines of knowledge.

Core Values

1. **Excellence**
   Commitment to achieving academic and research excellence in biotechnology through innovative teaching and scientific inquiry.
2. **Integrity**
   Upholding the highest ethical standards in education, research, and professional conduct.
3. **Innovation**
   Encouraging creativity and critical thinking to develop cutting-edge solutions in biotechnology for societal and industrial challenges.
4. **Sustainability**
   Promoting environmentally responsible practices and sustainable solutions in biotechnology.
5. **Collaboration**
   Fostering teamwork and partnerships across disciplines to enhance learning and research outcomes.
6. **Empowerment**
   Equipping students with knowledge, skills, and values to become responsible scientists and leaders in the field.
7. **Inclusivity**
   Creating an environment that values diversity, mutual respect, and equal opportunities for all students and faculty members.
8. **Service to Society**
   Applying biotechnological advancements for the betterment of public health, food security, and environmental conservation.

INTRODUCTION TO THE LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK (LOCF) FOR THE BSc BIOTECHNOLOGY PROGRAMME

The Learning Outcomes-Based Curriculum Framework (LOCF) for the **B.Sc. Biotechnology Programme** at EMEA College of Arts and Science, Kondotty, is designed to align with the guidelines set by the University Grants Commission (UGC) and reflects the institution's commitment to outcome-based education. This framework emphasizes a student-centered approach, where learning outcomes define the knowledge, skills, and values students are expected to achieve upon completing the program.

The LOCF for the B.Sc. Biotechnology Programme is crafted to provide a comprehensive understanding of core biotechnology concepts, laboratory techniques, and interdisciplinary applications while promoting critical thinking, problem-solving abilities, and ethical responsibility. It also addresses the evolving demands of academia, industry, and research, ensuring students acquire practical skills relevant to real-world challenges. By mapping Programme Outcomes (POs) and Course Outcomes (COs) for each course, the LOCF framework establishes a coherent structure for educational objectives, teaching methodologies, and assessment strategies, enhancing the overall effectiveness of the curriculum.

This LOCF equips students with the ability to analyze and solve biotechnological problems, apply innovative approaches in their field, and engage in lifelong learning. Ultimately, it aims to produce well-rounded graduates prepared for diverse professional and academic opportunities, enabling them to make meaningful contributions to society and sustainable development.

GRADUATE ATTRIBUTES FOR THE BSC BIOTECHNOLOGY PROGRAMME

Graduates of the B.Sc. Biotechnology Programme possess a strong foundation in scientific knowledge and critical thinking, enabling them to analyze and solve complex biological problems while understanding their broader societal and environmental implications. They demonstrate proficiency in both theoretical concepts and practical skills, effectively applying biotechnological techniques in laboratory and industrial settings. Equipped with solid research abilities, these graduates are skilled in designing experiments, analyzing data, and synthesizing information for innovative applications in biotechnology.

Their education fosters ethical responsibility and a commitment to sustainability, guiding them to address global challenges with integrity and a sense of social responsibility. Creativity and reflection are integral to their approach, encouraging innovative problem-solving and open-minded exploration of new scientific possibilities. Teamwork skills enable them to collaborate effectively, respecting diverse perspectives and contributing constructively in multidisciplinary environments.

In today's technologically driven world, graduates are proficient in using advanced digital tools for research, data analysis, and communication, ensuring they adapt seamlessly to technological advancements. With strong self-management skills, they excel in goal setting, time management, and lifelong learning, staying updated with the dynamic advancements in the field of biotechnology.

Finally, their global competency allows them to engage with international scientific advancements and practices, preparing them to contribute meaningfully in both local and global contexts. Together, these attributes equip graduates for successful careers in research, industry, academia, and other biotechnological fields, driving positive change in society and the environment.

GRADUATE ATTRIBUTES – DEPARTMENT OF BIOTECHNOLOGY

Graduates from the Department of Biotechnology at EMEA College of Arts and Science, Kondotty, are equipped with essential attributes for academic, professional, and societal success. They possess critical thinking skills to analyze biological systems and solve scientific problems, along with strong research competence to design experiments, interpret data, and apply findings effectively.

Key graduate attributes include:

1. Analytical Thinking: Ability to evaluate and solve complex biological problems.
2. Scientific Communication: Proficiency in articulating scientific concepts clearly.
3. Research Skills: Expertise in conducting and applying independent research.
4. Ethical Responsibility: Commitment to ethical practices and sustainability.
5. Practical Expertise: Mastery of advanced biotechnological tools and techniques.
6. Creativity and Innovation: Original thinking to address real-world challenges.
7. Collaborative Skills: Effective teamwork and respect for diverse perspectives.
8. Digital Literacy: Competence with modern tools for research and analysis.
9. Lifelong Learning: Commitment to continuous learning and professional growth.
10. Global Perspective: Awareness of global trends in biotechnology and adaptability.

These attributes prepare graduates to excel in research, industry, and beyond, contributing meaningfully to science, society, and the environment.

PROGRAMME OUTCOME

BSC BIOTECHNOLOGY

PO1	Acquire foundational knowledge in key areas of biotechnology, such as cell biology, genetics, microbiology, and biochemistry, to understand and address biological challenges.
PO2	Develop essential laboratory skills in biotechnological techniques, preparing students for hands-on research and industrial applications.
PO3	Enhance analytical skills to design experiments, analyze data, and solve problems in fields like healthcare, agriculture, and environmental science
PO4	Understand and apply ethical principles in biotechnology, with a focus on biosafety, environmental sustainability, and social responsibility.
P05	Build effective communication and teamwork skills for collaborating in multidisciplinary research and professional environments.
PO6	Foster a commitment to ongoing learning and adaptability to stay current with technological advancements in biotechnology.

COURSE OUTCOME

A **Course Outcome (CO)** is a specific statement detailing what students are expected to know, understand, or be able to do by the end of a particular course. Course Outcomes are measurable goals that focus on the skills, knowledge, attitudes, and competencies a student should acquire through completing the course.

Course Outcomes serve as a benchmark for both students and instructors, guiding the teaching and learning process. They are designed to align with the broader **Program Outcomes (POs)**, ensuring that each course contributes effectively to the overarching goals of the academic program.

SCHEME FOR THE PROGRAMME

MINIMUM CREDIT REQUIREMENTS OF THE DIFFERENT PATHWAYS

IN THE THREE-YEAR PROGRAMME IN CUFYUGP

Sl. No.	Academic Pathway	Major Each course has 4 credits	Minor/ Other Disciplines Each course has 4 credits	Foundation Courses AEC: 4 MDC: 3 SEC: 3 VAC: 3 Each course has 3 credits	Intern -ship	Total Credits	Example
1	Single Major (A)	68 (17courses)	24 (6courses)	39 (13 courses)	2	133	Major: Biotechnology + six courses in different discipline in different combinations
2	Major (A) with Multiple Disciplines (B, C)	68 (17 courses)	12 + 12 (3 + 3 = 6 courses)	39 (13 courses)	2	133	Major: Biotechnolo with Two different minores in other disciplines
3	Major (A) with Minor (B)	68 (17courses)	24 (6courses)	39 (13 courses)	2	133	Major: Biotechnology With One Minor
4	Major (A) with Vocational Minor (B)	68 (17courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Biotechnology With One Vocational Minor
5	Double Major (A, B)	A: 48 (12 courses) B: 44 (11courses)	- The 24 credits in the Minor stream are distributed between the two Majors. 2 MDC, 2 SEC, 2 VAC and the Internship should be in Major A. Total credits in Major A should be 48 + 20 = 68 (50% of 133) 1 MDC, 1 SEC and 1 VAC should be in Major B. Total credits in Major B should be 44 + 9 = 53 (40% of 133)	12 + 18 + 9	2	133	Biotechnology and Other major

Exit with UG Degree / Proceed to Fourth Year with 133 Credits

B.Sc. BIOTECHNOLOGY HONOURS PROGRAMME
COURSE STRUCTURE FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	BTY1CJ 101/ BTY1MN 100	Core Course 1 in Major – Fundamentals of Biotechnology	75	5	4	30	70	100
		Minor Course 1	60/ 75	4/ 5	4	30	70	100
		Minor Course 2	60/ 75	4/ 5	4	30	70	100
	ENG1FA 101(2)	Ability Enhancement Course 1– English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 1 – Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
2	BTY2CJ 101/ BTY2MN 100	Core Course 2 in Major – Applications of Biotechnology	75	5	4	30	70	100
		Minor Course 3	60/ 75	4/ 5	4	30	70	100
		Minor Course 4	60/ 75	4/ 5	4	30	70	100
	ENG2FA 103(2)	Ability Enhancement Course 3– English	60	4	3	25	50	75

		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 2 – Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
3	BTY3CJ 201	Core Course 3 in Major – Biochemistry I- Biomolecules	60	4	4	30	70	100
	BTY3CJ 202/ BTY3MN 200	Core Course 4 in Major – Cell Biology	75	5	4	30	70	100
		Minor Course 5	60/ 75	4/ 5	4	30	70	100
		Minor Course 6	60/ 75	4/ 5	4	30	70	100
		Multi-Disciplinary Course 3 – Kerala Knowledge System	45	3	3	25	50	75
	ENG3FV 108(2)	Value-Added Course 1 – English	45	3	3	25	50	75
		Total		**23/ 25**	**22**			**550**
4	BTY4CJ 203	Core Course 5 in Major – Biochemistry II- Metabolism	75	5	4	30	70	100
	BTY4CJ 204	Core Course 6 in Major – Genetics	75	5	4	30	70	100
	BTY4CJ 205	Core Course 7 in Major – Microbiology	75	5	4	30	70	100
	ENG4FV 109(2)	Value-Added Course 2 – English	45	3	3	25	50	75
		Value-Added Course 3 – Additional Language	45	3	3	25	50	75
	ENG4FS 111(2)	Skill Enhancement Course 1 – English	60	4	3	25	50	75

		Total		**25**	**21**			**525**
5	BTY5CJ 301	Core Course 8 in Major – Environmental Biotechnology	75	5	4	30	70	100
	BTY5CJ 302	Core Course 9 in Major – Plant Biotechnology	75	5	4	30	70	100
	BTY5CJ 303	Core Course 10 in Major – Molecular Biology	60	4	4	30	70	100
		Elective Course 1 in Major	60	4	4	30	70	100
		Elective Course 2 in Major	60	4	4	30	70	100
		Skill Enhancement Course 2	45	3	3	25	50	75
		Total		**25**	**23**			**575**
6	BTY6CJ 304/ BTY8MN 304	Core Course 11 in Major – Genetic Engineering	75	5	4	30	70	100
	BTY6CJ 305/ BTY8MN 305	Core Course 12 in Major– Bioprocess Technology	75	5	4	30	70	100
	BTY6CJ 306/ BTY8MN 306	Core Course 13 in Major – Animal Biotechnology	60	4	4	30	70	100
		Elective Course 3 in Major	60	4	4	30	70	100
		Elective Course 4 in Major	60	4	4	30	70	100
	BTY6FS 113	Skill Enhancement Course 3 – Clinical research and medical translation	45	3	3	25	50	75
	BTY6CJ 349	Internship in Major (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		**25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**
7	BTY7CJ 401	Core Course 14 in Major – Bio-entrepreneurship	75	5	4	30	70	100

	BTY7CJ 402	Core Course 15 in Major – OMICS for Biotechnology	75	5	4	30	70	100
	BTY7CJ 403	Core Course 16 in Major – Virology	75	5	4	30	70	100
	BTY7CJ 404	Core Course 17 in Major – IPR, Bioethics & Biosafety	75	5	4	30	70	100
	BTY7CJ 405	Core Course 18 in Major – Analytical techniques	75	5	4	30	70	100
		Total		**25**	**20**			**500**
8	BTY8CJ 406 / BTY8MN 406	Core Course 19 in Major – Phyto-medicine	75	5	4	30	70	100
	BTY8CJ 407 / BTY8MN 407	Core Course 20 in Major – Cancer biology	60	4	4	30	70	100
	BTY8CJ 408 / BTY8MN 408	Core Course 21 in Major – Biomaterials and nanotechnology	60	4	4	30	70	100
	OR (instead of Core Courses 20 and 21 in Major)							
	BTY8CJ 449	Project (in Honours programme)	360	13	12	60	140	200
	(instead of Core Courses 19 – 21 in Major)							
	BTY8CJ 499	Research Project (in Honours with Research programme)	360	13	12	90	210	300
		Elective Course 5 in Major / Minor Course 7	60	4	4	30	70	100
		Elective Course 6 in Major / Minor Course 8	60	4	4	30	70	100

		Elective Course 7 in Major / Minor Course 9 / Major Course in any Other Discipline	60	4	4	30	70	100
	OR (instead of Elective Course 7 in Major, in the case of Honours with Research Programme)							
	BTY8CJ 489	Research Methodology in Biotechnology	60	4	4	30	70	100
		Total		**25**	**24**			**600**
Total Credits for Four Years					**177**			**4425**

CREDIT DISTRIBUTION FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	**Major Courses**	**Minor Courses**	**General Foundation Courses**	**Internship/ Project**	**Total**
1	4	4 + 4	3 + 3 + 3	-	21
2	4	4 + 4	3 + 3 + 3	-	21
3	4 + 4	4 + 4	3 + 3	-	22
4	4 + 4 + 4	-	3 + 3 + 3	-	21
5	4 + 4 + 4 + 4 + 4	-	3	-	23
6	4 + 4 + 4 + 4 + 4	-	3	2	25
Total for Three Years	**68**	**24**	**39**	**2**	**133**
7	4 + 4 + 4 + 4 + 4	-	-	-	20
8	4 + 4 + 4	4 + 4 + 4	-	8* / 12**	24
* Instead of two Major courses; ** instead of three Major courses					
Total for Four Years	**88 + 12 = 100**	**36**	**39**	**2**	**177**

DISTRIBUTION OF MAJOR COURSES IN BIOTECHNOLOGY FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Course Code	Course Title	Hours/ Week	Credits
1	BTY1CJ 101 / BTY1MN 100	Core Course 1 in Major – Fundamentals of Biotechnology	5	4
2	BTY2CJ 101 / BTY2MN 100	Core Course 2 in Major – Applications of Biotechnology	5	4
3	BTY3CJ 201	Core Course 3 in Major – Biochemistry I- Biomolecules	4	4
	BTY3CJ 202 / BTY3MN 200	Core Course 4 in Major – Cell Biology	5	4
4	BTY4CJ 203	Core Course 5 in Major – Biochemistry II- Metabolism	5	4
	BTY4CJ 204	Core Course 6 in Major – Genetics	5	4
	BTY4CJ 205	Core Course 7 in Major – Microbiology	5	4
5	BTY5CJ 301	Core Course 8 in Major – Environmental Biotechnology	5	4
	BTY5CJ 302	Core Course 9 in Major – Plant Biotechnology	5	4
	BTY5CJ	Core Course 10 in Major – Molecular Biology	4	4

	303			
		Elective Course 1 in Major	4	4
		Elective Course 2 in Major	4	4
6	BTY6CJ 304 / BTY8MN 304	Core Course 11 in Major – Genetic Engineering	5	4
	BTY6CJ 305 / BTY8MN 305	Core Course 12 in Major – Bioprocess Technology	5	4
	BTY6CJ 306 / BTY8MN 306	Core Course 13 in Major – Animal Biotechnology	4	4
		Elective Course 3 in Major	4	4
		Elective Course 4 in Major	4	4
	BTY6CJ 349	Internship in Major	-	2
Total for the Three Years				**70**
7	BTY7CJ 401	Core Course 14 in Major – Bio-entrepreneurship	5	4
	BTY7CJ 402	Core Course 15 in Major – OMICS for Biotechnology	5	4
	BTY7CJ 403	Core Course 16 in Major – Virology	5	4
	BTY7CJ 404	Core Course 17 in Major – IPR, Bioethics & Biosafety	5	4
	BTY7CJ 405	Core Course 18 in Major – Analytical techniques	5	4
	BTY8CJ	Core Course 19 in Major – Phyto-medicine	5	4

	406 / BTY8MN 406			
	BTY8CJ 407 / BTY8MN 407	Core Course 20 in Major – Cancer biology	4	4
	BTY8CJ 408 / BTY8MN 408	Core Course 21 in Major – Biomaterials and nanotechnology	4	4
	OR (instead of Core Courses 19, 20 and 21 in Major)			
	BTY8CJ 449	Project (in Honours programme)	13	12
	BTY8CJ 499	Research Project (in Honours with Research programme)	13	12
8		Elective Course 5 in Major	4	4
		Elective Course 6 in Major	4	4
		Elective Course 7 in Major	4	4
	OR (instead of Elective course 7 in Major, in Honours with Research programme)			
	BTY8CJ 489	Research Methodology in Biotechnology	4	4
Total for the Four Years				**114**

Choose any two elective courses each from the course basket of four elective courses in 5th and 6th semesters 6, as listed below in the two tables of elective courses with specialisation and elective courses with no specialisation.

Choose any three elective courses from the course basket of six elective courses in semester 8, as listed below in the table of elective courses with no specialisation

ELECTIVE COURSES IN BIOTECHNOLOGY WITH SPECIALISATION

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		**Medical Biotechnology**								
	1	BTY5EJ 301(1)	Immunology	5	60	4	4	30	70	100
	2	BTY5EJ 302(1)	Medical biotechnology	5	60	4	4	30	70	100
	3	BTY6EJ 301(1)	Pharmacology & Toxicology	6	60	4	4	30	70	100
	4	BTY6EJ 302(1)/ BTY6EJ 304(2)	Stem Cells and regenerative medicine	6	60	4	4	30	70	100

ELECTIVE COURSES IN BIOTECHNOLOGY WITH NO SPECIALISATION

Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
							Internal	External	Total
1.	BTY5EJ 303(2)	Enzyme Technology	5	60	4	4	30	70	100
2.	BTY5EJ 304(2)	Immuno-technology	5	60	4	4	30	70	100
3.	BTY6EJ 303(2)	Molecular Diagnostics and Gene therapy	6	60	4	4	30	70	100
4.	BTY6EJ 304(2)/ BTY6EJ 302(1)	Bioinformatics	6	60	4	4	30	70	100

5.	BTY8EJ 401	Molecular Forensics	8	60	4	4	30	70	100
6.	BTY8EJ 402	Food and dairy Technology	8	60	4	4	30	70	100
7.	BTY8EJ 403	Green Biotechnology	8	60	4	4	30	70	100
8.	BTY8EJ 404	Vaccine technology	8	60	4	4	30	70	100
9.	BTY8EJ 405	Neuroscience	8	60	4	4	30	70	100
10.	BTY8EJ 406	Developmental Biology	8	60	4	4	30	70	100

GROUPING OF MINOR COURSES IN BIOTECHNOLOGY

(Title of the Minor Course in the certificate : **APPLIED BIOSCIENCES AND TECHNOLOGY)**

The Minor courses given in the table constitute an academic discipline distinctly different from the Major discipline. Hence, they can be offered to students who have taken Biotechnology as the Major discipline in addition to the students from other Major disciplines.

These courses are part of any Biological science so on completion of these courses the students can pursue Post graduation programme in Biosciences, life sciences, Applied Biosciences, Bioscience and Technology, Applied Biosciences and Technology, Genetics, Molecular Biology, Biotechnology, Environmental Sciences, Biophysics or any other allied Biological sciences or Life sciences etc.

Group No.	**Sl. No.**	**Course Code**	**Title**	**Semester**	**Total Hrs**	**Hrs/ Week**	**Credits**	**Marks**		
								Internal	**External**	**Total**
1		**Technological advancements in Biosciences**								
	1	BTY1MN 101	Introductory Biology	1	75	5	4	30	70	100
	2	BTY2MN 101	Computer for Biosciences	2	75	5	4	30	70	100

	3	BTY3MN 201	Food and fermentation Technology	3	75	5	4	30	70	100
2		**Laboratory Technology for Biosciences**								
	1	BTY1MN 102	Bio-instrumentation	1	75	5	4	30	70	100
	2	BTY2MN 102	Good Laboratory Practices and Quality Control in Biotechnology Labs	2	75	5	4	30	70	100
	3	BTY3MN 202	Microbial technology	3	75	5	4	30	70	100
3		**Applied Biosciences**								
	1	BTY1MN 103	Biophysics and Biostatistics	1	75	5	4	30	70	100
	2	BTY2MN 103	Bioprospecting	2	75	5	4	30	70	100
	3	BTY3MN 203	Applied Biology for sustainable development	3	75	5	4	30	70	100

(i). Students in Single Major pathway can choose course/courses from any of the Minor/ Vocational Minor groups offered by a discipline other than their Major discipline.

(ii). Students in Major with Multiple Disciplines pathway can choose as one of the multiple disciplines, all the three courses from any one of the Minor/ Vocational Minor groups offered by any discipline, including their Major discipline. If they choose one of the Minor/ Vocational Minor groups offered by their Major discipline as the first one of the multiple disciplines, then their choice as the second one of the multiple disciplines should be any one of the Minor/ Vocational Minor groups offered by a discipline other than the Major discipline. If the students choose any one of the Minor groups in Biotechnology as given above, then the title of the group will be the title of that multiple discipline.

(iii). Students in Major with Minor pathway can choose all the courses from any two Minor groups offered by any discipline. If the students choose any two Minor groups in Biotechnology as given above, then the title of the Minor will be Applied Biotechnology.

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN BIOTECHNOLOGY

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	BTY1FM 105	Multi-Disciplinary Course 1 – Basic Biotechnology	45	3	3	25	50	75
2	BTY2FM 106	Multi-Disciplinary Course 2 – Biotechnological Innovations and Applications	45	3	3	25	50	75
3	BTY3FV 108	Value-Added Course 1 – Biotech Startups	45	3	3	25	50	75
4	BTY4FV 110	Value-Added Course 2 – Scientific Communication	45	3	3	25	50	75
5	BTY5FS 112	Skill Enhancement Course 2 – Quality control in bio-industry	45	3	3	25	50	75
6	BTY6FS 113	Skill Enhancement Course 3 – Clinical research and medical translation	45	3	3	25	50	75

COURSE STRUCTURE FOR BATCH A1(B2) IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Biotechnology (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Biotechnology (Major A) ***B2: 53 credits in Major B***

The combinations available to the students: (A1 & B2), (B1 & A2)

Note: Unless the batch is specified, the course is for all the students of the class

Seme	Course	Course Title	Total	Hours/	Credits	Marks

ster	Code		Hours	Week		Internal	External	Total
1	BTY1CJ 101 / BTY1MN 100	Core Course 1 in Major Biotechnology – Fundamentals of Biotechnology	75	5	4	30	70	100
	BBB1CJ 101	Core Course 1 in Major B –	60/ 75	4/ 5	4	30	70	100
	BTY1CJ 102 / BTY2CJ 102 / BTY4CJ 205*	Core Course 2 in Major Biotechnology –Biotechnology and industry (for batch A1 only)	75	5	4	30	70	100
	ENG1FA 101(2)	Ability Enhancement Course 1 – English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
	BTY1FM 105	Multi-Disciplinary Course 1 in Biotechnology – Basic Biotechnology (for batch A1 only)	45	3	3	25	50	75
		Total		**24/ 25**	**21**			**525**
2	BTY2CJ 101 / BTY2MN 100	Core Course 3 in Major Biotechnology – Applications of Biotechnology	75	5	4	30	70	100
	BBB2CJ 101	Core Course 2 in Major B –	60/ 75	4/ 5	4	30	70	100

	BBB2CJ 102 / BBB1CJ 102	Core Course 3 in Major B – (for batch B2 only)	60/ 75	4/ 5	4	30	70	100
	ENG2FA 103(2)	Ability Enhancement Course 3 – English	60	4	3	25	50	75
		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
	BTY2FM 106 / BTY3FM 106	Multi-Disciplinary Course 2 in Biotechnology – Biotechnological Innovations and Applications	45	3	3	25	50	75
		Total		**23 – 25**	**21**			**525**
3	BTY3CJ 201	Core Course 4 in Major Biotechnology – Biochemistry I- Biomolecules	60	4	4	30	70	100
	BTY3CJ 202 / BTY3MN 200	Core Course 5 in Major Biotechnology – Cell Biology	75	5	4	30	70	100
	BBB3CJ 201	Core Course 4 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3CJ 202	Core Course 5 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3FM 106 / BBB2FM 106	Multi-Disciplinary Course 1 in B –	45	3	3	25	50	75

	BTY3FV 108	Value-Added Course 1 in Biotechnology – Biotech Startups (for batch A1 only)	45	3	3	25	50	75
		Total		**23 – 25**	**22**			**550**
4	BTY4CJ 203	Core Course 6 in Major Biotechnology – Biochemistry II-Metabolism	75	5	4	30	70	100
		Core Course 6 in Major B	60/ 75	4/ 5	4	30	70	100
	BTY4CJ 204	Core Course 7 in Major Biotechnology – Genetics (for batch A1 only)	75	5	4	30	70	100
	BTY4FV 110	Value-Added Course 2 in Biotechnology – Scientific Communication	45	3	3	25	50	75
	BBB4FV 110	Value-Added Course 1 in B –	45	3	3	25	50	75
	BTY4FS 112 / BTY5FS 112	Skill Enhancement Course 1 in Biotechnology – Quality control in bio-industry	45	3	3	25	50	75
		Total		**23/ 24**	**21**			**525**
5	BTY5CJ 302	Core Course 8 in Major Biotechnology – Environmental Biotechnology	75	5	4	30	70	100
		Core Course 7 in Major B –	60/ 75	4/ 5	4	30	70	100
	BTY5CJ 303	Core Course 9 in Major Biotechnology – Molecular Biology (for batch A1 only)	60	4	4	30	70	100
		Elective Course 1 in Major Biotechnology	60	4	4	30	70	100
		Elective Course 1 in Major B	60	4	4	30	70	100

	BBB5FS 112 / BBB4FS 112	Skill Enhancement Course 1 in B	45	3	3	25	50	75
		Total		**24/ 25**	**23**			**575**
6	BTY6CJ 305/ BTY8MN 305	Core Course 10 in Major Biotechnology – Bioprocess Technology	75	5	4	30	70	100
		Core Course 8 in Major B –	60/ 75	4/ 5	4	30	70	100
	BBB6CJ 305	Core Course 9 in Major B – (for batch B2 only)	60	4	4	30	70	100
		Elective Course 2 in Major Biotechnology	60	4	4	30	70	100
		Elective Course 2 in Major B	60	4	4	30	70	100
	BTY6FS 113	Skill Enhancement Course 2 in Biotechnology – Clinical research and medical translation (for batch A1 only)	45	3	3	25	50	75
	BTY6CJ 349	Internship in Major Biotechnology (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		**24/ 25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**
For batch A1(B2), the course structure in semesters 7 and 8 is the same as for pathways 1 – 4, except that the number of the core and elective courses is in continuation of the number of courses in the two categories completed at the end of semester 6.								

* The course code of the same course as used for the pathways 1 – 4

CREDIT DISTRIBUTION FOR BATCH A1(B2)

IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in Biotechnology	General Foundation Courses in Biotechnology	Internship/ Project in Biotechnology	Major Courses in B	General Foundation Courses in B	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	3	-	4 + 4	-	3 + 3	21
3	4 + 4	3	-	4 + 4	3	-	22
4	4 + 4	3 + 3	-	4	3	-	21
5	4 + 4 + 4	-	-	4 + 4	3	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	**48**	**18**	**2**	**44**	**9**	**12**	**133**
	68			**53**		**12**	**133**
	Major Courses in Biotechnology	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	8* / 12**		-	-	24
* Instead of two Major courses; ** instead of three Major courses							
Total for Four Years	**88 + 12 = 100**	**12**					**177**

COURSE STRUCTURE FOR BATCH B1(A2)
IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Biotechnology (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Biotechnology (Major A) ***B2: 53 credits in Major B***

The combinations available to the students: (A1 & B2), (B1 & A2)

Note: Unless the batch is specified, the course is for all the students of the class

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	BTY1CJ 101 / BTY1MN 100	Core Course 1 in Major Biotechnology – Fundamentals of Biotechnology	75	5	4	30	70	100
	BBB1CJ 101	Core Course 1 in Major B –	60/ 75	4/ 5	4	30	70	100
	BBB1CJ 102 / BBB2CJ 102	Core Course 2 in Major B – (for batch B1 only)	60/ 75	4/ 5	4	30	70	100
	ENG1FA 101(2)	Ability Enhancement Course 1 – English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
	BBB1FM 105	Multi-Disciplinary Course 1 in B – (for batch B1 only)	45	3	3	25	50	75
		Total		**23 – 25**	**21**			**525**

2	BTY2CJ 101 / BTY2MN 100	Core Course 2 in Major Biotechnology – Applications of Biotechnology	75	5	4	30	70	100
	BBB2CJ 101	Core Course 3 in Major B –	60/ 75	4/ 5	4	30	70	100
	BTY2CJ 102 / BTY1CJ 102 / BTY4CJ 205*	Core Course 3 in Major Biotechnology – Biotechnology and Industry (for batch A2 only)	75	5	4	30	70	100
	ENG2FA 103(2)	Ability Enhancement Course 3 – English	60	4	3	25	50	75
		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
	BTY2FM 106 / BTY3FM 106	Multi-Disciplinary Course 1 in Biotechnology – Basic Biotechnology	45	3	3	25	50	75
		Total		**24/ 25**	**21**			**525**
3	BTY3CJ 201	Core Course 4 in Major Biotechnology – Biochemistry I- Biomolecules	60	4	4	30	70	100
	BTY3CJ 202 / BTY3MN 200	Core Course 5 in Major Biotechnology – Cell Biology	75	5	4	30	70	100

	BBB3CJ 201	Core Course 4 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3CJ 202	Core Course 5 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB3FM 106 / BBB2FM 106	Multi-Disciplinary Course 2 in B –	45	3	3	25	50	75
	BBB3FV 108	Value-Added Course 1 in B – (for batch B1 only)	45	3	3	25	50	75
		Total		**23 – 25**	**22**			**550**
4	BTY4CJ 203	Core Course 6 in Major Biotechnology – Biochemistry II- Metabolism	75	5	4	30	70	100
		Core Course 6 in Major B	60/ 75	4/ 5	4	30	70	100
		Core Course 7 in Major B – (for batch B1 only)	60/ 75	4/ 5	4	30	70	100
	BTY4FV 110	Value-Added Course 1 in Biotechnology – Biotech Startups	45	3	3	25	50	75
	BBB4FV 110	Value-Added Course 2 in B –	45	3	3	25	50	75
	BTY4FS 112 / BTY5FS 112	Skill Enhancement Course 1 in Biotechnology – Quality control in bio-industry	45	3	3	25	50	75
		Total		**22 – 24**	**21**			**525**
5	BTY5CJ 302	Core Course 7 in Major Biotechnology – Environmental Biotechnology	75	5	4	30	70	100

		Core Course 8 in Major B –	60/ 75	4/ 5	4	30	70	100
		Core Course 9 in Major B – (for batch B1 only)	60	4	4	30	70	100
		Elective Course 1 in Major Biotechnology	60	4	4	30	70	100
		Elective Course 1 in Major B	60	4	4	30	70	100
	BBB5FS 112 / BBB4FS 112	Skill Enhancement Course 1 in B	45	3	3	25	50	75
		Total		**24/ 25**	**23**			**575**
6	BTY6CJ 305/ BTY8MN 305	Core Course 8 in Major Biotechnology – Bioprocess Technology	75	5	4	30	70	100
		Core Course 10 in Major B –	60/ 75	4/ 5	4	30	70	100
	BTY6CJ 306/ BTY8MN 306	Core Course 9 in Major Biotechnology – Bioinformatics (for batch A2 only)	60	4	4	30	70	100
		Elective Course 2 in Major Biotechnology	60	4	4	30	70	100
		Elective Course 2 in Major B	60	4	4	30	70	100
	BBB6FS 113	Skill Enhancement Course 2 in B – (for batch B1 only)	45	3	3	25	50	75
	BBB6CJ 349	Internship in Major B (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50

		Total		**24/ 25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**
To continue to study Biotechnology in semesters 7 and 8, batch B1(A2) needs to earn additional 15 credits in Biotechnology to make the total credits of 68. Suppose this condition is achieved, and the student of batch B1(A2) proceeds to the next semesters to study Biotechnology. The course structure in semesters 7 and 8 is the same as for pathways 1 – 4, except that the number of the core and elective courses is in continuation of the number of courses in the two categories completed at the end of semester 6, taking into account the number of courses in Biotechnology taken online to earn the additional 15 credits.								

* The course code of the same course as used for the pathways 1 – 4

CREDIT DISTRIBUTION FOR BATCH B1(A2) IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in B	General Foundation Courses in B	Internship/ Project in B	Major Courses in Biotechnology	General Foundation Courses in Biotechnology	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	-	-	4 + 4	3	3 + 3	21
3	4 + 4	3 + 3	-	4 + 4	-	-	22
4	4 + 4	3	-	4	3 + 3	-	21
5	4 + 4 + 4	3	-	4 + 4	-	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	**48**	**18**	**2**	**44**	**9**	**12**	**133**
	68			**53**		**12**	**133**
	Major Courses in B	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	8* / 12**		-	-	24
* Instead of two Major courses; ** instead of three Major courses							

Total for Four Years	**88 + 12 = 100**	**12**					**177**

EVALUATION SCHEME

1. The evaluation scheme for each course contains two parts: internal evaluation (about 30%) and external evaluation (about 70%). Each of the Major and Minor courses is of 4-credits. It is evaluated for 100 marks, out of which 30 marks is from internal evaluation and 70 marks, from external evaluation. Each of the General Foundation course is of 3-credits. It is evaluated for 75 marks, out of which 25 marks is from internal evaluation and 50 marks, from external evaluation.
2. The 4-credit courses (Major and Minor courses) are of two types: (i) courses with only theory and (ii) courses with 3-credit theory and 1-credit practical.

    - In 4-credit courses with only theory component, out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 10 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.
    - In 4-credit courses with 3-credit theory and 1-credit practical components, out of the total 5 modules of the syllabus, 4 modules are for theory and the fifth module is for practical. The practical component is internally evaluated for 20 marks. The internal evaluation of the 4 theory modules is for 10 marks.

3. All the 3-credit courses (General Foundational Courses) in Biotechnology are with only theory component. Out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 5 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

Sl. No.	Nature of the Course		Internal Evaluation in Marks (about 30% of the total)		External Exam on 4 modules (Marks)	Total Marks
			Open-ended module / Practical	On the other 4 modules		
1	4-credit course	only theory (5 modules)	10	20	70	100
2	4-credit course	Theory (4 modules) + Practical	20	10	70	100
3	3-credit course	only theory (5 modules)	5	20	50	75

1. MAJOR AND MINOR COURSES

1.1. INTERNAL EVALUATION OF THEORY COMPONENT

Sl. No.	Components of Internal Evaluation of Theory Part of a Major / Minor Course	Internal Marks for the Theory Part of a Major / Minor Course of 4-credits			
		Theory Only		Theory + Practical	
		4 Theory Modules	Open-ended Module	4 Theory Modules	Practical
1	Test paper/ Mid-semester Exam	10	4	5	-
2	Seminar/ Viva/ Quiz	6	4	3	-
3	Assignment	4	2	2	-
		20	10	10	20*
	Total	30		30	

* Refer the table in section 1.2 for the evaluation of practical component

1.2. EVALUATION OF PRACTICAL COMPONENT

The evaluation of practical component in Major and Minor courses is completely by internal evaluation.

- Continuous evaluation of practical by the teacher-in-charge shall carry a weightage of 50%.
- The end-semester practical examination and viva-voce, and the evaluation of practical records shall be conducted by the teacher in-charge and an internal examiner appointed by the Department Council.
- The process of continuous evaluation of practical courses shall be completed before 10 days from the commencement of the end-semester examination.
- Those who passed in continuous evaluation alone will be permitted to appear for the end-semester examination and viva-voce.

The scheme of continuous evaluation and the end-semester examination and viva-voce of practical component shall be as given below:

Sl. No.	Evaluation of Practical Component of Credit-1 in a Major / Minor Course	Marks for Practical	Weightage
1	Continuous evaluation of practical/ exercise performed in practical classes by the students	10	50%
2	End-semester examination and viva-voce to be conducted by teacher-in-charge along with an additional examiner arranged internally by the Department Council	7	35%
3	Evaluation of the Practical records submitted for the end semester viva–voce examination by the teacher-in-charge and additional examiner	3	15%

Total Marks	20	

1.3. EXTERNAL EVALUATION OF THEORY COMPONENT

External evaluation carries 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR MAJOR AND MINOR COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
2 Hours	Short Answer	10	8 – 10	3	24
	Paragraph/ Problem	8	6 – 8	6	36
	Essay	2	1	10	10
				Total Marks	70

QUESTION PAPER PATTERN MODEL

BSc Biotechnology.....(I/II/III/IV/V/VI/VII/VIIISemester) Examination..... (Month & year)

(Major, Minor, Elective or other)..... Course

Time 2 Hours **Maximum Marks 70**

Section A Short Answer type questions.
Each question carries 3 marks
All questions can be attempted.
Ceiling of Marks 24 (3marks x 8questions)

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Section B Paragraph or Problem type.
Each question carries 6 marks
All questions can be attempted.
Ceiling of Marks 36 (6marks x 6questions)

11.
12.
13.
14.
15.
16.

17.

18.

Section C Assay type.
Each question carries 10 marks
Answer any one question

19.
20.

xxxxxxxxxxxx

2. INTERNSHIP

- All students should undergo Internship of 2-credits during the first six semesters in a firm, industry or organization, or training in labs with faculty and researchers of their own institution or other Higher Educational Institutions (HEIs) or research institutions.
- Internship can be for enhancing the employability of the student or for developing the research aptitude.
- Internship can involve hands-on training on a particular skill/ equipment/ software. It can be a short project on a specific problem or area. Attending seminars or workshops related to an area of learning or skill can be a component of Internship.
- A faculty member/ scientist/ instructor of the respective institution, where the student does the Internship, should be the supervisor of the Internship.

2.1. GUIDELINES FOR INTERNSHIP

1. Internship can be in Biotechnology or allied disciplines.
2. There should be minimum 60 hrs. of engagement from the student in the Internship.
3. Summer vacations and other holidays can be used for completing the Internship.
4. In BSc. Biotechnology (Honours) programme, institute/ industry visit or study tour is a requirement for the completion of Internship. Visit to minimum one national research institute, research laboratory and place of scientific importance should be

part of the study tour. A brief report of the study tour has to be submitted with photos and analysis.

5. The students should make regular and detailed entries in to a personal log book through the period of Internship. The log book will be a record of the progress of the Internship and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.
6. The log book and the typed report must be submitted at the end of the Internship.
7. The institution at which the Internship will be carried out should be prior-approved by the Department Council of the college where the student has enrolled for the UG (Honours) programme.

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2.2. EVALUATION OF INTERNSHIP

- The evaluation of Internship shall be done internally through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG (Honours) programme.
- The credits and marks for the Internship will be awarded only at the end of semester 6.
- The scheme of continuous evaluation and the end-semester viva-voce examination based on the submitted report shall be as given below:

Sl. No.	Components of Evaluation of Internship		Marks for Internship 2 Credits	Weightage
1	Continuous evaluation of internship through interim presentations and reports by the committee internally constituted by the	Acquisition of skill set	10	40%
2		Interim Presentation and Viva-voce	5	
3		Punctuality and Log Book	5	

	Department Council			
4	Report of Institute Visit/ Study Tour		5	10%
5	End-semester viva-voce examination to be conducted by the committee internally constituted by the Department Council	Quality of the work	6	35%
6		Presentation of the work	5	
7		Viva-voce	6	
8	Evaluation of the day-to-day records, the report of internship supervisor, and final report submitted for the end semester viva–voce examination before the committee internally constituted by the Department Council		8	15%
	Total Marks		50	

3. PROJECT

3.1. PROJECT IN HONOURS PROGRAMME

- In Honours programme, the student has the option to do a Project of 8-credits instead of two Core Courses in Major in semester 8.
- The Project can be done in the same institution or any other higher educational institution (HEI) or research centre.
- A faculty member of the respective institution, where the student does the Project, should be the supervisor of the Project.

3.2. PROJECT IN HONOURS WITH RESEARCH PROGRAMME

- Students who secure 75% marks and above (equivalently, CGPA 7.5 and above) cumulatively in the first six semesters are eligible to get selected to Honours with Research stream in the fourth year.

- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits in semester 8.

- The approved research centres of University of Calicut or any other university/ HEI can offer the Honours with Research programme. The departments in the affiliated colleges under University of Calicut, which are not the approved research centres of the University, should get prior approval from the University to offer the Honours with Research programme. Such departments should have minimum one faculty member with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.

- A faculty member of the University/ College with a Ph.D. degree can supervise the research project of the students who have enrolled for Honours with Research. One such faculty member can supervise maximum four students in Honours with Research stream.

3.3. GUIDELINES FOR THE PROJECT IN HONOURS PROGRAMME AND HONOURS WITH RESEARCH PROGRAMME

1. Project can be in Biotechnology or allied disciplines.
2. Project should be done individually.
3. Project work can be of experimental/ theoretical/ computational in nature.
4. There should be minimum 240 hrs. of engagement from the student in the Project work in Honours programme.
5. There should be minimum 360 hrs. of engagement from the student in the Project work in Honours with Research programme.
6. The various steps in project works are the following:
    - Wide review of a topic.
    - Investigation on a problem in systematic way using appropriate techniques.
    - Systematic recording of the work.

- Reporting the results with interpretation in a standard documented form.
- Presenting the results before the examiners.

7. During the Project the students should make regular and detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.
8. The log book and the typed report must be submitted at the end of the Project. A copy of the report should be kept for reference at the department. A soft copy of the report too should be submitted, to be sent to the external examiner in advance.
9. It is desirable, but not mandatory, to publish the results of the Project in a peer reviewed journal.
10. The project report shall have an undertaking from the student and a certificate from the research supervisor for originality of the work, stating that there is no plagiarism, and that the work has not been submitted for the award of any other degree/ diploma in the same institution or any other institution.
11. The project proposal, institution at which the project is being carried out, and the project supervisor should be prior-approved by the Department Council of the college where the student has enrolled for the UG (Honours) programme.

3.4. EVALUATION OF PROJECT

- The evaluation of Project will be conducted at the end of the eighth semester by both internal and external modes.
- The Project in Honours programme will be evaluated for 200 marks. Out of this, 60 marks is from internal evaluation and 140 marks, from external evaluation.
- The Project in Honours with Research programme will be evaluated for 300 marks. Out of this, 90 marks is from internal evaluation and 210 marks, from external evaluation.

- The internal evaluation of the Project work shall be done through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG (Honours) programme. 30% of the weightage shall be given through this mode.
- The remaining 70% shall be awarded by the external examiner appointed by the University.
- The scheme of continuous evaluation and the end-semester viva-voce of the Project shall be as given below:

Components of Evaluation of Project	Marks for the Research Project (Honours with Research)	Marks for the Optional Project (Honours)	Weightage
	12 Credits	8 Credits	
Continuous evaluation of project work through interim presentations and reports by the committee internally constituted by the Department Council	90	60	30%
End-semester viva-voce examination to be conducted by the external examiner appointed by the University	150	100	50%
Evaluation of the day-to-day records and project report submitted for the end-semester viva–voce examination conducted by the external examiner	60	40	20%
Total Marks	300	200	

INTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Research Project (Honours with Research programme)	Marks for the Optional Project (Honours programme)

		12 credits	8 credits
1	Skill in doing project work	30	20
2	Interim Presentation and Viva-Voce	20	15
3	Punctuality and Log book	20	15
4	Scheme/ Organization of Project Report	20	10
	Total Marks	90	60

EXTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Research Project (Honours with Research programme) 12 credits	Marks for the Optional Project (Honours programme) 8 credits
1	Content and relevance of the Project, Methodology, Quality of analysis, and Innovations of Research	50	40
2	Presentation of the Project	50	30
3	Project Report (typed copy), Log Book and References	60	40
4	Viva-Voce	50	30
	Total Marks	210	140

4. GENERAL FOUNDATION COURSES

- All the General Foundation Courses (3-credits) in Biotechnology are with only theory component.

4.1. INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in	Internal Marks of a General Foundation Course of 3-credits in Biotechnology	
		4 Theory Modules	Open-ended Module

	Biotechnology		
1	Test paper/ Mid-semester Exam	10	2
2	Seminar/ Viva/ Quiz	6	2
3	Assignment	4	1
		20	5
	Total	25	

4.2. EXTERNAL EVALUATION

External evaluation carries about 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR GENERAL FOUNDATION COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
1.5 Hours	Short Answer	10	8 – 10	2	16
	Paragraph/ Problem	5	4 – 5	6	24
	Essay	2	1	10	10
				Total Marks	50

5. LETTER GRADES AND GRADE POINTS

- Mark system is followed for evaluating each question.
- For each course in the semester letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below.

- The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester.
- The Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

Sl. No.	Percentage of Marks (Internal & External Put Together)	Description	Letter Grade	Grade Point	Range of Grade Points	Class
1	95% and above	Outstanding	O	10	9.50 – 10	First Class with Distinction
2	Above 85% and below 95%	Excellent	A+	9	8.50 – 9. 49	
3	75% to below 85%	Very Good	A	8	7.50 – 8.49	
4	65% to below 75%	Good	B+	7	6.50 – 7.49	
5	55% to below 65%	Above Average	B	6	5.50 – 6.49	First Class
6	45% to below 55%	Average	C	5	4.50 – 5.49	Second Class
7	35% to below 45% aggregate (internal and external put together) with a minimum of 30% in external valuation	Pass	P	4	3.50 – 4.49	Third Class
8	Below an aggregate of 35% or below 30% in external evaluation	Fail	F	0	0 – 3.49	Fail
9	Not attending the examination	Absent	Ab	0	0	Fail

- When students take audit courses, they will be given Pass (P) or Fail (F) grade without any credits.
- The successful completion of all the courses and capstone components prescribed for the three-year or four-year programme with 'P' grade shall be the minimum

requirement for the award of UG Degree or UG Degree (Honours) or UG Degree (Honours with Research), as the case may be.

5.1. COMPUTATION OF SGPA AND CGPA

- The following method shall be used to compute the Semester Grade Point Average (SGPA):

  The SGPA equals the product of the number of credits (Ci) with the grade points (Gi) scored by a student in each course in a semester, summed over all the courses taken by a student in the semester, and then divided by the total number of credits of all the courses taken by the student in the semester,

  $$\text{i.e. SGPA } (Si) = \Sigma i\ (Ci \times Gi) \,/\, \Sigma i\ (Ci)$$

  where Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course in the given semester. Credit Point of a course is the value obtained by multiplying the credit (Ci) of the course by the grade point (Gi) of the course.

$$\text{SGPA} = \frac{\text{Sum of the credit points of all the courses in a semester}}{\text{Total credits in that semester}}$$

ILLUSTRATION – COMPUTATION OF SGPA

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	Course 1	3	A	8	3 x 8 = 24
I	Course 2	4	B+	7	4 x 7 = 28
I	Course 3	3	B	6	3 x 6 = 18
I	Course 4	3	O	10	3 x 10 = 30
I	Course 5	3	C	5	3 x 5 = 15

I	Course 6	4	B	6	4 x 6 = 24
	Total	20			139
	SGPA				139/20 = 6.950

- The Cumulative Grade Point Average (CGPA) of the student shall be calculated at the end of a programme. The CGPA of a student determines the overall academic level of the student in a programme and is the criterion for ranking the students.

  CGPA for the three-year programme in CUFYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in six semesters}}{\text{Total credits in six semesters (133)}}$$

  CGPA for the four-year programme in CUFYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in eight semesters}}{\text{Total credits in eight semesters (177)}}$$

- The SGPA and CGPA shall be rounded off to three decimal points and reported in the transcripts.
- Based on the above letter grades, grade points, SGPA and CGPA, the University shall issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

SYLLABUS

Discipline Specific Courses

	Fundamentals of Biotechnology	
Semester 1	**Discipline Specific Courses**	**Level: 100-199**
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70

Course Outcomes (CO)			
CO1	Define biotechnology and its historical development, recognizing key contributors and stages of advancement.	U	
CO2	Identify and categorize branches of biotechnology, understanding their applications and significance.	Ap	
CO3	Analyze the role of biotechnology in the developing world, including institutes, success stories, and societal perceptions.	An	
CO4	Demonstrate proficiency in basic biotechnological instrumentation, applying principles and techniques in laboratory settings.	E	

Course Content		
I	History and Scope: Introduction to biotechnology- Definition of biotechnology, multidisciplinary nature. Eminent contributors to biotechnology- Anton Van leeven hook, Alexander fleming, Ian Willmut. Stages of development of biotechnology-Ancient biotechnology, classical biotechnology and modern biotechnology.	10 Hours
II	Branches of Biotechnology: Green biotechnology- Biofertilizer: types and applications of biofertilizer, Red biotechnology-Antibiotics: defenition, classification with examples. White biotechnology- Applications- Amylase. Blue biotechnology- Spirulina uses and applications. Grey Biotechnology- Catabolic plasmids and Superbug	12 Hours
III	Biotechnology and developing World: Biotechnology institutes in India- Public and private sector, Biotech success stories, Public perception of biotechnology. Biotechnology in context of developing world.	12 Hours
IV	Basic Instrumentation in Biotechnology: Glasswares, pH meter, Autoclave, Hot air oven, Deep freezer, Refrigerator, Orbital shaker, Laminar air flow,Incubator, Bright field microscope, Analytical Balance,Water bath- Working principle and Application.	11 Hours

V	***Practical*** • Isolation of microorganisms • DNA Extraction • Wine production • Biogas Production	30 Hours

References

- Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company
- Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology.
- William J. Thieman, Michael A. Palladino. Introduction to Biotechnology. Benjamin Cummings

	Applications of Biotechnology	
Semester 2	**Discipline Specific Courses**	**Level: 100-199**
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70

Course Outcomes (CO)

CO1	Understanding genetic modifications in agriculture, students will explore herbicide and pest-resistant plants, along with fruit ripening engineering, critically assessing the associated environmental and ethical implications.	U	
CO2	Exploring biotechnological applications in food production, this module covers fermentation principles, production of high-value food items, and provides a holistic view of how biotechnology contributes to food technology.	Ap	
CO3	Focused on biotechnological innovations in healthcare, understand applications like genetically engineered insulin, monoclonal antibodies, DNA vaccines, and gene therapy, gaining insights into the transformative impact of BT on medical treatments.	Ap	
CO4	Understand biotechnological solutions for industry and environment, covering biomining, biosensors, and bioremediation, offering sustainable approaches to address resource extraction, pollution, and environmental challenges.	An	

Course Content

I	BT in agriculture: Introduction to Genetically modified crops. Pros and Cons of GM foods. Herbicide resistant plant : Corn, soy, cotton-glycophospate and glufosinate resistant plants. Pest resistant plant: BT Cotton, BT Brinjal , Golden rice, Slow ripening of fruits and vegetables-flavr savr tomato	10 Hours
II	BT in Food Technology : Basic principle of fermentation , Production	12 Hours

	of fermented food productions, Bread, wines, vinegar Fermented milk products-Yoghurt, butter, butter milk and traditional indian foods- Iddli, pickles. High value food products- Single Cell Protein and Mushroom	
III	BT in Medicine: Application in treatment and diagnosis of disease. Genetically engineered insulin, Monoclonal antibodies, DNA Vaccines, Tissue plasminogen activator, Blood factors. Gene therapy, DNA fingerprinting	12 Hours
IV	BT in Industry and environment: Overview and applications of Environmental Biotechnolgy, Biomining, Biosensers, Bioremediation- Use of superbug, biofiltration	11 Hours
V	***Practical*** • Biopesticide production • Visit to Biotech Industry • Fermentation of milk for value added products • Biosorption	30 Hours

References

- William J. Thieman, Michael A. Palladino. Introduction to Biotechnology. Benjamin Cummings
- Chawla. Introduction To Plant Biotechnology, Oxford and IBH Publishing
- Genetic Modification of Plants - Agriculture, Horticulture and Forestry – edited by Frank Kempken, Christian Jung,Publisher- Springer Berlin, Heidelberg
- Advances in Biotechnology for Food Industry A volume in Handbook of Food Bioengineering Book 2018 Edited by: Alina Maria Holban and Alexandru Mihai Grumezescu.

	Biochemistry I- Biomolecules	
Semester 3	**Discipline Specific Courses**	**Level: 200-299**
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70

Course Outcomes (CO)

CO1	Understand the classification, properties, and biological functions of carbohydrates, proteins, nucleic acids, lipids, and vitamins.	U	
CO2	Describe the interconversion of sugars and the structure-function relationships of mono-, di-, oligo-, and polysaccharides, as well as homopolysaccharides and heteropolysaccharides.	U	

CO3	Explain the structure, properties, and classifications of amino acids, proteins, nucleic acids, and lipids, emphasizing their biological significance.	Ap	
CO4	Analyze the sources, structures, functions, and deficiency manifestations of lipids and vitamins in biological systems.	An	
Course Content			
I	**Carbohydrates:** Classification, preparation, properties and structure. Interconversion of sugars. Properties, structure and biological functions of mono, di, oligo and polysaccharides.Homopolysaccharides – Starch, glycogen, cellulose. Heteropolysaccharides – Hyaluronic acid and chondrointin sulphate.		10 Hours
II	**Proteins:**Structure,properties, classification, properties and chemical reactions of aminoacids. peptide bond. Proteins. Biological importance, classification- Properties of Collagen, albumin. Forces stabilizing the structure of proteins. classification, general properties,Structural hierarchy of protein- Denaturation.		12 Hours
III	**Nucleic acids:** Purine and Pyrimidines – structure and properties. Nucleosides. Nucleotides. DNA and RNA. Composition, structure, their biological importance, Comparison between DNA and RNA, Denaturation and Renaturation of nucleic acid .		11 Hours
IV	**Lipids and Vitamines:**Biological significance, classification. Structure, properties and functions- Fatty acids, triglycerides, waxes , terpenes, cholesterol and its derivatives. Compound lipids- Phosphoglycerides, sphingolipids and glycolipids. Source, biological role, daily requirement and deficiency manifestation - fat soluble vitamins and Water soluble vitamins		12 Hours
V	Open ended chapter		15 Hours
References			

- Robort k, Murray, David Bender, Kathleen M Botham and Peter J Kennelly, Harpers “ Illustrated Biochemistry” 29 th Edition Mc Graw Hill 2018
- Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H.
- Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons,Principles of Biochemistry (2008) 3rd edition (New York), ISBN:13: 978-0470-23396-2

	Cell Biology		
Semester 3	**Discipline Specific Courses**	**Level: 200-299**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the foundational milestones, cell theory, properties, and classification of cells, including a comparative analysis of prokaryotic and eukaryotic cells and their evolutionary origins.	U	
CO2	Explain the structure and functions of the plasma membrane, including detailed insights into membrane composition and various modes of cellular transport such as diffusion, osmosis, and active/passive transport.	U	
CO3	Explore cell compartments and their roles, including organelles such as the endoplasmic reticulum, Golgi complex, lysosomes, and mitochondria.	An	
CO4	Analyze key cellular structures such as the nucleus, cytoskeleton, and cell cycle, including mitosis and meiosis.	An	
Course Content			
I	**Introduction to cell biology:** Milestones in cell biology, Cell theory, Properties of cell, Classification of cell, Structural organization of prokaryotic and eukaryotic cell. Comparison of microbial, plant and animal cells. Origin and evolution of cells.		10 Hours
II	**Structure and function of plasma membrane**. Detailed study on plasma membranes and its structure. Transport across membranes: active, passive, diffusion and osmosis. Interaction between cell and its environment- cell adhesions, cell junction, extracellular matrix and cell wall		12 Hours
III	**Cell compartments** Endoplasmic reticulum, Golgi complex, lysosomes, vesicular trafficking- endocytosis and exocytosis, peroxisomes, glyoxysomes and vacuoles. Ribosome, Mitochondion, chloroplast		12 Hours
IV	**Structure, function of nucleus ,cytoskeleton and cell cycle**		11

	Nucleus, chromosomes, Cytoskeleton- microfilaments, intermediate filaments, microtubule. Cilia and flagella. **cell cycle -**Mitosis and Meiosis	Hours
V	**Practical** • Study of mitosis • Study of meosis • Analysis of different cell morphology- • Identify the presence of Barr Bodies	30 Hours
References		
• Gerald Karp and Nancy L Pruitt Cell and Molecular Biology: Concepts and Experiments • S C Rastogi, Cell Biology, New Age International (P) Ltd., Publishers,Edition-4 • Cell Biology: A Short Course, • DOI:10.1002/047146158X,https://onlinelibrary.wiley.com/doi/book/10.1002/047146158X		

	Biochemistry II- Metabolism			
Semester 4	**Discipline Specific Courses**		**Level: 200-299**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2		**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)				
CO1	Understand carbohydrate metabolism pathways, including glycolysis, TCA cycle, gluconeogenesis, and pentose phosphate pathway, and their associated energetics.		An	
CO2	Explain protein catabolism mechanisms, covering oxidative deamination, transamination, and their interactions with other metabolic pathways.		An	
CO3	Describe nucleic acid metabolism, focusing on purine and pyrimidine synthesis, salvage pathways, and catabolism, and their connections to other cellular processes.		An	
CO4	Explore lipid metabolism processes, including fatty acid oxidation, biosynthesis, and their integration with carbohydrate and protein metabolism.		An	
Course Content				
I	**Carbohydrates:** Fate of absorbed carbohydrates-Glycolysis-pathways and energetics.,oxidation of pyruvate to acetyl CoA.TCA cycle-pathway and enegetics.Gluconeogenesis,Glycogenesis and glycogenolyis,Pentose phosphate pathway(HMP shunt).			10 Hours
II	**Proteins:**Fate of dietary proteins, Catabolism of amino acid: Oxidative deamination,non-oxidative deamination,transamination and decarboxylation.			12 Hours
III	**Nucleic acids:** Metabolism of purines- de novo synthesis,salvage pathways; catabolism.Metabolism of pyrimidines-de novo synthesis,salvage pathways,Interrelation between carbohydrates, fat and protein metabolism.			11 Hours
IV	**Lipids and Vitamines:**Oxidation of fatty acids-Carnitine cycle.,beta oxidation.Fatty acids Biosynthesis.			12 Hours
V	**Practical** • Estimation of Carbohydrate • Quantification of protein by Folin Lowry Method			30 Hours

	• Determination of quantity and purity of nucleic acids • Estimation of Lipids	

References

- Lehninger principles of Biochemistry international edition-David L Nelson,Michael Cox.WH freeman,7th edition(2017)
- Principles and techniques of Biochemistry and molecular Biology-Wilson and Walker Cambridge University press.8th edition(2018)
- Biochemistry –Geoffrey L.Zubay,William cBrown pub.4 th edition (1999)

	Genetics		
Semester 4	**Discipline Specific Courses**	**Level: 200-299**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the history, scope, and significance of genetics, including Mendel's experiments and genetic transmission principles.	U	
CO2	Explain allelic variation, gene function, and inheritance patterns, including dominance, segregation, and interactions.	An	
CO3	Describe chromosomal organization, aberrations, and karyotyping.	An	
CO4	Analyze population genetics concepts, such as equilibrium, deviations, drift, and gene flow, in evolutionary biology.	An	
Course Content			
I	**Introduction To Genetics: And Principle Of Genetic Transmission** History of genetics,Scope and significance of genetics, Mendels' Experiments, Symbols and terminology, Principle of dominance and segregation and independent assortment. Bacterial genetics- transformation, transduction and conjugation		10 Hours
II	**Extension of Mendelism** Allelic variation and gene function- Incomplete dominance, co-dominance, multiple alleles. Gene interaction, penetrance, expressivity, epistasis, pleiotropy, Extranuclear Inheritance, Maternal Effect and Pedigree Analysis.		12 Hours
III	**Chromosomal organization and chromosomal abbretions** Chromosome: Morphology,- Classification- Karyotyping. Feartures of centromere and telomere. Special Chromosomes, Euchromatin and heterochromatin, Special chromosomes, Characteristics. Variation in Chromosome number and Structure.		11 Hours
IV	**Population Genetics** Importance of population genetics in evolutionary biology. Hardy-		12 Hours

	Weinberg equilibrium and its significance. Deviations from Hardy-Weinberg equilibrium. Genetic drift- Founder effect and bottleneck effect. Gene Flow.	
V	**Practical** • Mitosis in plants • Polythene Chromosome • Pedigree Analysis • Genetics problems	30 Hours

References

- Pierce, B. A. (2012). Genetics: a conceptual approach. Macmillan publication.
- Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.

	Microbiology	
Semester 4	**Discipline Specific Courses**	**Level: 200-299**
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70

Course Outcomes (CO)

CO1	Understand the definition and historical development of microbiology, including the contributions of key figures such as Antony van Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, and Alexander Fleming.	U	
CO2	Explain the importance and scope of microbiology as a modern science, including an overview of its branches and applications.	Ap	
CO3	Describe the structure and working principles of different types of microscopes, including compound, dark field contrast, fluorescence, and electron microscopes.	Ap	
CO4	Demonstrate proficiency in microbial techniques, including sterilization methods (physical, chemical, and radiation), staining techniques, and the principles of virus and bacteria classification.	Ap	

Course Content

I	**Introduction and Scope of Microbiology:** Definition and history of microbiology, contributions of Antony van Leeuwenhoek, Louis Paster, Koch Joseph Lister, and Alexander Flanging. Importance and scope of Microbiology as a modern science Branches of Microbiology. Structure and working principles of different types of microscopes-Compounds, Dark field contrast. Fluorescence and Election	10 Hours
II	**Microbial Techniques:** Sterilisation: Principles and applications of a. Physical Methods: Autoclave, Hot air oven, Laminar airflow, Seitz filter, Sintered glass filter, membrane filter. b. Chemical Methods: Alcohol, Aldehydes, Phenols, Halogens and Gaseous agents.c. Radiation Methods: UV rays and Gamma rays.Stains and staining techniques: Principles of staining, Types of stains-simple structural stains and Differential stains.	12 Hours
III	**General Account of Microorganisms:** Viruses- Structure and Classification Plant viruses-CAMV Animal Viruses-Hepatitis. Bacteria-Ultra structure of a bacterial cell (both Gram positive and Gram negative) includes end spore and capsule.	12 Hours
IV	**Eukaryotic microorganisms and Microbial pathogenesis:** Salient features, classification and reproduction of fungi, mycoplasma and algae. Bacterial diseases of man-Tetanus, Tuberculosis, pneumonia,	11 Hours

	AIDS, Amoebiasis.	
V	***Practical*** • Prepare Microbial media and subculture (Bacteria / Fungus) • Perform Gram staining of Given bacterial Isolate. • Isolation of bacteria and fungi from soil/ air/ water. • Perform catalase and Oxidase test of given strain.	30 Hours
References		
• Microbiology-Pelzer, Chan, Krieg Tata McGraw Hill Publications • Microbiology- Concepts and applications by Paul A. Ketchum Wiley Publications • Fundamentals of Microbiology –Furbisher, Saunders & Toppan Publications • Introductory Biotechnology-R. B Singh C.B.D India (1990)		

	Environmental Biotechnology		
Semester 5	**Discipline Specific Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the concepts of renewable and non-renewable energy sources and their environmental implications.	U	
CO2	Explain the sources and impacts of water, soil, and air pollution, including xenobiotic compounds, biomagnification, and bioindicators.	Ap	
CO3	Describe water management practices, including rainwater harvesting, and various methods of wastewater treatment.	An	
CO4	Analyze strategies for biomining, biofuel production, and bioremediation techniques for environmental cleanup.	E	
Course Content			
I	**Environment and monitoring:** Introduction, renewable and non-renewable sources of energy; Environmental pollution- water pollution, soil pollution and air pollution. Xenobiotic compounds and their sources, Biomagnification, Bioindicators. Biomonitoring: Biosensors and biochips.		10 Hours
II	**Water management and wastewater treatment:** Water as a scarce natural resource, water management including rainwater harvesting. Wastewater characteristics, waste water treatment- physical, chemical, biological processes. Aerobic processes; activated sludge, oxidation ditches, trickling filter, oxidation ponds; Anaerobic processes; anaerobic digestion, anaerobic filters, anaerobic sludge, membrane bioreactors. Reverse osmosis and ultra-filtration. Solid waste management.		12 Hours
III	**Biomining and Biofuels:** Bioleaching of ores to retrieve scarce metals, Bio-mining. Strategies for the production of Bioethanol, Biobutanol and Biodiesel. Biogas production, methanol production from organic wastes, and byproducts of sugar industries.		11 Hours
IV	**Bioremediation:** Concept and principles, bioremediation using microbes, in situ and ex situ bioremediation, biosorption and bioaccumulation of heavy metals; Phytoremediation, bioremediation of xenobiotics (heavy metals, pesticides, plastic). Bioremediation of soil and water contaminated with hydrocarbons and surfactants, biofilms.		12 Hours

V	***Practical*** • Assessment of water pollution • Waste water treatment methods • Biogas production • Isolation of xenobiotic degrading microorganism	30 Hours

References

- Anderson L and Tilman D A. (1997) Fuels from waste, Academic Press.
- Christon, J. Harst (1997) Manual of Environmental Microbiology, ASM Press, Washington DC.
- Ericksson Ed., (1997) Biotechnology in the pulp and paper industry, Springer –Verleg.
- Evans G G and Judy Furlong., (2011) Environmental Biotechnology: Theory and Application (2nd).Wiley

	Plant Biotechnology		
Semester 5	**Discipline Specific Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Evaluate plant tissue culture techniques and their applications, including micropropagation and somatic embryogenesis.	E	
CO2	Analyze metabolic engineering principles for the production of useful chemicals and secondary metabolites in plants.	An	
CO3	Assess the impact of genetic modification on crop improvement and stress tolerance.	E	
CO4	Critically examine post-harvest technologies for extending the shelf life of fruits and protecting cereals and pulses.	C	
Course Content			
I	**Plant tissue culture;** Scope and applications of plant tissue culture, Media composition and types, explants, Micropropagation, organogenesis, somatic embryogenesis, somaclonal variation, cell line selection and its maintenance. Protoplast culture and somatic hybridization. Germplasm collection and conservation, cryopreservation, plant tissue culture certification.		10 Hours
II	**Metabolic engineering of plants:** Plant cell culture for the production of useful chemicals and secondary metabolites (Hairy root culture, Biotransformation, Elicitation) -Terpenoids, phenolic compounds and alkaloids. Mechanism and manipulation of MEP, MVA and shikimate pathway. Production of Industrial enzymes, therapeutic proteins, edible vaccines and antibiotics using transgenic technology.		12 Hours
III	**GM Technology:** Crop improvement, productivity, performance and fortification of Bt cotton and Bt brinjal. Stress tolerance, herbicide resistance, viral resistance, bacterial resistance, fungal resistance crops. Golden rice and sweet potato. Current status of transgenic plants in India and other countries, Importance of integrated pest management and terminator gene technology.		12 Hours
IV	**Post-harvest technology:** Antisense RNA technology for extending the shelf life of fruits and flowers (ACC synthase gene and polygalacturonase); delay of softening and ripening of fruits (tomato,		11 Hours

	banana, watermelons). Post-harvest protection of cereals, millets and pulses.	
V	A. Plant protoplast Isolation B. Preparation of Synthetic Seeds. C. Plant propagation through Tissue culture (shoot tip and Nadal culture) D. Production of Callus and Suspension culture	30 Hours
References		
• Buchanan, B. B., Gruissem, W., & Jones, R. L.. Biochemistry & Molecular Biology of Plants. Chichester, (2015)West Sussex: John Wiley & Sons • Chrispeels M.J.et al. Plants, Genes and Agriculture-Jones and Bartlett Publishers, Boston.1994. • Gamborg O.L. and Philips G.C .Plant cell, tissue and organ culture (2nd Ed.). 1998. • Glick, B. R., & Pasternak, J. J.. Molecular Biotechnology: Principles and Applications		

	Molecular Biology		
Semester 5	**Discipline Specific Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the structure and types of DNA, RNA, and the genetic code.	U	
CO2	Explain the process of DNA replication, including its stages, enzymes, and comparison between prokaryotic and eukaryotic replication.	An	
CO3	Analyze DNA damage, mutations, and repair mechanisms, including various repair pathways.	An	
CO4	Explore transcription and RNA processing in prokaryotes and eukaryotes, along with the regulation of gene expression and translation processes.	E	
Course Content			
I	**DNA structure and replication** Discovery of DNA as genetic material Structure of DNA, Types of DNA. RNA structure and types of RNA Genetic code, properties of genetic code, Wobble hypothesis Features of DNA Replication, chemistry of DNA synthesis, the replication fork, origin of replication, stages of DNA replication, enzymes and proteins involved in DNA replication, replication in eukaryotes. Comparison of replication in prokaryotes and eukaryotes.		10 Hours

II	**DNA damage and repair** Causes and types of DNA damage- Different types of mutations. Mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair. Double strand breakage repair. Recombination	12 Hours
III	**Transcription and RNA processing** Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains. Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5’ cap formation, polyadenylation, splicing.	11 Hours
IV	**Regulation of gene expression and translation** Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides,Posttranslational modifications of proteins.	12 Hours
V	Open ended chapter	15 Hours

References

- Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington.
- Watson, J.D., Baker, T.A., Bell , Molecular Biology of the Gene (2008) 6th edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor

	Genetic Engineering		
Semester 6	**Discipline Specific Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Analyze the historical progression and scope of genetic engineering, while evaluating the structural and functional attributes of DNA and RNA.	An	
CO2	Evaluate the principles underlying recombinant DNA technology, including the utilization of molecular cloning and a diverse range of vectors	E	
CO3	Apply advanced tools and techniques in genetic engineering, assessing the role of various enzymes and gene manipulation methods in molecular biology research.	Ap	
CO4	Synthesize knowledge of cutting-edge rDNA applications and demonstrating critical thinking skills in assessing their ethical and societal implications.	C	
Course Content			
I	**Introduction & Vectors:** History, Definition, scope, of genetic engineering. DNA & RNA – Structure, types and functions. Recombinant DNA technology – Introduction to molecular cloning, Overview of cloning vectors. Plasmids, Marker genes, pBR 322, pBR 325, pUC 18, vectors and expression vectors. Bacteriophage as vectors, lambda vectors, phagemids, cosmids, BAC, YAC, vectors for animals-SV40 and Bovine papilloma virus.	10 Hours	
II	**Tools & Techniques in Genetic Engineering:** Enzymes – Endo &Exo nucleases, DNase, RNase, Polymerases, Kinases, Phosphatases, Phosphorylases, Ligases, DNA modifying enzymes, Restriction endonucleases. Electrophoretic techniques – Proteins and nucleic acids; Gene Manipulation Techniques - Methods of gene delivery. Physical, chemical, and biological methods. Transformation, transfection, electroporation, and micro-injection, screening.	12 Hours	
III	**Gene cloning and gene library:** Genome Editing – Introduction, Principles and applications of genome editing techniques. CRISPR-Cas9, site-directed mutagenesis, and other genome editing methods. Cloning – Concept, scope and applications. Isolation, Purification of DNA & RNA, Cloning of genomic DNA and mRNA. cDNA library, construction of genomic libraries.	12 Hours	
IV	**Advanced techniques:** Genetic Engineering in crop improvement, disease resistance; Genetic Engineering in therapeutics, vaccines, diagnostics; Genetic Engineering for enhancine the yield of Biotech products, Gene therapy and its potential in treating genetic disorders, DNA fingerprinting and its applications in forensics, PCR, Hybridization, blotting, RAPD, RFLP	11 Hours	

V	**Practical** • Good Laboratory Practices and Safety guidelines • Isolation, quantification and analysis of genomic DNA from plant animal and bacteria • Isolation plasmid DNA by agarose gel electrophoresis • Isolation and analysis of RNA by gel electrophoresis. • Induction of Lac Operon	30 Hours

References

- Reinert, J., and Bajaj, Y.P.S. (1997). Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Berlin: Springer.
- Sambrook, J., Fritsch, E.F., and Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual. 2nd edition. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Gahlawat, S.K., Duhan, J.S., Salar, R.K., Siwach, P., Kumar, S., & Kaur, P. (2018). Advances in Animal Biotechnology and its Applications. Springer. ISBN: 978-981-10-47015
- Wilson, K., & Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge University Press. ISBN: 978-1316614761.
- Freshney, I. (2016). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (8th ed.). Wiley-Blackwell.

	Bioprocess Technology		
Semester 6	**Discipline Specific Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	

Course Outcomes (CO)

CO1	Explore microorganisms for industrial use and their improvement,stoichiometric analysis, and formulation of media for production of microbial products.	An	
CO2	Formulate and operate conversion processes of biological resources intobio- based value-added materials related to food, feed, fuels, pharmaceutical, nutraceutical, biomaterials, or biochemical.	An	
CO3	Design biological reactions and reactors including instrumentation,control, and modelling.	C	
CO4	Bioprocessing and bio products manufacturing, development usingentrepreneurship principles.	E	

Course Content

I	**Introduction:** Introduction to bioprocess technology. History and basic principle of fermentation technology. Development and strain improvement of industrially important microorganisms. Types of microbial culture and its growth kinetics– Batch, Fed-batch, and Continuous culture.	10 Hours

II	**Fermentation Media and Bio reactor:** Fermentation media – Media components and Inoculum preparation. Fermenter design: Basic construction of fermenter, Impeller, Baffles, Sparger; Types of bioreactor - design and their functions: airlift bioreactor, tubular bioreactors, membrane bioreactors, tower bioreactors, fluidized bed reactor, packed bed reactors and photobioreactors. Solid State Fermentation (SSF): Advantages and applications	12 Hours
III	**Inoculum preparation:** Isolation and screening of industrially important microorganisms: primary and secondary metabolites; Specific screening strategies for the desired industrial product. Maintenance of strains; Strain improvement: Mutant selection and Recombinant DNA technology.	12 Hours
IV	**Up-stream&, Down-stream processing:** Upstream processing, Down-stream processing and product recovery: cell disruption, precipitation methods, solid- liquid separation, liquid-liquid extraction, filtration, centrifugation, chromatography, drying devices (Lyophilization and spray dry technology), crystallization. Microbial production amylase and lactic acid.	11 Hours
V	**Practical** • Study of Bacterial growth curve. • Preparation of wine and Determination of alcohol percentage • Isolation, screening and partial purification of amylase. • Screening and isolation of microorganisms for the production of antibiotics. • Enzyme immobilisation	30 Hours

References

- Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
- Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition.Panima Publishing Co. New Delhi.
- Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition,Elsevier

	Animal Biotechnology		
Semester 6	**Discipline Specific Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Evaluate the historical development and theoretical foundations of animal cell culture techniques.	E	
CO2	Apply advanced laboratory skills and critical thinking in selecting and operating specialized equipment for animal cell	Ap	

	culture.		
CO3	Synthesize complex protocols and methodologies for primary cell culture, demonstrating proficiency in experimental design and troubleshooting.	E	
CO4	Analyze and interpret cytotoxicity data to make recommendations for therapeutics or vaccine development.	An	

Course Content

I	**Introduction to animal cell culture:** Introduction, significance, history of cell culture development, different tissue culture techniques including primary and secondary culture, continuous cell lines, monolayer culture, suspension culture, organ culture etc.	10 Hours
II	**Instruments and Media:** Lab Design and equipments. Sterile area, Laminar flow hood. CO2 incubator. Cryostorage (liquid Nitrogen flask), refrigerated centrifuges freezers (-80^{0}C) inverted microscope. Different type of cell culture media, growth supplements, serum free media, balanced salt solution, other cell culture reagents, culture of different tissues and its application	12 Hours
III	**Primary Cell Culture:** Isolation of mouse embryo, Primary explants, Desegregation: Mechanical and Enzymatic Desegregation. Secondary cell culture, Cryopreservation. Application of animal cell culture: vaccine production	12 Hours
IV	**Cytotoxicity:** Cell cloning, micromanipulation and types of cloning. Cell transformation. Estimation of viability by Dye exclusion, cell proliferation assays, MTT-based cytotoxicity assay.	11 Hours
V	Open ended chapter	15 Hours

References

- Culture of Animal cells, 3rd Edition, R. Ian Freshney. A John Wiley& Sons, Inc., publications.
- Animal Cell Culture-Practical Approach, R.W. Masters, Oxford.Animal Cell Culture Techniques. Ed. Martin Clynes, Springer.
- Animal Cell Biotechnology, Methods and protocols, Nigel Jenkins,Humana Press. 4.Biotechnology of Animal Tissue. P.R.Yadav&Rajiv Tyagi. 2006. Discovery Publishing House. New Delhi.
- Reinert, J., and Bajaj, Y.P.S. (1997). Applied and FundamentalAspects of Plant Cell, Tissue and Organ Culture. Berlin: Springer.
- Sambrook, J., Fritsch, E.F., and Maniatis, T. (1989). MolecularCloning: A Laboratory Manual. 2nd edition. Cold Spring Harbor,NY: Cold Spring Harbor Laboratory Press.
- Gahlawat, S.K., Duhan, J.S., Salar, R.K., Siwach, P., Kumar, S., &Kaur, P. (2018). Advances in Animal Biotechnology and itsApplications. Springer. ISBN: 978-981-10- 4701-5.

	Bio-entrepreneurship		
Semester 7	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand entrepreneurship: types, characteristics, innovation, risks, growth factors, barriers, success traits	U	
CO2	Navigate bio-entrepreneurship: bio-business, innovation, products, legal aspects, IPR, bioethics	Ap	
CO3	Navigate project management: phases, formulation, report, and seize entrepreneurial opportunities.	Ap	
CO4	Spot biotech business opportunities: government initiatives, strategy, parks, incubators, MSMEs, Kerala context.	An	
Course Content			
I	**Entrepreneur and Fundamentals of Entrepreneurship:** Meaning, definition and type of entrepreneur, entrepreneurship, characteristics and nature of an entrepreneur, innovation and entrepreneurship, risks involved with entrepreneurship, factors affecting entrepreneurial growth, barriers to entrepreneurship, qualities of a successful entrepreneur, entrepreneurship in Kerala		10 Hours
II	**Bio-entrepreneurship:** Introduction to bio-business, Bio-entrepreneurship, Bio-economy, innovation as a strategic approach within biotechnology firms, biotech based products, services, technology acquisition, development, licencing and protection. Legal issues IPR, biosafety bioethics in Bio-entrepreneursh**ip.**		12 Hours
III	**Project Management and Entrepreneurial Opportunity:** Definition of business project, characteristics of a project, classification of projects, project life cycle, phases of project management, project formulation, project report, Entrepreneurial Opportunity- Environment Scanning, Problem Identification, Idea Generation, Innovative Efforts, Transformation of Ideas into Opportunities, Idea and Opportunity Assessment, Market Assessment, Trend Spotting, Creativity, Misconceptions about Generating Ideas for Entrepreneurial Opportunities		12 Hours
IV	**Identification of Biotech Business Opportunities at National and state level:** Government initiatives for startups, DBT National Biotechnology Development Strategy 2015 – 2020, Biotech Parks, Technology Business Incubators, Special Economic Zones, Startup India Initiative, Business Opportunities in Kerala, Industrial and Commercial Policy Of Kerala, Measures To Speed Up Industrial Growth. State level public enterprises. micro small & medium enterprises (MSMEs), Biotechnology (Agriculture, environmental, medical, industrial) business opportunities in Kerala, ED club, IEDC, Kerala startup mission**.**		11 Hours

V	Practical • Discuss technology acquisition, development, licensing, & IPR in biotech firms. • Explore phases of project management and project formulation. • Identify specific biotech business opportunities in Kerala	30 Hours

References

- Bioentrepreneurship Development: A Resource Book, Biotech Consortium India Limited (BCIL), New Delh, 2018
- Introduction to Biotech Entrepreneurship: From Idea to Business, Florentina Matei • Daniela Zirra Editors, Springer, 2019
- Adams, D.J., & Sparrow,J. C. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham:Scion, 2008
- Shimasaki, C. D. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. AcademicPress is an imprint of Elsevier, 2014.

	OMICS for Biotechnology		
Semester 7	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Analyze genome mapping techniques, including physical and genetic maps, genome sequencing, and next-generation sequencing methods.	An	
CO2	Evaluate transcriptome analysis using high-throughput sequencing techniques such as Sanger's sequencing, next-generation sequencing, and bioinformatics pipelines.	E	
CO3	Apply proteomic tools such as SDS-PAGE, 2D-PAGE, liquid chromatography, and mass spectrometry for protein identification and characterization.	Ap	
CO4	Assess metabolomics techniques for studying metabolomes, recognizing the significance of metabolome analysis.	E	
Course Content			
I	**Genomics**: Genome mapping: Physical and Genetic Map, Genome Sequencing, Next-generation sequencing methods, Genome Annotation, Functional Genomics.		10 Hours
II	**Transcriptomics:** Transcriptome Analysis: High-Throughput Sequencing Techniques - Sanger’s Sequencing Technology, Next Generation Sequencing, 454 Sequencing, Illumina Sequencing, Bioinformatics Pipelines, and software for Transcriptome analysis		12 Hours

III	**Proteomics:** Basic concepts , Tools of proteomics- SDS PAGE, 2D PAGE , Liquid chromatography , Mass Spectrometry (ESI and MALDI) ,Protein identification by peptide mass fingerprinting ,Applications of proteomics.	12 Hours
FIV	**Metabolomics:** Metabolomics: Introduction to metabolomics, significance of the study of metabolome, techniques to study metabolome, challenges, limitations in the existing techniques. Targeted Metabolomics and Untargeted Metabolomics.	11 Hours
V	Practical • Perform Genome Sequencing and Annotation. • Perform Protein Identification by Peptide Mass Fingerprinting. • Explore Targeted and Untargeted Metabolomics approaches.	30 Hours

References

- Introduction to Proteomics -Tools for the New Biology by Daniel C. Liebler, Humana Press.
- Metabolomics- Methods and Protocols by Wolfram Weckwerth, Humana Press.
- Essentials of Transcriptomics, Kayeen Vadakkan and Selvaraj Vijayanand,Lambert Academic Publication, UK, 2023
- Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore; VDM Publishing, 2009 – Science.

	Virology		
Semester 7	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the origin evolution and classification of virus and their morphology and structure	U	
CO2	Understand the major RNA and DNA phages and sub-viral agents	U	
CO3	Describe the mode of transmission, types of infections and emerging major viral diseases of humans and their management	Ap	
CO4	Learn the basic concepts of isolation, cultivation and assay of the viruses	U	
Course Content			
I	Brief History of virology – Origin of Virology. General properties of viruses- Structure and Morphology, Classification (nucleic acid and structural level)- Criteria used for naming and classification, Current ICTV classification of viruses of bacteria, plants and animals and humans. Replication – replication of RNA and DNA viruses		10 Hours
II	Bacteriophages: Biology of major RNA (MS2, Qβ) and DNA (T4, lambda, M13) bacteriophages, replication of M13, T4 and lambda phages. Sub viral agents - Satellite viruses, sat-RNAs, DI particles, viroids, virusoids and prions.		12 Hours
III	Mode of transmission of viruses- vector mode, non vector mode. Effects of viruses on host cell. Host virus interaction. Types of infections –acute, chronic, latent and slowly progressive infections. Virus inclusion bodies. Antigen Shift. Emerging viral diseases- Nipah, Corona, H1N1. Advanced Treatment methods.		12 Hours
IV	Isolation and Cultivation. Laboratory requirements for cultivation. Experimental plants and tissue culture, experimental animals, embryonated eggs, organ cultures, primary and secondary cell cultures, suspension and monolayer cell cultures, cell strains, cell lines. Cytopathic effect, Plaque forming unit. Assay of viruses- Infectivity assay methods (plaque, pock, end point, local / systemic assay of plant viruses), physical (EM), serological (HA, HI, immunofluorescence, ELISA) and chemical (viral protein and nucleic		11 Hours

	acid based) approaches.	
V	Practical • Explore virus classification based on ICTV classifications. • Set up laboratory requirements for virus isolation and cultivation. • Perform virus assays • Virology lab visit	30 Hours
References		
• Virology (2019), P. Saravanan. • Virology (2017) Ren Warom, Titan Books. • Introduction to Modern Virology. (2001). 5th ed. Dimmock et al., Blackwell Sci. 17 Publ • Textbook of Microbiology (2016) R. Ananthanarayan,OrientBlacksman publications. • Virology (2017) RenWarom, Titan Books.		

	IPR, Bioethics & Biosafety		
Semester 7	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the international and Indian frameworks of intellectual property rights (IPR) and their application in biotechnology.	U	
CO2	Evaluate the rationale for IPR in biotechnology, focusing on novelty, patenting, and protection of new plant varieties.	E	
CO3	Demonstrate knowledge of biosafety principles, including risk assessment, regulations, and GMO labeling.	Ap	
CO4	Analyze ethical conflicts in biological sciences, addressing issues in healthcare, research, and agricultural biotechnology.	An	
Course Content			
I	**Overview of intellectual property:** Introduction and the need of intellectual property right (IPR). International framework for the protection of IP. IPR in India. Patent, Copyright, Trademarks, Geographical indications and Industrial designs.		10 Hours
II	**Biotechnology and IPR:** Rationale for intellectual property protection in biotechnology. Concept of novelty in Biotechnology inventions. Palatability (difference between basic science and applied science). Patenting biological inventions. Patenting microorganisms, biological processes and products. Protection of new varieties of plants. Biotechnology and International Treaties: Convention on Biological Diversity and TRIPs.		12 Hours
III	**Biosafety:** Biohazards; biological safety cabinets; biosafety levels; GRAS organisms, GMOs & LMOs; Environmental risk assessment and food and feed safety assessment; risk assessment of transgenic crops. National and international regulations- Cartagena protocol, EPA act and rules, regulatory framework – RCGM and GEAC. GM labeling – Food Safety and Standards Authority of India (FSSAI).		12 Hours
IV	**Bioethics:** Ethical conflicts in biological sciences - interference with nature, bioethics in health care. Bioethics in research – cloning and stem cell research, Human and animal experimentation, CPCSEA, animal rights/welfare, Agricultural biotechnology – Farmers rights, Genetically engineered food, environmental risk, labelling and public		11 Hours

	opinion. Sharing benefits and protecting future generations, biopiracy.	
V	Practical • Review Convention on Biological Diversity and TRIPs. • Investigate GMOs, LMOs, and risk assessments. • Discuss ethical conflicts in biotechnology.	30 Hours
References		
• T.M.Murray M.J Mehlman, 2000. Encyclopaedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons • P N Cheremisinoff PR P Ouellette and R M Bartholomew. 1985 Biotechnology Applications and Research, Technomic publishing Co. INc • B L Wardehra 2000 Law Relating to Patents Trade marks Copyright design & Geographical Indications Universl law Publishing Pvt Ltd • NS Gopalakrishnan, T.G.Agitha 2009 Principles of Intellectual property.Eastern Book Company • Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.		

	Analytical techniques		
Semester 7	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand various microscopy techniques, including light microscopy, electron microscopy, atomic force microscopy, and confocal microscopy.	U	
CO2	Analyze chromatography methods, such as paper chromatography, thin-layer chromatography, and liquid chromatography.	An	
CO3	Evaluate electrophoresis and centrifugation techniques, including SDS-PAGE and density gradient centrifugation.	E	
CO4	Explore modern analytical techniques like nuclear magnetic resonance spectroscopy, mass spectrometry, and fluorescence spectroscopy.	E	
Course Content			
I	**Microscopy:** Basic concept of microscopy, Light Microscopy: Brightfield Microscopy, Phase-Contrast Microscopy: Darkfield Microscopy, Fluorescence Microscopy, Electron Microscopy (SEM, TEM), Atomic Force Microscopy, Confocal microscopy, High resolution microscopy		10 Hours

II	**Chromatography:** Basic concept of chromatography, Paper Chromatography, Thin-Layer Chromatography, Ion exchange chromatography, Affinity Chromatography, Gel Permeation Chromatography, Liquid Chromatography (LPLC, HPLC), Gas Chromatography	12 Hours
III	**Electrophoresis and Centrifugation:** Basic concept in electrophoresis, Horizontal and vertical electrophoresis, Native and SDS PAGE, AGE, Isoelectric Focusing, Pulse Field Gel Electrophoresis, Two-Dimensional Electrophoresis, Capillary Electrophoresis, Density gradient centrifugation, Ultracentrifugation, Differential centrifugation	12 Hours
IV	**Modern Techniques in Analytics**: Nuclear Magnetic Resonance Spectroscopy, Atomic spectroscopy and Mass Spectrometry, Fluorescence Spectroscopy. Inductively coupled plasma mass spectrometry, Autoradiography, FACS, FISH.	11 Hours
V	Practical • Explore Microscopy Techniques • Investigate Chromatography Methods: Paper and TLC • Study Electrophoresis Techniques: PAGE and Agarose • Centrifugation Separation: Density and Ultracentrifugation.	30 Hours

References

- Wilson K, Walker J, eds. Frontmatter. In: Principles and Techniques of Biochemistry and Molecular Biology. 7th ed. Cambridge: Cambridge University Press; 2010
- Sharma, B.K. Instrumental Methods of Chemical Analysis: Analytical Chemistry, Krishna Prakashan Media (P) Ltd, 2014
- Haven, Mary C., etal., Laboratory Instrumentation . 4th Edition, Wiley India Pvt Ltd, 2010
- Philopose P.M.Analytical Biotechnology. Domihant Publishers & distributors, New Delhi, 2016.

	Phyto-medicine		
Semester 8	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the scope and importance of ethnobotany, exploring the traditional plant usage among Kerala's tribal communities for medicinal, culinary, and cultural purposes.	U	
CO2	Apply interdisciplinary approaches in ethnobotanical research, including the extraction and identification of active compounds from medicinal plants and insilico efficacy studies.	Ap	
CO3	Implement cultivation, multiplication, collection, processing, and marketing strategies for medicinal plants.	Ap	
CO4	Analyze phyto-medical technologies and the development of herbal cosmetics and dietetics.	An	
Course Content			
I	**Ethnobotany:** Scope and importance, inter-disciplinary approaches in Ethnobotany, tribals of Kerala and their traditional usage of plants in medicine, food and other purposes. Applications of Ethnobotany. Active compound extraction and identification. Insilico efficacy study. Access and benefit-sharing (ABS)		10 Hours
II	**Cultivation, Multiplication, Collection, Processing and Marketing:** Macro and Micro Propagation and cultivation of medicinal plants; Multiplication of Medicinal Plants and Production of Specific Biologically Active Molecules through Tissue culture; Methods of Collection, Processing, Storage, Market Potential and Trade of Plant Medicines. Adoption of GATT and TRIP		12 Hours
III	**Phyto-medical technology:** Systems of medicine, brief history, origin and scope of plant medicines, identification of locally available medicinal plants. Vitamins, Various secondary metabolites and Biosynthesis; Adulteration and Alternations of the Drugs. Macroscopy and microscopy of medicinally useful plant parts such as leaves, stems, underground parts, flowers, fruits and seeds (Senna, Datura, Cinnamon, Cinchona, Ginger, Clove, Fennel)		12 Hours
IV	**Formulations, Diagnostic features and biological activity:** Formulations and dosage forms of plant medicines; Pharmacology and Pharmacognosy; Study of the important Diagnostic Features of Active Constituents, Quality, Purity; and pharmaceutical uses of important		11 Hours

	Plant Medicines. Biological Active Principles of Established Herbal Medicines. Herbal Cosmetics and Dietetics.	
V	Practical • Explore traditional plant usage by Kerala tribals in medicine. • Collection, processing, storage & marketing strategies for plant medicines. • Study formulations and dosage forms of plant medicines.	30 Hours

References

- Jain, S.K., Medicinal Plants National Book Trust of India, New Delhi, 1968.
- Jain, S.K., Glimpses of Indian Ethnobotany, Oxford and IBH Publishing Co., New Delhi, 1981.
- Rao, P.S. Venkaiah, K. & Padmaja, R. Field guide on Medicinal Plants. A. P. Forest Department, 1999.
- Sinha, R.K.. Global Biodiversity, INA Shree Publications, Jaipur, India, 1997
- Trivedi, P.C. Ethnobotany, Avishkar Publishers, Jaipur, India, 2002.

	Cancer biology		
Semester 8	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Analyze the properties and differences between normal and cancerous cells, as well as benign and malignant tumors.	U	
CO2	Evaluate the molecular mechanisms underlying carcinogenesis, focusing on alterations in cancer genes, signal pathways, angiogenesis, invasion, metastasis, and metabolism in cancer cells.	E	
CO3	Assess cancer diagnosis methods, including imaging, biomarkers, and staging, and understand cancer heterogeneity.	An	
CO4	Examine various cancer treatment modalities, considering emerging treatment strategies and the socioeconomic impact of cancer on healthcare systems.	Ap	
Course Content			
I	Cancer cell: Definition of cancer - Properties of normal cells – properties of cancerous cells (in vivo and in vitro). Tumors –nature and types of tumors – benign and malignant. Types of cancers. Common symptoms, causative factors – Physical, chemical and biological agents, genetic syndromes, lifestyle and dietary factors, Hormones. Primary and secondary cancers.		10 Hours

II	Molecular basis of carcinogenesis: Multi step process of carcinogenesis, Cancer genes – oncogenes (RSA & c-Sis) – tumor suppressor genes (p53 and Rb) and their mutations – signal pathways, cell cycle check points, angiogenesis, invasion and metastasis, altered metabolism in cancer cells, epigenetics of cancer cells	12 Hours
III	Cancer diagnosis and treatment: Cancer screening methods – imaging techniques, biomarkers and tumour markers, liquid biopsies. Heterogeneity in cancer. Cancer staging and grading.	12 Hours
IV	Cancer therapies - surgery, chemotherapy, radiation therapy, immunotherapy, targeted therapy, hormone therapy. Pharmacogenomics and personalized therapy. Emerging treatment strategies. Socioeconomic impact of cancer and its implications on healthcare systems. Cancer prevention: Cancer vaccines, lifestyle modifications, early detection	11 Hours
V	Open ended chapter	15 Hours

References

- Weinberg, Robert A. The Biology of Cancer. Garland Science, 2013.
- Hanahan, Douglas, and Robert A. Weinberg. "Hallmarks of cancer: the next generation." Cell, vol. 144, no. 5, 2011, pp. 646-674.
- Kumar, Vinay, et al. Robbins and Cotran Pathologic Basis of Disease. Elsevier, 2021.
- DeVita, Vincent T., et al. DeVita, Hellman, and Rosenberg's Cancer: Principles & Practice of Oncology. Wolters Kluwer, 2019.

	Biomaterials and nanotechnology		
Semester 8	**Discipline Specific Elective Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the basics of bionanomaterial and bionanotechnology	U	
CO2	Elucidate the properties of nanomaterials	An	
CO3	To learn the techniques and characterisation of nanomaterial	Ap	
CO4	To explore the application aspects of nanotechnology	Ap	
Course Content			
I	Introduction to Biomaterials and Nanobiotechnology: Introduction to biomaterials and their classifications, Properties of biomaterials: Mechanical, Thermal, Optical and Biological. Introduction to nanoscale materials and phenomena, nanoparticle synthesis and characterization techniques.	10 Hours	
II	Introduction to Biomaterials and Nanobiotechnology: Introduction to biomaterials and their classifications, Properties of biomaterials: Mechanical, Thermal, Optical and Biological. Introduction to nanoscale materials and phenomena, nanoparticle synthesis and characterization techniques.	12 Hours	
III	Nanostructure and basic characterization techniques; Electron microscopy (TEM, SEM); Atomic force microscopy;Photon correlation spectroscopy. Characterisation of nanomaterials; Nanovesicles; Nanocapsules.	12 Hours	
IV	Concept ofNanostructures for drug delivery, targeting and routes; Nanostructures for diagnostics, imaging and biosensor development.	11 Hours	
V	Open ended chapter	15 Hours	
References			

- Multilayer Thin Films, Editors(s): Gero Decher, Joseph B. Schlenoff, Multilayer Thin Films, Wiley-VCH Verlag, GmbH & Co. KGaA ISBN: 3527304401
- Bionanotechnology: Lessons from Nature Author: David S. Goodsell Publisher: Wiley-Liss ISBN: 047141719X.
- Biomedical Nanotechnology Editor: Neelina H. Malsch Publisher: CRC Press

ISBN: 0-8247-2579-4
- Gero Decher, Joseph B. Schlenoff, Multilayer Thin Films, Wiley-VCD Verlag, GmbH &Co.KGaA, 2003.
- David S. Goodsell, Bionanotechnology: Lessons from Nature, 1st Edition, Wiley- Liss, 2004.

	Research methodology in Biotechnology		
Semester 8	**Discipline Specific Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Develop foundational skills in research preparation, including selecting a mentor, defining objectives, and maintaining a lab notebook.	U	
CO2	Acquire proficiency in literature collection using various sources, digital libraries, and search engines, and develop the ability to critically evaluate and select suitable methods based on research plans.	An	
CO3	Enhance presentation skills, including formal presentation techniques, using presentation tools, defending research findings, and creating and presenting scientific posters.	An	
CO4	Attain technical writing skills for scientific communication, including understanding different report types, scientific writing principles, and the process of publishing articles, with a focus on elements like abstract, introduction, materials & methods, results, discussion, and references.	Ap	
Course Content			
I	Preparation for research: Choosing a mentor, lab and research question; maintaining a lab notebook. Topic selection – Planning research – defining objectives – Preparation of work plans. Identification of suitable methodology – Preparation of project proposal – summer school- Training in research institutes.		10 Hours
II	Collection of literature –News articles – Books – Journals. Digital library and search of articles - Google Scholar – PubMed-Inflibnet – Medline – Open access Journals – virtual sources-. Short communications – review articles. Collection of protocols and selection of suitable methods according to work plan. Observational and experimental research. Data analysis – construction of tables – headings –footer – Tabulation – Presentation of results – Use of statistical software to analyze the results.		12 Hours
III	Presentation skills - formal presentation skills; preparing and presenting using presentation tools; AI tools, defending interrogation; scientific poster preparation & presentation; participating in group discussions. Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching;		12 Hours

	effective email strategy using the right tone and conciseness	
IV	Publishing of Articles: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers – peer review process.	11 Hours
V	Open ended chapter	15 Hours
References		
• Anderson, Dinston & Polle 1970 : Thesis and assignment , writing Wiley Eastern Limited • Booth W C 2016 The Craft of Research Univerity of Chicago Press • Rajendrakumar C. 2008 Research Methodology . New Age International Publishers • Kothari C R 2004 Research Methodology . New Age International Publishers • Gurumani N 2006 Research Methodology for Biological Sciences. MJP Publishers		

Discipline Specific Elective Courses

	Immunology		
Semester 5	**Discipline Specific Elective Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the different types of immunity, including passive, active, and acquired immunity, and differentiate between humoral and cell-mediated immune responses.	U	
CO2	Identify the cells, organs, and tissues involved in immune responses and explain their respective functions.	An	
CO3	Describe antigens, including their types, epitopes, and factors influencing antigenicity, as well as the structure, types, and functions of antibodies (immunoglobulins).	An	
CO4	Explain the major histocompatibility complex (MHC) and human leukocyte antigen (HLA) systems, antigen processing and presentation pathways, and the structure, components, and functions of the complement system.	Ap	
Course Content			
I	**Introduction to Immunology:** Types of Immunity Passive, Active and Acquired immunity, Humoral, and Cell-Mediated Immunity. Cell and organs of immune responses and their functions.		10 Hours
II	**Antigens and Antibodies:** Antigen Types, haptens, epitomes and Factors influencing antigenicity, Immunogenicity. Antibodies Structure, types, properties and functions of immunoglobulin.		12 Hours
III	**Major histocompatibility complex and Complement system**: Structure and functions of MHC and HLA systems. MHC restriction, Processing and presentation of antigens by MHC molecules- Cytosolic pathway and Endocytic pathway Complement system. Structure, Components, Properties and Functions.		12 Hours
IV	**Hypersensitivity and Allergic reactions:** Allergy, hypersensitivity reactions- types (I, II, III, and IV). Autoimmunity: Autoimmune diseases- Hashimoto's disease, Systemic lupus erythematosus, Multiple sclerosis, Rheumatoid arthritis.		11 Hours

V	Open ended chapter	15 Hours

References

- Abbas AK, Lichtman AH, and Pillai S.Basic Immunology- Functions and Disorders of the Immune system.(2019).Elsevier,
- Abdul, K., Abbas, Andrew K. L., Jordan, S. P. Cellular and Molecular Immunology. W.B. Saunders Publisher. (1998) Philadelphia.
- Benjamine, E., Cocoi., Sunshine. Immunology 4th edition (2000) Wiley-Liss. New York.
- Kuby, J. Immunology 5th Edition. (2003) WH. Freeman and Company, NY.

	Medical biotechnology		
Semester 5	**Discipline Specific Elective Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the principles of microbial pathogenesis.	U	
CO2	Demonstrate the proper use of diagnostic tools for identifying microbial pathogens.	Ap	
CO3	Analyse the epidemiology of infectious diseases and Interpret microbiological data from patient samples.	An	
CO4	Evaluate the appropriateness of different diagnostic methods for specific infections.	E	
Course Content			
I	General identification procedures for various pathogenic bacteria & fungi. Normal Microflora of Human body, Microbial genetics		10 Hours
II	**General properties infections caused by following bacteria** (morphology, cultural characteristics, biochemical reactions, resistance, prophylaxis, pathogenesis, epidemiology,laboratorydiagnosis,treatment) : Staphylococcus (*Staphylococcus aureus, Staphylococcus epidermidis*), Streptococcus (*Streptococcus pyogenes, Streptococcus agalactiae, Streptococcus mutans*,*Entercoccus*,) Pneumococcus, Clostridium (*Clostridium tetani*,*Clostridium botulinum, Clostridium perfringens)*Enterobacteriacea (Coliforms, Sheigella, Salmonella andKlebziella),Vibrio, Pseudomonas (*Pseudomonas aeruginosa*), Mycobacterium I : tuberculosis, Spirochetes & Mycoplasma, Rickettesia&Chlamydea		12 Hours
III	**General properties of viruses and their infections (**morphology, resistance, prophylaxis, pathogenesis, epidemiology, laboratory diagnosis, treatment)**:** Virus-host interaction, Nippah Virus, Corona virus, Omicron, Pox viruses, Herpes viruses, Adenovirus, Hepatitis viruses, Oncogenic viruses, H1N1 disease control and prevention, Human Immunodeficiency Virus : AIDS		12 Hours
IV	Acute diarrhoeal diseases, Nosocomial infections, Antimicrobial therapy, Regenerative medicine, diagnostic kits, gene editing, gene chip, medical reporting, genetic counselling, prenatal diagnostics,		11 Hours

	stem cell preservation, emerging technologies in treatment of microbial diseases	
V	Open ended chapter	15 Hours

References

- Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2015). Medical microbiology (8th ed.). Elsevier.
- Tortora, G. J., Funke., & Case, C. L. (2017). Microbiology: An Introduction (13th ed.). Pearson.
- Ryan, , Ray, & Sherris, (2014). Sherris Medical Microbiology (6th ed.). McGraw-Hill Education.

	Pharmacology & Toxicology	
Semester 6	**Discipline Specific Elective Courses**	**Level: 300- 399**
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70

Course Outcomes (CO)

CO1	Understand the fundamentals of pharmacology, including the mechanism of drug action, drug receptors, dose-response relationships, and the principles of drug antagonism, pharmacokinetics, and pharmacodynamics.	U	
CO2	Demonstrate knowledge of drug absorption, distribution, metabolism, and excretion (ADME), considering factors affecting the rate of absorption, various routes of administration, and the physiological processes involved in drug distribution, metabolism, and excretion.	An	
CO3	Gain an insight into the principles of toxicology, encompassing basic concepts, historical overview, and the scope of toxicology, with an understanding of dose-response relationships, routes of exposure, and the distinction between acute and chronic toxicity.	An	
CO4	Identify and analyze different types of toxic agents, including chemical toxicants such as cyanide, biological toxins produced by living organisms, and the toxic effects of physical agents like radiation, temperature extremes, and mechanical trauma. Understand the pathophysiology associated with toxicology.	Ap	

Course Content

I	**Fundamental of pharmacology:** Mechanism of drug action, drug receptors and biological responses, second-messenger systems, the chemistry of drug–receptor binding, dose–response relationship: therapeutic index, TD, ED, LD, Potency and Intrinsic Activity Drug	10 Hours

	antagonism, Pharmacokinetics, Pharmacodynamics	
II	**Drug Absorption, Distribution, Metabolism, and Excretion:** ADME, Absorption of drugs from the alimentary tract, lungs and skin. Factors affecting rate of absorption of drugs, drug distribution, drug metabolism, drug excretion	12 Hours
III	**Principles of Toxicology:** Introduction to Toxicology: Basic concepts, historical overview, and the scope of toxicology. Dose-Response Relationship, Routes of Exposure, Causation: degrees of certainty Classification, Acute vs. Chronic Toxicity	12 Hours
IV	**Types of Toxic Agents:** Chemical Toxicants- cyanide, methanol, ethylene glycol, hydrocarbons, volatile solvents, heavy metals Biological and Microbial Toxins- toxins produced by living organisms, including bacteria, fungi, and plants. Endotoxins, Exotoxins, Mycotoxins-aflatoxins, ochratoxin, Neurotoxins-lead, ethanol, glutamate, nitric oxide. Maitotoxin. Snake venom, Pathophysiology in toxicology, Physical Agents: toxic effects of physical factors such as radiation, temperature extremes, and mechanical trauma.	11 Hours
V	Open ended chapter	15 Hours

References

- Dipiro et al, Pharmacotherapy: A Pathophysiologic Approach, 11th Edition, McGraw-Hill Education, 2020
- Goodman & Gilman, The Pharmacological Basis of Therapeutics, 13th Edition, McGraw-Hill Education, 2017
- Gordon Gibson and Paul Skett, Introduction to Drug Metabolism, 3rd Edition, Cengage Learning, 2008
- Michael J. Derelanko, Carol S. Auletta, Handbook of Toxicology, CRC Press, 2014

	Stem Cells and regenerative medicine		
Semester 6	**Discipline Specific Elective Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the classification and sources of stem cells, including embryonic, adult, and induced pluripotent stem cells.	U	
CO2	Analyze stem cell properties, proliferation, and differentiation, focusing on blastocyst cells, organogenesis, and stem cell preservation.	An	
CO3	Explore adult stem cells, regeneration factors, and molecular signaling pathways (Notch, Wnt, Hedgehog) controlling proliferation and differentiation.	An	
CO4	Examine ethical considerations in human stem cell research, regulatory aspects of stem cell therapies, and advancements in tissue engineering for various medical applications.	Ap	
Course Content			
I	**Introduction to stem Cells:** Definition, Classification and Sources, Embryonic stem cells, Adult (somatic), stem cells, Induced pluripotent stem cells.		10 Hours
II	**Stem Cell Properties and preservation:** Stem Cell Properties, stem cell proliferation and differentiation, Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology Characterisation of stem cells, preservation of stem cells		12 Hours
III	**Introduction to regenerative medicine:** Adult stem cells and regeneration, factors influencing stem cell regeneration. Molecular signalling regulating stem cell proliferation and differentiation- Notch Signalling, Wntsignalling, Hedgehog signalling, FGF, LIF- smad, Protein Kinase		12 Hours
IV	**Advances in Stem Cell Technologies and Tissue Engineering:** Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy, Approaches to Skin Tissue and Cartilage Regeneration Using Stem Cells, Progress in Bone Marrow Transplantation Techniques, Therapeutic Potential of Umbilical Cord Blood Stem Cells, Pioneering Stem Cell Therapies in Experimental Treatment of Heart Diseases and Spinal Cord Injuries.		11 Hours
V	Open ended chapter		15 Hour

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References

- Ann A.Kiessling, Human Embryonic Stem Cells: An Introduction to the Science and Therapeutic Potential, Jones and Bartett, 2003.
- Peter J. Quesenberry, Stem Cell Biology and Gene Therapy, 1st Edition, Willy-Less, 1998.
- Robert Lanja, Essential of Stem Cell Biology, 2nd Edition, Academic Press, 2006.
- A.D.Ho., R.Hoffiman, Stem Cell Transplantation Biology Processes Therapy, Willy-VCH, 2006.
- C.S. Potten, Stem Cells, Elsevier, 2006.
- Essentials of Stem Cell Biology by Robert Lanza and Anthony Atala

	Enzyme Technology		
Semester 5	**Discipline Specific Elective Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand enzyme structure, classification, and coenzymes, including holoenzyme and prosthetic groups.	U	
CO2	Explore enzyme catalysis theories, active site concepts, and immobilization techniques.	An	
CO3	Analyze enzyme kinetics, including factors affecting reactions, Michaelis-Menten equation, and Lineweaver-Burk plots.	An	
CO4	Examine enzyme regulation, covering reversible and irreversible inhibition types, isoenzymes, and zymogens.	Ap	
Course Content			
I	**Introduction and Classification of Enzymes:** Introduction to enzymes. History. Proteins as enzymes. Briefly mention about ribozymes and abzymes. holoenzyme, apoenzyme and prosthetic group. Classification of enzymes: IUPAC system of classification and nomenclature of enzymes: (Class and subclass with one example). Units of activity; specific activity- definition and significance. International unit (IU) and Katal. Coenzymes and cofactors.		10 Hours
II	**Enzyme catalysis and Mechanism of enzyme action:** Specificity of enzymes and types (with examples), Concept of the active site, 'Lock and key' model of Emil Fischer, Koshland's induced fit theory , Substrate Strain theory of enzyme catalysis. Nature of non-enzymatic and enzymatic catalysis. Transition state, the energy of activation. Enzyme immobilization.		12 Hours
III	**Enzyme kinetics:** Order of reactions. Study of the factors affecting the velocity of enzyme-catalyzed reaction - enzyme concentration, temperature, pH, substrate concentration, inhibitors, and activators - Derivation of Michaelis - Menten equation. Km value determination and its significance, Definition of Vo and Vmax value of enzyme-catalyzed reaction and its significance, LineweaverBurk plot (Only for single substrate enzyme-catalyzed reaction).		12 Hours
IV	**Enzyme regulation:** Enzyme inhibition: reversible and irreversible with examples. Reversible- competitive, noncompetitive and uncompetitive inhibition - explanation of inhibition types with double		11 Hours

	reciprocal plot and examples of each type of enzyme inhibition. Isoenzymes (lactate dehydrogenase and creatine phosphokinase); zymogens (pepsin, trypsin).	
V	Open ended chapter	15 Hours

References

- Nelson, and Cox. Lehninger Principles of Biochemistry, 8th Edition, W.H. Freeman and Company, N.Y.
- Palmer, T, and Bonne Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, Horwood Publishing
- Stryer, L. Biochemistry, 8th Edition, Pub.W.H. Freeman, 2015
- Voet, D. and. Voet, J. G, Biochemistry, 5th Edition, John Wiley & Sons Inc. New York, 2016

	Immuno-technology		
Semester 5	**Discipline Specific Elective Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand antigen and antibodies, types and their interactions	U	
CO2	Explain various immunotechniques in detail	U	
CO3	Learn transplantation immunology and mechanism of immune suppression	Ap	
CO4	Provide knowledge in the application of monoclonal antibodies and antibody engineering	Ap	
Course Content			
I	**Antibody-antigen interaction :** Affinity, avidity, cross reactivity, Precipitation reaction: Radial immuno diffusion (RID), Ouchterlony double diffusion (ODD), Agglutination, Bacterial Agglutination, Passive Agglutination, Hemeagglutination, Blood groups: AB, Rh system, Lewis-Luthern systems, significance, practical application of immuno methodology in blood transfusions ABO blood grouping and Rh incompatibility, Agglutination Inhibition**.**		10 Hours
II	**Immuno-electrophoresis:** Rocket immuno-electrophoresis, CIE, Graber and William technique. Agglutination: Direct and Indirect, Widal test, VDRL test. Radioimmunoassay: ELISA – Principle, Methodology and applications, Indirect ELISA, Sandwitch ELISA, Competitive ELISA, FACS, Western blotting,, Immunofluorescence:		12 Hours

	in situ localization by techniques such as FISH and GISH	
III	**Transplantation:** Terminology, Auto graft, Isograft, Allograft, Xenograft, Immunological basis of transplantation reactions, GVH reaction, Immuno suppression, General mechanisms of Immune suppression, Immune suppression, drugs (azothioprine, methotrexate, cyclophosphamide, cycosporin-A, Steroids).	12 Hours
IV	**Hybridoma technology:** production of monoclonal antibodies using hybridoma technology, Applications of monoclonal antibodies, antibody engineering, Finger printing and Immunohistochemistry. Antibody diversity: Mini gene theory, Mutation theory, Germ line theory, Somatic recombination, V (D) J recombination, Combinatorial diversity, Junctional diversity	11 Hours
V	Open ended chapter	15 Hours

References

- Kuby Immunology by Thomas Kindt and Richard A. Goldsby and Barbara A.Osborne; Ed. 6th; W.H. Freeman and Company, New York; 2007.
- Cellular and molecular immunology by Abul K. Abbas and Andrew H. Lichtman and Shiv Pillai; Ed. 6th; Saunders, 2007.
- Immuno biology: the immune system in health and disease by Charles A. Janeway and Paul Travers and Mark Walport and Mark J. Shlomchik; 7th Ed; Garland Science;2008.
- Essentials of immunology & serology by Jacqueline H. Stanley; DELMAR;Australia; 2002.
- Essential immunology- Ivan M. Roitt.
- Introduction to Immunology – John W.Kinball.

	Molecular Diagnostics and Gene therapy		
Semester 6	**Discipline Specific Elective Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Comprehend the history and significance of molecular diagnostics, including the rise of the diagnostic industry globally and in India, and acquire knowledge of evidence-based molecular diagnostics.	E	
CO2	Demonstrate proficiency in various molecular techniques for diagnosis, such as PCR, RFLP, ARMS-PCR, ELISA, and DNA sequencing, while understanding molecular markers, viral pathogen detection, and ensuring diagnostic sensitivity and specificity.	An	
CO3	Gain an understanding of gene therapy, including barriers to gene delivery, inherited and acquired diseases, and various delivery methods such as retro and adeno virus-mediated, liposome,	U	

	nanoparticles, and CRISPR gene editing.		
CO4	Evaluate clinical applications of recombinant technology, products related to gene therapy, and advancements in gene silencing technology, including antisense therapy, siRNA, tissue and organ transplantation, and the use of transgenics for humanized organs.	E	

Course Content

I	History of diagnostics; Molecular diagnostics; Significance, Scope, Rise of diagnostic industry in Indian and global scenario; Design and operation of a molecular diagnostics laboratory; Introduction to evidence-based molecular diagnostics	10 Hours
II	Molecular Techniques for diagnosis - PCR- RFLP, ARMS-PCR, ELISA, Multiplex-PCR, SSCP, , DNA Sequencing, Molecular markers: Protein Markers, 16SrRNA ribotyping; detection of viral pathogens through PCR; diagnostic sensitivity and specificity; quality oversight; regulations and approved testing.	12 Hours
III	Gene therapy; Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro and adeno virus mediated gene transter; Liposome and nanoparticles mediated gene delivery. CRISPR gene editing.	12 Hours
IV	Recombinant therapy; Clinical applications of recombinant technology, Products relared to gene therapy, Erythropoietin; humanised insulin and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors. Humanized organs. Gene silencing technology; Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses	11 Hours
V	Open ended chapter	15 Hours

References

- David E Bruns, Edward R Ashwood, & Carl A Burtis; Fundamentals of Molecular Diagnostics, Saunders/Elsevier 2007
- Lela Buckingham and Maribeth Flaws; Molecular Diagnostics: Fundamentals, Methods, & Clinical Applications; F. A. Davis Company 2008

	Bioinformatics		
Semester 6	**Discipline Specific Elective Courses**	**Level: 300- 399**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Analyze the components of bioinformatics, including omics and DNA sequencing methods, RNA sequencing, and protein structure determination.	An	
CO2	Evaluate biological databases like GenBank, PDB, and EMBL, and demonstrate proficiency in database searching using tools like NCBI, BLAST, and FASTA.	E	
CO3	Apply sequence alignment techniques, including multiple sequence alignment methods like Clustal, to analyze evolutionary relationships and infer biological function.	Ap	
CO4	Utilize visualization tools such as PyMOL and VMD to explore genome structures and analyze genome anatomy, with an understanding of whole genome analysis techniques like shotgun sequencing and molecular docking.	C	
Course Content			
I	**Introduction** Bioinformatics; Components; Different fields in bioinformatics; Omics; Biological Data Acquisition; Types of DNA sequences; RNA sequencing methods; Protein sequencing and structure determination methods; Gene expression data		10 Hours
II	**Database** biological databases, primary and secondary sequence databases, composite protein sequence databases, Gen bank, PDB, EMBL, INSDC; database searching NCBI, EMB, FASTA, BLAST BITS etc. Pattern recognition and prediction, Geneome annotation		12 Hours
III	**Sequence alignments** Sequence Similarity Searches: Sequence homology as product of molecular evolution; Measurement of sequence similarity and homology. Methods of Sequence Alignment, Multiple Sequence Alignment, Significance of multiple sequence alignment, clustal,		12 Hours

	Omega, Phylogenic tree.	
IV	**Visualization tools and genome analysis** Pymol, VMD, Rasmol, Swiss pdb viewer. Structure of genome; Anatomy of genomes of virus, prokaryotes, eukaryotes; Human genome Genome Analysis, Whole genome analysis – shotgun sequencing, clone contig; Molecular Docking, AI tools in Bioinfirmatics.	11 Hours
V	Open ended chapter	15 Hours

References

- VittalR.Srinivas, " BIOINFORMATICS : A MODERN APPROACH" , 2005, ISBN : 978-81-203-2858-7, published by PHI Learning Private Limited, New Delhi.
- Andreas D.Baxevanis, B.F. Francis Ouellette, "Bioinformatics - A Practical Guide to theAnalysis of Genes and Proteins", Third Edition, 2005-2006, ISBN: 978-81-265-2192-0,published by John Wiley & Sons INC. , U.K. 62
- Jean-Michel Claverie, Cedric Notredame, “Bioinformatics For Dummies”, 2nd Edition,2006, ISBN: 978-0-470-08985-9

	Molecular Forensics	
Semester 8	**Discipline Specific Elective Courses**	**Level: 400-499**
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70

Course Outcomes (CO)

CO1	Understand the fundamentals of forensic science, including crime scene procedures, evidence collection, document examination, and ethical considerations in forensic practice.	U	
CO2	Gain knowledge of the discovery and recovery of human remains, covering the history of forensic genetics, biological sample collections, autopsy procedures, and determining factors in decomposition.	An	
CO3	Acquire proficiency in methods of molecular forensics, focusing on human identification techniques such as autosomal STR profiling, Y chromosome analysis, mitochondrial DNA analysis, SNP typing, biomarkers, polymorphic enzymes, and DNA fingerprinting (RFLP).	Ap	
CO4	Apply molecular biology techniques in forensic scenarios through case studies, including the use of PCR-directed Y chromosome sequences, Amelogenein gene analysis, Next Generation Sequencing, and real-world applications in identifying kinship, resolving paternity disputes, handling missing person cases, and detecting illegal activities such as narcotics in body fluids.	Ap	

Course Content

I	**Introduction to Forensic Science:** Introduction to crime laboratories, Responsibilities of the forensic scientist, Securing and Searching the Crime Scene, Recording and collection of crime scene evidence, Document examination, Ethics and Integrity	10 Hours
II	**Discovery and recovery of human remains:** History of Forensic Genetics, Biological sample collections, Sample source, collection precautions, The Autopsy and handling of a Dead Body, The Stages and factors of decomposition, Determining the Age and Provenance of Remains, Asphyxia, Gunshot Wounds, Bite Marks.	12 Hours
III	**Methods of Molecular Forensics:** Methods used in forensic for human identification: Autosomal STR Profiling, Analysis of Y chromosome, Analysis of Mitochondrial DNA, Autosomal single-nucleotide polymorphisms (SNP) typing, Biomarkers in forensic identification, Polymorphic Enzymes, DNA Finger Printing- RFLP.	12 Hours
IV	**Forensic Applications of Molecular Biology- case studies:** PCR directed Y chromosome sequences, PCR Amelogenein Gene, Next	11 Hours

	generation Sequencing, Case studies of Royal Romanov Family, Study of Kinship by DNA Profiling, Paternity disputes, child swapping, missing person's identity- civil immigration Illegal hunting case identification using Molecular markers; detection of narcotics in body fluids.	
V	Open ended chapter	15 Hours

References

- Molecular Forensics. Edited by Ralph Rapley and David Whitehouse. Chichester (United Kingdom) and Hoboken (New Jersey): John Wiley & Sons, 2007
- John M. Butler, Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers, Elsevier 2005,
- Jane Moira, Taupin:Introduction to Forensic DNA Evidence for Criminal Justice Professionals, CRC Press, 2013,
- Kelly M. Elkins , Forensic DNA Biology: A Laboratory Manual, Academic Press, 2013

	Food and dairy Technology		
Semester 8	**Discipline Specific Elective Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the basics of food and dairy technology	U	
CO2	Explains the processing techniques of food and dairy products	An	
CO3	Evaluating different diary products, its processing and standardisation	E	
CO4	Provide knowledge regarding food quality and safety	E	
Course Content			
I	**Introduction to Food and Dairy Technology:** Overview of Food and Dairy Industry: Historical development, Importance and role in the global economy. Food and Dairy Processing Technologies: Traditional vs modern processing methods Microbiology in Food and Dairy: Microorganisms in food and dairy products, Microbial spoilage and preservation methods. Basics of Dairy Chemistry: Composition of milk, Chemical properties of dairy products		10 Hours
II	**Food and Dairy Processing Techniques Thermal Processing**: Pasteurization and sterilization, Heat exchangers and processing equipment.Refrigeration and Freezing: Cold storage and preservation techniques,Freezing methods and equipment.Drying and Dehydration: Spray drying, freeze-drying, and sun drying, Dehydrated food products.Fermentation and Cultured Products: Role of microorganisms in fermentation. Yogurt,		12 Hours

	cheese, and other fermented products.Novel Food Processing Technologies: High-pressure processing, pulsed electric fieldprocessing, Irradiation and emerging technologies.	
III	**Dairy Product Technology**: **Milk Processing and Standardization**: Raw milk reception and quality control, Milk standardization and homogenization.Cheese Technology: Cheese classification and manufacturing.Ripening and flavordevelopment.Butter and Ghee Production: Churning and processing of butter. Ghee manufacturing and quality control. Ice Cream Technology:Ingredients and formulation, Production and freezing techniques. Dairy By-products: Whey processing. Casein and lactose production.	12 Hours
IV	**Food Quality and Safety:** Food Quality Assurance: Quality control and assurance principles, Sensory evaluationtechniques.Food Safety Management Systems:Hazard Analysis and Critical Control Points (HACCP).Good Manufacturing Practices (GMP). Preservation methods and impacts on food safety, Packaging materials and labeling regulations, Emerging food safety issues like pathogens and outbreaks in a globalized world, Analytical techniques in food and dairy including chemical, physical, and microbiological methods, Quality parameters in milk and dairy products covering fat, protein, lactose determination, Sensory evaluation, Flavor profiling, Nutritional analysis, and Current trends in food research and innovation.	11 Hours
V	Open ended chapter	15 Hours

References

- Smith, J. (2019). "Introduction to Food and Dairy Industry." Publisher.
- Johnson, A. et al. (2020). "Global Regulations in the Food and Dairy Sector." Journal of Food Science, 45(2), 123-145.
- Fellows, P. (2017). "Food Processing Technology: Principles and Practice." Publisher.
- Steinkraus, K. H. (2018). "Handbook of Indigenous Fermented Foods." CRC Press.

	Green Biotechnology	
Semester 8	**Discipline Specific Elective Courses**	**Level: 400-499**
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70

Course Outcomes (CO)

CO1	Understand the basics of green biotechnology, plant breeding and precision agriculture	U	
CO2	Explains about the biopharmaceuticals and different approaches, bioenergy production.	An	
CO3	Details the environmental biotechnology, conservation, and climate smart agriculture	An	

CO4	Provide insights into the applications of green biotechnology	Ap	
Course Content			
I	Agroforestry and Plantation Management, Soil health and conservation practices, Plant Breeding and Improvement-Traditional vs. modern breeding methods, Marker-assisted breeding and genetic engineering, Agricultural Biotechnology, Crop Improvement Techniques, Development and regulation of genetically modified (GM) crops, Precision Agriculture-Use of technology in crop management, Remote sensing and data-driven farming practices, Sustainable Agriculture. (10 hours)		10 Hours
II	Industrial and Pharmaceutical biotechnology, Plant-based Medicines-Medicinal plants and their active compounds, Biotechnological approaches in pharmaceuticals, Plant metabolic engineering-Secondary metabolites and their applications, Bioenergy Production-Plant-based feedstocks for biofuel production.		12 Hours
III	Environmental biotechnology, Phytoremediation, Biodiversity Conservation, Climate-Smart Agriculture- Mitigating climate change through plant-based approaches, carbon farming, conservation farming, organic farming, precision irrigation, drip irrigation.		12 Hours
IV	Advanced topics in green biotechnology, synthetic biology in plants-Engineering plant systems for novel functions, Ethical considerations in synthetic biology, Nanotechnology in Plant biotechnology, Future Trends and Challenges-Emerging technologies in green biotechnology, Addressing ethical, social, and regulatory challenges.		11 Hours
V	Open ended chapter		15 Hours
References			

- Green Biotechnology, Anjani Singh Tomar, 2019.
- Text book of Green Biotechnology, Pooja, 2011.
- Green Biotechnology, David Christie Murray, 2011
- Green Biotechnology and Allied fields. Teressa Brocco.
- Biotechnology for a Second Green Revolution in India: Socioeconomic, Political, and Public Policy Issues, 2019. N. ChandrasekharaRao, Carl E. Pray, Ronald J. Herring

	Vaccine technology		
Semester 8	**Discipline Specific Elective Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the basics of Vaccines	U	
CO2	Explains about vaccine development and designs .	Ap	
CO3	Details of manufacturing vaccines	Ap	
CO4	Provide insights into the emerging techniques of Vaccinology	E	
Course Content			
I	**Introduction to Vaccines**: Fundamentals of Immunology: History and Types of Vaccines: Historical evolution of vaccines, Classification of vaccines: Live attenuated, inactivated, subunit, etc, Vaccine platforms and their mechanisms		10 Hours
II	**Vaccine Development and Design**: Vaccine Design Strategies: Antigen selection and characterization, Adjuvants and their role in enhancing immunogenicity, Formulation development. Preclinical and Clinical Development: Preclinical testing: animal models, safety, and efficacy studies, Phases of clinical trials: from Phase I to Phase IV, Vaccine licensure and post-licensure monitoring. Vaccine-associated accidents - Allergic reactions, Injection site reactions, Fever or mild illness, Rare severe reactions, Contamination or administration errors.		12 Hours
III	**Vaccine Manufacturing and Production**: Manufacturing Processes: Upstream processes: cell culture, antigen production, Downstream processes: purification, formulation, Quality control and assurance. Regulatory Affairs in Vaccine Manufacturing, Good Manufacturing Practices (GMP). Live vaccines include Recombinant vaccines, Cell Vaccines, Food Vaccines etc - Examples include the measles, mumps, rubella (MMR) vaccine, oral polio vaccine (OPV), chickenpox vaccine, and yellow fever vaccine.		12 Hours
IV	**Emerging Technologies in Vaccinology**: Advanced Vaccine Technologies: mRNA vaccines: principles and applications, Viral vector-based vaccines, Nanotechnology in vaccine delivery. Future Trends and Challenges, Personalized vaccines and their potential, Global access and equity in vaccine distribution, Ethical considerations and public perception. India boasts key vaccine producers like Serum Institute of India (SII), Bharat Biotech, Biological E, Panacea Biotec, and Zydus Cadila. Vaccines for animals, including pets and livestock, ensuring animal health and disease prevention. Case Studies on Vaccines: Case discussions on		11 Hours

	successful vaccines, Failure analysis of vaccine development	
V	Open ended chapter	15 Hours

References

- Giese M, Kang Z, Yuan R. Vaccine Development and Manufacturing. John Wiley & Sons, 2020.
- Levine MM. New Generation Vaccines. CRC Press, 2017.
- Smith K, Meagher M, DiLeo MV. Bioprocessing Piping and Equipment Design: A Companion Guide for the ASME BPE Standard. John Wiley & Sons, 2016.
- Aunins JG, Mikhailopulo IA. Vaccine Manufacturing and Production. Springer, 2020.
- Plotkin SA, Mahmoud AAF, Farrar J. Vaccines: Expert Consult. Elsevier Health Sciences, 2017.
- Bloom DE, Madhavan G, editors. Vaccines: From Concept to Clinic. Academic Press, 2020.

	Neuroscience		
Semester 8	**Discipline Specific Elective Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Delve into the intricacies of neuroscience, covering neuron function, synaptic transmission, and basic neuroanatomy.	U	
CO2	Explore neurophysiology and neurochemistry, learning about membrane potentials, synaptic transmission mechanisms, and neuroplasticity.	U	
CO3	Investigate the brain's impact on behavior and cognition, studying sensory systems, motor control, learning, memory, emotions, and cognitive functions.	E	
CO4	Examine neurobiology of diseases such as Alzheimer's, Parkinson's, epilepsy, and psychiatric disorders.	Ap	
Course Content			
I	**Introduction to Neuroscience:** Organization of the nervous system, Neuron structure and function, Neural communication (synaptic transmission), Basic neuroanatomy		12 Hours
II	**Neurophysiology and Neurochemistry:** Membrane potentials, Action potentials, Synaptic transmission mechanisms, Neuroplasticity, Neurochemical signaling.		10 Hours
III	**Brain and Behavior:** Sensory and motor systems, Neural control of movement, Sensory processing (vision, hearing, touch, taste, smell), Learning and memory, Emotions and cognitive functions.		10 Hours
IV	**Neurobiology of Disease and Therapeutics:** Neurobiology of diseases (Alzheimer's, Parkinson's, epilepsy, stroke, psychiatric disorders), Molecular and cellular mechanisms of disorders, Diagnostic techniques (neuroimaging, electrophysiology), Therapeutic approaches (pharmacology, gene therapy, neurorehabilitation), Ethical considerations in neuroscience.		13 Hours
V	Open ended chapter		15 Hours
References			
• Bear, M. F., Connors, B. W., & Paradiso, M. A. (2016). Neuroscience: Exploring the Brain (4th ed.). Wolters Kluwer.			

- Kandel, E. R., Schwartz, J. H., & Jessell, T. M. (2013). Principles of Neural Science (5th ed.). McGraw-Hill Education.
- Purves, D., Augustine, G. J., Fitzpatrick, D., et al. (2011). Neuroscience (5th ed.). Sinauer Associates.

	Developmental Biology		
Semester 8	**Discipline Specific Elective Courses**	**Level: 400-499**	
4 Credit	**Hours per week: 4** Theory	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Explore the foundational concepts and historical evolution of developmental biology.	U	
CO2	Investigate the intricate processes of gametogenesis and fertilization	E	
CO3	Delve into the complexities of embryonic development and exploring the signaling pathways responsible for embryonic patterning.	E	
CO4	Examine the genetic mechanisms regulating cell differentiation during development, including the role of transcription factors, signaling pathways, and epigenetic modifications.	Ap	
Course Content			
I	**Introduction to Developmental Biology:** Historical perspectives on developmental biology, Basic principles of embryonic development, Model organisms in developmental biology research.		10 Hours
II	**Gametogenesis and Fertilization:** Gamete formation (spermatogenesis and oogenesis), Mechanisms of fertilization and early embryonic development, Genetic and epigenetic factors influencing gametogenesis and fertilization.		10 Hours
III	**Embryonic Development:** Early embryonic development: cleavage, gastrulation, and organogenesis, Establishment of body axes and germ layers, Signaling pathways (e.g., Notch, Wnt, Hedgehog) in embryonic patterning.		12 Hours
IV	**Developmental Genetics and Cell Differentiation:** Gene regulation during development: transcription factors, signaling pathways, and epigenetic modifications, Cell differentiation and determination: stem cells, cell fate specification, and cell lineage tracing techniques, Developmental abnormalities and genetic disorders.		13 Hours
V	Open ended chapter		15 Hours
References			

- Wolpert, L., Tickle, C., et al. (2015). Principles of Development (6th ed.). Oxford University Press.
- Gilbert, S. F. (2016). Developmental Biology (11th ed.). Sinauer Associates.
- Slack, J. M. W. (2012). Essential Developmental Biology. Wiley-Blackwell.

Minor Pathway Courses

	Introductory Biology		
Semester 1	**Minor Pathway Courses**	**Level: 100-199**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the fundamental principles of biology and examining the intricate Tree of Life and Three Domains Classification.	U	
CO2	Understand the molecular basis of life by analysing the structures and functions of biomolecules, and delve into basic chemistry concepts	U	
CO3	Explore the intricacies of cellular biology, principles of genetics and the processes of DNA replication, transcription, and translation.	An	
CO4	Analysing the scope and significance of recombinant DNA technology in pharmaceuticals, gene therapy, molecular diagnostics, crop improvement, and industrial biotechnology.	An	
Course Content			
I	**Introduction to Biology:** Definition and scope of biology, Biodiversity: Tree of Life, Three Domains Classification. Prokaryotic and eukaryotic cells. Non-living infectious agents. Structure and function of carbohydrates, proteins, lipids, and nucleic acids.		10 Hours
II	**Basic Chemistry for Biology:** Elements and atoms important for life (e.g., carbon, hydrogen, oxygen, nitrogen). Chemical bonds (ionic, covalent, hydrogen bonds). Water properties and their importance to biological systems		12 Hours
III	**Cell Structure and Function:** Cell organelles and their functions. Mendelian genetics: laws of inheritance. Central Dogma of Molecular Biology: DNA replication, transcription, and translation. Cellular Communication: Signalling molecules and receptors. Cell Cycle and Division.		12 Hours
IV	**Applied Biology:** Definition and scope of biotechnology. Introduction to recombinant DNA technology. Biotechnology applications: Pharmaceutical Biotechnology (production of therapeutic proteins, vaccines, and monoclonal antibodies), Gene therapy, Molecular diagnostics (RTPCR), Crop Improvement (GMOs), Industrial Biotechnology (Enzyme technology and Fermentation technology)		11 Hours

V	• **Compare prokaryotic and eukaryotic cells under a microscope.** • **Biochemical Analysis of Biomolecules (Qualitative)** • **DNA Extraction** • **Wine or Biogas Production**	30 Hours

References

- Campbell Biology – 12th Edition - Lisa A. Urry, Michael L. Cain, Las Cruces, Steven A. Wasserman, Peter V. Minorsky, Rebecca Orr, Pearson (2021).
- The Cell: A Molecular Approach 8e, by Geoffrey M. Cooper. Sinauer Associates, Inc.
- Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology.
- William J. Thieman, Michael A. Palladino. Introduction to Biotechnology. Benjamin Cummings

	Computer for Biosciences		
Semester 2	**Minor Pathway Courses**	**Level: 100-199**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Demonstrate a fundamental understanding of computer hardware and software	U	
CO2	Develop and execute basic Python scripts, employing essential programming constructs	Ap	
CO3	Utilize office applications proficiently to perform data management tasks and produce data visualizations.	Ap	
CO4	Apply computational tools to retrieve data from major biological databases, perform basic molecular visualization and conduct introductory statistical analyses	Ap	
Course Content			
I	**Overview of Computers:** Functional block diagram of computer, hardware specifications. Types of computers: desktops, laptops, and		10 Hours

	servers. Introduction to software: Types of software - Operating systems (Windows, Linux).	
II	**Basic Programming Concepts:** Introduction to programming languages (Python). Basic constructs: variables, data types, operators, and control structures (if statements, loops). Writing and executing simple scripts in Python	12 Hours
III	**Office Applications:** Basic operations in word processor like styles, table of contents, inserting objects and references. Using spreadsheets for data management (Microsoft Excel, Google Sheets). Data entry, formatting, and basic formulas. Data visualization: creating charts and graphs.	12 Hours
IV	**Computational Tools in Biosciences:** Overview of major biological databases (NCBI, UniProt). Accessing and retrieving data from databases. Basics of molecular visualization (introduction to tools like PyMOL). Introduction to statistical analysis software (e.g., R)	11 Hours
V	• Exercises in basic programming • Managing biological data using spreadsheets • Exercises using bioinformatics software • Using software for data analysis and visualization	30 Hours

References

- Computer Fundamentals: Concepts, Systems & Applications- 8th Edition, Pradeep K. Sinha , Priti Sinha, BPB Publications; 6th edition, 2004
- Sweigart, A. (2015). Automate the Boring Stuff with Python: Practical Programming for Total Beginners. No Starch Press.
- Govindarulu, IBM PC and Clones, Tata McGraw-Hill Education,2nd edition 2002
- Wünschiers, R. (2013). Computational Biology: A Practical Introduction to BioData Processing and Analysis with Linux, MySQL, and R. Springer.

	Food and fermentation Technology		
Semester 3	**Minor Pathway Courses**	**Level: 200-299**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Define fermentation and explain its significance in producing fermented foods.	U	
CO2	Identify industrial microorganisms used in fermentation processes and describe the production of single-cell protein.	Ap	
CO3	Explain the types of fermentation, including ethanolic, lactic acid, and mixed alcoholic and acid fermentation.	Ap	
CO4	Understand the functions and design of fermenters, and analyze upstream, fermentation, and downstream processing techniques, with a case study.	Ap	
Course Content			
I	**Introduction to fermentation:** Define fermentation, fermented foods: definition nutritive value, microbial changes in fermented foods – microorganism – proteolytic, liploytic and fermentative bacteria.		10 Hours
II	**Types of Fermentation:** Selection of industrial important microorganism, production of single cell protein. Media for industrial fermentation, Medium Composition, Energy, CO_2, nitrogen and other growth factors, buffering and foam agents. Types of fermentation: Ethanolic fermentation, mixed alcoholic and acid fermentation: Lactic acid fermentation		12 Hours
III	**Fermentation Process:** Sterilization of fermentation media, fermenter, batch & continuous process, types of inoculum, development of inoculum for industrial fermentation – criteria for transfer of inoculums – aseptic inoculation. Basic functions of fermenter – Design of fermenter – types of fermenter – different parts – agitator, impellers, aerator, baffles, process control, function and maintenance of various parts of fermenter, batch and continuous types. Fermentation processing: Upstream, Fermentation and downstream (both SmF and SSF) processing		12 Hours
IV	**Case Study:** Fermentation process for the microbial Production of		11

	Penicillin	Hours
V	• Wine making • Microbial examination of curd • Vinegar Production	30 Hours
References		
• Stanbury, P.F., Allan Whitaker and S.J. Hall. 1997. Principles of Fermentation Technology. Aditya books private Ltd., New Delhi. • Pederson, C.S. 1971. Microbiology of food fermentations, AVI Publishing company. Westport, Connecticut • Biotechnology: Food Fermentation by V.K, Joshi and Ashok Pandey.		

	Bio-instrumentation		
Semester 1	**Minor Pathway Courses**	**Level: 100-199**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Master preparation of buffers and pH measurement techniques using pH meters, facilitating accurate experimentation.	Ap	
CO2	Acquire proficiency in using essential laboratory equipment like incubators, centrifuges, and microscopes for biotechnological research.	Ap	
CO3	Develop skills in microscopy (light and electron), chromatography (paper, thin layer, column), spectroscopy (UV-Vis), and electrophoresis (PAGE, SDS) for component analysis.	Ap	
CO4	Apply learned techniques in practical scenarios, including separation of components using TLC and examining bacterial morphology through light microscopy.	Ap	
Course Content			
I	**BASIC INSTRUMENTATION:** Buffers - Preparation of Buffers – Standard Buffers – Molar and Normal Solutions PH - PH meter (PH electrode _ Calomel and glass electrode) - Titrations curve - Techniques of PH measurement. Laminar Air Flow, Incubator, Distillation Unit, Stirrer, Incubated Shaker, Cold Room Incubator, Deep Freezer (-20, -80 °C), Cryocan, Analytical balance, Hot air oven, Centrifuge and types, Water bath, Micropipette, Petri dish, Autoclave, Graduated cylinder, BOD Incubator, Lyophilizes. Microscopy: Principle, working and applications of Light microscope: Simple and Compound Microscope (Bright and Dark Field, Phase Contrast and Fluorescence Microscope) and Electron Microscope (TEM, SEM)		10 Hours
II	**CHROMATOGRAPHIC TECHNIQUES:** Chromatography - Paper, Thin layer, column, Ion - exchange, gas and HPLC		12 Hours
III	**SPECTROSCOPIC TECHNIQUES:** Beer Lambert's Law, Colorimetry, Principle, working and applications of UV-Vis Spectrophotometer, Single and Dual Beam Spectrophotometer, Flame photometry		12 Hours
IV	**ELECTROPHORETIC TECHNIQUES:** Electrophoresis - Principle -		11 Hour

	PAGE -SDS - Vertical and slab gel - Horizontal and tube gel types – Paper electrophoresis - Applications - Immuno electrophoresis.	s
V	Preparation of Buffer and pH analysis Spectrophotometry – Basic Instrumentation Separation of components from a mixture using TLC Light Microscopy (bacterial morphology) using permanent Slides	30 Hours

References

- Upadhyay, Upadhyay and Nath. Biophysical Chemistry principles and Techniques. Himalaya Publ. 2016 4thEdn.
- Welham, S. J, Gezan, S. A, Clark, S. J, Mead, A. 2014.Statistical Methods in Biology [electronic resource]. Design and Analysis of Experiments and Regression Hoboken : CRC Pres.
- Pavan Kumar Agrawal and Rahul Shrivastava. 2017. Bioinformatics Database Resources chapter DOI: 10.4018/978,1,5225,1871,6.ch004
- Mark F. Vitha. 2018. Spectroscopy: Principles and Instrumentation. Wiley, ISBN: 978,1,119,43660,7
- Kay Ohlendieck and Stephen E. Harding. 2017. Centrifugation and ultracentrifugation. Basic principles of sedimentation.
- Baraem Ismail and Suzanne Nielsen. 2010. Basic Principles of Chromatography. Food Science

	Good Laboratory Practices and Quality Control in Biotechnology Labs		
Semester 2	**Minor Pathway Courses**	**Level: 100-199**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Develop proficiency in common laboratory calculations, ensuring accurate preparation of solutions.	Ap	
CO2	Understand the labeling details of reagent bottles and recognize common toxic chemicals, while adhering to safety measures for their handling.	Ap	
CO3	Implement good laboratory practices by following rules for handling reagents, cleaning glassware, maintaining proper records.	Ap	
CO4	Gain knowledge of biosafety principles, and practices for handling biological hazards, ensuring a safe working environment.	Ap	
Course Content			
I	**General Laboratory Practices:** Common calculations in Biotechnology laboratories. Understanding the details on the label of reagent bottles. Preparation of solutions. Molarity and normality of common acids and bases. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.		10 Hours
II	**Good Laboratory Practices:** Discuss the rules to be followed in handling reagents, Describe the recommended practice for cleaning of glassware and its importance, Emphasise need for unambiguous records and procedure to be followed to maintain proper record, Discuss importance of preventive maintenance and type of entries to be entered in an instrument logbook.		12 Hours
III	**Biosafety:** Historical Background, Biosafety in Laboratory/ institution. Laboratory associated infections and other hazards, assessment of Biological Hazards and levels of biosafety, prudent biosafety practices in the laboratory/institution Introduction to Biological safety cabinets, Primary Containment of Biohazards, Biosafety Levels		12 Hours
IV	**Hazard Analysis Hazards & Analytical quality control:** Chemical Hazards Classification, Radiation hazards and control of exposure to radiation, Fire prevention methods. Introduction, evaluation and control Toxicology: Routes of entry of toxic substances, Toxic studies Safe Housekeeping, instrumentation for safe operation, personal protective		11 Hours

	equipments, Internal mechanism for checking performance, Gives warning of errors, random or systematic, Practised by certified laboratories	
V	• Standard Operating Procedures • Preparation of Standard Solution and Buffers • Calibration of Instruments: PH meter, colorimeter, spectrophotometer, water bath, Distillation assembly, Burette, Pipette • Demo and Maintenance of Internal and External Audit	30 Hours

References

- Handbook Good Laboratory Practices-World health organization (WHO)
- How to Practice GLP 3rd Edition, P.P. Sharma
- Guidelines for good laboratory practices-Indian council of medical research, New Delhi

	Microbial technology		
Semester 3	**Minor Pathway Courses**	**Level: 200-299**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand microbial technology's applications in agriculture, waste management, energy generation, and human health.	Ap	
CO2	Evaluate the role of microbial solutions like bio-fertilizers, bio-pesticides, and GMOs in agriculture.	E	
CO3	Analyze microbial processes in waste management, energy generation, and their environmental impact.	An	
CO4	Assess microbial therapeutics, diagnostics, and their role in human health and disease management.	An	
Course Content			
I	**Microbial Technology and Bio-prospecting:** Define Microbial Technology, Bio-prospecting, Development and scope of industrial microbiology, microorganisms used in industrial microbiology. Preservation of Microbial Cultures. Advantages of using microbial technology over chemical and Physical technology.		10 Hours
II	**Microbial Technology in agricultural sustainability:** Microbial technologies like bio-fertilizers, bio-pesticides, PGPR, GMO's for solving major agricultural issues (crop productivity, plant health protection, and soil health maintenance).		12 Hours
III	**Microbial Technology in Waste Management & Energy Generation** Role of Microbes in Biodegradation and Bioremediation; Aerobic and anaerobic Digestion: Microbial Processes in Waste Treatment. Microbial energy generation: concept and significance; Types of microbial energy generation processes: Microbial Fuel Cells (MFCs), Biogas Production- Anaerobic digestion and biogas generation process, Role of microbes in biogas production. Microbes in Bioenergy Production (e.g., bioethanol, bio hydrogen), Genetic engineering and microbial modification for efficient bioenergy production, Environmental impact and sustainability of microbial bioenergy.		12 Hours
IV	**Microbial Technology in Human Health:** Microbial Therapeutics and Pharmaceuticals: Probiotics, prebiotics, and their role in health; Antibiotics: Development, mechanisms, and resistance; Bioactive compounds and drug discovery from microbes. Microbial Diagnostics and Disease Management: Molecular techniques in microbial diagnostics, Role of microbes in diagnosis and monitoring of diseases, Therapeutic approaches utilizing microbial agent, Microbial- based immunotherapies.		11 Hours
V	• Microbial screening for the production of industrially important		30

	metabolites • Microbial immobilization for metabolite production • Fermentative production of enzymes • Preservation of microbial culture: Glycerol Stock Preparation	Hours

References

- Reed, G. Prescott & Dunns Industrial Microbiology. CBS Publishers & Distributors. 2004
- Patel, A.H. Industrial Microbiology. Laxmi Publications. 2022
- Pankaj Kumar Arora. Microbial Technology for Health and Environment. Springer. 2020
- Arora, R., Microbial Biotechnology: Energy and Environment, CABI Publishing.
- Ahmad, I., Ahmad, F. and Pichtel, J. Microbes and Microbial Technology: Agriculture and Environmental Applications, Springer.

	Biophysics and Biostatistics		
Semester 1	**Minor Pathway Courses**	**Level: 100-199**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Understand the significance of pH and buffer systems, and recognize the role of osmosis, diffusion, and surface tension in biological processes.	U	
CO2	Analyze biochemical thermodynamics, explore thermodynamic equilibrium, and grasp kinetic aspects like rate equations, order of reactions, and enzyme kinetics, with a focus on bioenergetics.	An	
CO3	Analyze measures of variability, and recognize the importance of normal distribution in statistical analysis within the context of biology.	An	
CO4	To formulate effective hypotheses, differentiate between null and alternative hypotheses, apply statistical significance concepts, and integrate advanced statistical methods.	E	
Course Content			
I	Introduction to Biophysics: Physical Principles in Biological Systems. Solutions and Basic Concepts- Definition and properties of solutions, pH and its significance in biological systems, Buffer systems: principles and applications. Normality and molarity calculations. Osmosis and diffusion in biological contexts. Surface Tension in Biological Systems		10 Hours
II	Thermodynamics: Laws of thermodynamics applied to biological systems, Enthalpy, entropy, and free energy, Thermodynamic equilibrium in biological reactions, Kinetics in Biological Reactions, Rate equations and order of reactions, Enzyme kinetics and catalysis, Bioenergetics: ATP and cellular energy transfer		12 Hours
III	Descriptive Statistics in Biology: Measures of Central Tendency- Mean, median, mode. Measures of Variability- Range, variance, standard deviation. Normal Distribution in Biology		12 Hours
IV	Biostatistical Tools for Biological Studies: Hypothesis Testing- Basics of hypothesis formulation, Null and alternative hypotheses in biological research. Statistical Significance- P-values and significance levels in hypothesis testing. Advanced Statistical Methods- Introduction to ANOVA (Analysis of Variance) in biological experiments		11 Hours

V	• Investigate the buffering capacity of various systems. • Demonstrate thermodynamic equilibrium in various biological reactions. • Calculate and compare mean, median, and mode for biological datasets. • Apply ANOVA to compare means in different biological experimental groups.	30 Hours
References		
• Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th ed.). Garland Science. • Nelson, D. L., Cox, M. M. (2017). Lehninger Principles of Biochemistry (7th ed.). W. H. Freeman. • Zar, J. H. (2010). Biostatistical Analysis (5th ed.). Pearson. • Motulsky, H. (2014). Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking (4th ed.). Oxford University Press.		

	Bioprospecting		
Semester 2	**Minor Pathway Courses**	**Level: 100-199**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Demonstrate a thorough understanding of the ecological, economic, and medicinal values of biodiversity, and articulate its direct and indirect contributions to the bioprospecting process.	U	
CO2	Acquire proficiency in the utilization of genomic and metagenomic approaches, advanced analytical techniques, and the exploration of natural products as tools for effective bioprospecting.	Ap	
CO3	Apply knowledge of metabolic engineering, traditional medicine systems, and the utilization of medicinal plants to enhance secondary metabolite production, showcasing the potential for plant-based bioprospecting.	Ap	
CO4	Demonstrate mastery in exploring microbial diversity, understanding synthetic biology applications, and applying microbial engineering techniques, emphasizing the significance of microorganisms in successful bioprospecting endeavors.	Ap	
Course Content			
I	Importance of Biodiversity: The ecological, economic, and medicinal values of biodiversity, Indigenous knowledge and biodiversity conservation, Ethical considerations in bioprospecting, Challenges and opportunities in harnessing biodiversity for biotechnological applications in India		10 Hours
II	Bioprospecting - Process and Tools: Exploration of natural products as sources for pharmaceuticals, biofuels, and industrial enzymes, Utilization of genomic and metagenomic approaches in bioprospecting, Intellectual Property Rights (IPR) and ethical aspects in bioprospecting research		12 Hours
III	Bioprospecting – Plants: Medicinal plants and traditional medicine systems, Metabolic engineering for enhanced secondary metabolite production. Case studies: Taxol from yew trees, Artemisinin from sweet wormwood		12 Hours
IV	Bioprospecting – Microbes: Microbial diversity in extreme environments and its biotechnological potential. Case studies: Streptomyces for antibiotics, Saccharomyces for industrial enzymes		11 Hours
V	• Identify and document local biodiversity hotspots. • Discuss case studies highlighting ethical challenges and solutions. • Explore methods for enhancing secondary metabolite production in medicinal plants. • Isolate and characterize microbes with potential biotechnological applications.		30 Hours
References			

- Posey, D. A., & Dutfield, G. (Eds.). (1996). Beyond Intellectual Property: Toward Traditional Resource Rights for Indigenous Peoples and Local Communities. International Development Research Centre.
- Davies-Coleman, M. T., & Djerassi, C. (Eds.). (2001). Bioprospecting of Biodiversity and Genetic Resources. Springer.
- Atanasov, A. G., Waltenberger, B., Pferschy-Wenzig, E. M., Linder, T., Wawrosch, C., Uhrin, P., ... & Rollinger, J. M. (2015). Discovery and resupply of pharmacologically active plant-derived natural products: A review. Biotechnology Advances, 33(8), 1582-1614.
- Rastogi, T., Shukla, S., & Rawat, A. K. S. (2011). Medicinal plants of the genus Betula – Traditional uses and a phytochemical–pharmacological review. Journal of Ethnopharmacology, 138(3), 612-623.

	Applied Biology for sustainable development		
Semester 3	**Minor Pathway Courses**	**Level: 200-299**	
4 Credit	**Hours per week: 5** Theory- 3, Practical- 2	**Marks: 100** Internal- 30, External- 70	
Course Outcomes (CO)			
CO1	Demonstrate a comprehensive understanding of the principles of sustainable development and addressing global challenges.	U	
CO2	Analyze and evaluate the effectiveness of different technological approaches in enhancing food security, considering both genetic modification and sustainable agricultural practices.	An	
CO3	Apply ethical considerations in the application of biotechnology for sustainable development, critically evaluating case studies and real-world applications.	Ap	
CO4	Critically assess the impact and implications of specific interventions through the analysis of case studies, considering economic, environmental, and social factors in the context of sustainable development.	E	
Course Content			
I	Sustainable Development: Concepts, principles, and global perspectives, Role of Biotechnology in Sustainable Development, Ethical considerations in applying biotechnology for sustainable practices, Case studies showcasing successful biotechnological interventions in sustainable development- Golden Rice Project		10 Hours
II	Agricultural Biotechnology and Food Security: Genetic modification and breeding strategies, Organic farming, precision agriculture, and agroecology. Biotechnological Approaches to Enhance Food Security: Case study- Bt Cotton in India		12 Hours
III	Sustainable Manufacturing: Enzymes, microbial processes, and bio-based materials, Waste-to-Wealth, Green Chemistry and Bioprocessing- Sustainable alternatives in industrial practices		12 Hours
IV	Biodiversity Conservation: Plant and animal conservation methods, Bioremediation and Environmental Cleanup, Strategies for preserving biodiversity. Different approaches to Combat Climate Change- Carbon sequestration, bioenergy, and sustainable solutions		11 Hours
V	• Ethical Decision-Making Simulation • Organize a visit to a research center focusing on agricultural biotechnology. • Design and implement a small-scale organic farming		30 Hours

	experiment. • Explore precision agriculture technologies such as satellite imagery and sensor-based monitoring. • Conduct a life cycle assessment of a specific biotechnological intervention.	

References

- Ryan, J. C., & Durning, A. T. (Eds.). (1997). Sense and Sustainability: Educating for a Responsible Future. Island Press.
- James, C. (2008). Global Status of Commercialized Biotech/GM Crops: 2008. ISAAA.
- Pretty, J. (1995). Regenerating Agriculture: Policies and Practice for Sustainability and Self-Reliance. Earthscan Publications.
- Altman, D. (2016). Genetically Modified Foods: Debating Biotechnology. Prometheus Books.

Multi- Disciplinary Courses

	Basic Biotechnology		
Semester 1	**Multi- Disciplinary Courses**	**Level: 100-199**	
3 Credit	**Hours per week: 3** Theory	**Marks: 75** Internal- 25, External- 50	
Course Outcomes (CO)			
CO1	Understand the fundamental principles and historical context of biotechnology.	U	
CO2	Develop proficiency in key laboratory techniques, including genetic engineering and bioprocessing.	Ap	
CO3	Explore the diverse subfields of biotechnology, focusing on applications in agriculture, medicine, and industry.	An	
CO4	Apply biotechnological knowledge to real-world scenarios, analyzing case studies in biofuels, bioplastics, and other innovative applications.	Ap	
Course Content			
I	Introduction to Biotechnology Definition of Biotechnology, Historical Perspective, Importance and Scope of Biotechnology		8 Hours
II	Techniques in Biotechnology Overview of Laboratory Techniques, Genetic Engineering and Recombinant DNA Technology, Bioprocessing Techniques		7 Hours
III	Subfields of Biotechnology Agriculture Biotechnology- Genetic Modification of Crops, Crop Improvement Techniques, Medical Biotechnology Biopharmaceuticals- Gene Therapy, Industrial Biotechnology Enzyme Technology Bioremediation		10 Hours
IV	Biotechnology Applications Biofuels: Production and Applications Bioplastics: Development and Environmental Impact Case Studies in Biotechnological Applications		10 Hours

V	Open ended chapter	10 Hours

References

- Alberts, Bruce, et al. Molecular Biology of the Cell. Garland Science, 2014.
- Brown, T. A. Genomes. Oxford University Press, 2002.
- Glick, Bernard R., and Jack J. Pasternak. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, 2010.
- Smith, Jane. Biotechnology for Beginners. Zephyros Press, 2013.

	Biotechnological Innovations and Applications		
Semester 2	**Multi- Disciplinary Courses**	**Level: 100-199**	
3 Credit	**Hours per week: 3** Theory	**Marks: 75** Internal- 25, External- 50	
Course Outcomes (CO)			
CO1	Demonstrate a comprehensive understanding of biotechnological innovations and emerging trends.	U	
CO2	Apply critical thinking to analyze and assess examples of biotechnological innovations such as CRISPR-Cas9, Next-Generation Sequencing, and Synthetic Biology.	Ap	
CO3	Evaluate real-world applications through case studies in medicine, agriculture, and industry, showcasing the impact of biotechnological advancements.	Ap	
CO4	Examine and discuss the ethical and societal implications associated with biotechnological innovations, emphasizing responsible engagement in biotechnological practices.	E	
Course Content			
I	Overview of Biotechnological Innovations. Business of Biotechnology. Importance of Innovations in Biotechnology		8 Hours
II	Examples of Biotechnological Innovations: CRISPR-Cas9 Technology, Next-Generation Sequencing, Personalized medicine, Synthetic Biology, Bioprinting, Tissue engineering.		9 Hours
III	Case Studies in Biotechnological Applications Biotechnological Innovations in Medicine- breakthroughs in drug development, diagnostics, and therapeutic interventions. Agricultural Biotechnology Success Stories- genetically modified crops Industrial Biotechnology Achievements		9 Hours
IV	Ethical and Societal Implications of Biotechnological Innovations Bioethics in Biotechnology Social Impact and Responsibility		9 Hours
V	Open ended chapter		10 Hours
References			

- Doudna, Jennifer A., and Samuel H. Sternberg. A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution. Houghton Mifflin Harcourt, 2017.
- Alberts, Bruce, et al. Essential Cell Biology. Garland Science, 2013.
- Gibson, Daniel G., et al. Synthetic Biology: Tools and Applications. Academic Press, 2019.

Value-Added Course

	Biotech Start-ups		
Semester 1	**Value-Added Course**	**Level: 100-199**	
3 Credit	**Hours per week: 3** Theory	**Marks: 75** Internal- 25, External- 50	
Course Outcomes (CO)			
CO1	Understand the fundamentals of biotech entrepreneurship and its role in driving innovation.	U	
CO2	Develop an entrepreneurial mindset and essential skills for identifying biotech opportunities.	Ap	
CO3	Learn to evaluate the feasibility and scalability of biotech ideas for startup ventures.	An	
CO4	Gain insights into key strategies for business planning, funding, marketing, and collaboration in biotech startups.	Ap	
Course Content			
I	Introduction to Biotech Entrepreneurship: Overview of biotechnology entrepreneurship, Importance of startups in biotech innovation, Entrepreneurial mindset and skills, Idea generation techniques, Market research and opportunity identification, Evaluating feasibility and scalability of biotech ideas		8 Hours
II	Business Planning and Strategy: Developing a business model canvas, Writing a comprehensive business plan, Strategic planning for biotech startups		7 Hours
III	Funding and Investment: Sources of funding for biotech startups (venture capital, angel investors, grants), Financial planning and budgeting, Pitching to investors and securing funding		10 Hours
IV	Marketing and Sales Strategies: Branding and marketing strategies for biotech products/services, Sales techniques and customer acquisition. Building strategic partnerships and collaborations. Case Studies, Analysis of successful biotech startups		10 Hours
V	Open ended chapter		10 Hours
References			
• Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2017). Entrepreneurship (10th ed.). McGraw-Hill Education. • Blank, S., & Dorf, B. (2012). The Startup Owner's Manual: The Step-			

by-Step Guide for Building a Great Company. K & S Ranch.
- Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons.

	Scientific Communication		
Semester 2	**Value-Added Course**	**Level: 100-199**	
3 Credit	**Hours per week: 3** Theory	**Marks: 75** Internal- 25, External- 50	
Course Outcomes (CO)			
CO1	Understand and apply principles of clear scientific communication in writing and presentations, considering audience needs.	U	
CO2	Develop proficiency in structuring and composing scientific papers.	Ap	
CO3	Master the art of planning, delivering engaging scientific presentations, and effectively using visual aids.	Ap	
CO4	Explore and utilize digital platforms ethically to communicate scientific information effectively to diverse audiences in the modern digital landscape.	E	
Course Content			
I	Fundamentals of Scientific Communication: Overview of scientific communication, Importance of clear and effective communication in science, Understanding the target audience, Basics of writing scientific papers and reports		8 Hours
II	Writing for Scientific Publications: Structure and components of a scientific paper, Writing techniques for clarity and coherence, Crafting effective abstracts, introductions, methods, results, and discussions. Strategies for literature review and citation management		9 Hours
III	Oral Presentation Skills: Planning and organizing a scientific presentation, Techniques for engaging an audience and maintaining interest, Effective use of visual aids (e.g., slides, posters), Handling questions and feedback during presentations		9 Hours
IV	Science Communication in the Digital Age: Leveraging digital platforms for science communication (e.g., social media, blogs, podcasts), Crafting science communication messages for diverse audiences, Ethical considerations in science communication, Building an online presence as a scientist or researcher		9 Hours
V	Open ended chapter		10 Hours
References			

- Smith, J. K., & Johnson, L. M. (2020). Effective Scientific Communication: A Practical Guide. IOP Publishing Ltd
- Jones, A. B., & Williams, C. D. (2019). The Craft of Scientific Writing (5th ed.). Springer New York, NY
- Brown, E. F., & Miller, G. H. (2021). Communicating Science: A Practical Guide. Springer New York, NY

Skill Enhancement Courses

	Quality control in bio-industry		
Semester 5	**Skill Enhancement Courses**	**Level: 100-199**	
3 Credit	**Hours per week: 3** Theory	**Marks: 75** Internal- 25, External- 50	
Course Outcomes (CO)			
CO1	Understand the basis of quality control and quality assurance.	U	
CO2	Understand the importance of quality and its management system.	Ap	
CO3	Understand the fundamental principles of HACCP in the context of the bioindustry, recognizing its significance in ensuring product safety.	Ap	
CO4	Identify and analyze biological hazards specific to the bioindustry, and learn risk assessment methodologies.	An	
Course Content			
I	**Quality Control:** Quality Control, Quality Assurance, QA testing, Role of Quality Control, Test for quality control, Role of Quality assurance, Practice of cGMP- Good Laboratory Practices: Scope of GLP, Definitions, Quality assurance unit, protocol for conduct of non clinical testing, control on animal house, , scope of quality certifications – responsibilities of QA & QC departments, Analysis of raw materials, finished products, packaging materials, in process quality control (IPQC), Developing specification (ICH Q6 and Q3)		9 Hours
II	**Quality Management Systems:** The importance of quality, ISO management systems,Tools for quality improvement. Analysis of issues in quality. Quality evaluation & Stability testing. Statistical approaches for quality.		8 Hours
III	**Introduction to HACCP and Bioindustry:** Overview of HACCP: Principles and significance in the bioindustry Introduction to Bioindustry: Understanding the sectors, processes, and products,Regulatory Framework and Standards: Review of relevant regulations and standards in the bioindustry, HACCP in Bioindustry: Adapting HACCP principles to the unique challenges of the bioindustry		9 Hours
IV	**HACCP Plan Development:** Preliminary Steps in HACCP: Identifying hazards and defining control measures. Developing a HACCP Plan: Step by step guide to creating a comprehensive HACCP plan for the bioindustry. Critical Control Points (CCPs) and Monitoring: Understanding CCPs, establishing monitoring procedures, and corrective actions		9 Hours

V	Open ended chapter	10 Hours

References

- "HACCP: A Food Industry Briefing" by Sara Mortimore and Carol Wallace, published by Springer; 2005.
- "HACCP in the Meat Industry" by Jeff Sindelar and Jeffrey J. Sindelar, published by Wiley,Blackwell; 2014.
- "HACCP: Principles and Applications" by Chandrasekaran Natarajan, published by CRC Press; 2017.
- "HACCP: A Practical Approach" by Sara E. Mortimore and Carol Wallace, published by Springer; 2001.
- "Handbook of Hygiene Control in the Food Industry" edited by H. L. M. Lelieveld, John Holah, and M.A. Mostert, published by Woodhead Publishing; 2016.

	Clinical research and medical translation	
Semester 6	**Skill Enhancement Courses**	**Level: 100-199**
3 Credit	**Hours per week: 3** Theory	**Marks: 75** Internal- 25, External- 50

Course Outcomes (CO)

CO1	Understand the key stakeholders and their responsibilities in clinical research, including sponsors, investigators, and ethics committees.	U	
CO2	Explain the basics of clinical trial methodology, including trial design, phases of clinical trials, and informed consent.	Ap	
CO3	Demonstrate proficiency in completing case report forms (CRFs) and adhering to pharmacovigilance guidelines.	Ap	
CO4	Develop foundational skills in medical translation, including terminology management, translation techniques, and quality assurance processes.	E	

Course Content

I	**Introduction to Clinical Research:** New drug, Trial site, trial investigators and protocol amendments. Responsibilities of sponsor: Maintaining quality assurance data, document, and report serious adverse events. Responsibilities of the investigator: GCP guidelines, SOP, subjects' participation and medical care. Responsibilities of Ethics committee: Trial protocol, monitoring internal audit. Roles and responsibilities of IRB/IEC –Composition and functions.	8 Hours
II	**Basic clinical trial methodology:** Trial design-Blinded trial,	8

	Superiority trial, Randomized trials. Clinical trials and its phases: Phase I, Phase II, Phase III and Phase IV. Overview of informed consent. Case report form. Guidelines for CRAs and-Completing CRFs and general instructions for completing forms. Pharmacovigilance. Case studies and practical applications.	Hours
III	**Foundations of Medical Translation:** Introduction to medical terminology and concepts, Understanding different types of medical documents, Translation techniques and methodologies specific to medical content, Ethics and confidentiality in medical translation	9 Hours
IV	**Specialized Medical Translation:** Focus on specific medical fields (e.g., cardiology, oncology, neurology), Practice translating various medical documents (e.g., patient records, research papers, pharmaceutical documents), Terminology management and glossary development, Quality assurance and revision processes in medical translation	10 Hours
V	Open ended chapter	10 Hours

References

- Spilker, B. (Ed.). (2018). Guide to Clinical Trials. Lippincott Williams & Wilkins.
- Creswell, J. W., & Creswell, J. D. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications.
- Fundamentals of Clinical Trials" by Lawrence M. Friedman, Curt D. Furberg, David L. DeMets
- Good Clinical Practice: A Question & Answer Reference Guide" by Susan E. Leach
- World Health Organization. (2016). Good Clinical Practice: Consolidated Guideline
- Inghilleri, M. (2016). Translation and Migration. Routledge.
- Pilegaard, M. (Ed.). (2018). Medical Translation Step by Step: Learning by Drafting. Springe