

Syllabus Book
for
4 Years Undergraduate Programme
B.Sc. Biotechnology



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

School of Biotechnology
Centurion University of Technology and Management

India's First and Best Skill University



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Constituent Campuses

Bhubaneswar | Paralakhemundi | Rayagada | Bolangir | Chattarpur | Balasore

Programme Educational Objectives (PEOs)

PEO-01	To acquire a strong foundation in biotechnology for employment in scientific research and experimental design.
PEO-02	To apply essential biotechnology knowledge for postgraduate studies, competitive tests, and interdisciplinary learning.
PEO-03	To recognize the ethical aspects of biotechnology and make responsible contributions to health, agriculture, and the environment.

Programme Specific Outcomes (PSOs)

PSO-1	Core Competence in Biotechnology Applications: Graduates will develop expertise in applying biotechnological tools and techniques to address challenges in fields such as healthcare, agriculture, environment, and industrial biotechnology, fostering innovative solutions.
PSO-2	Practical and Analytical Skills: Graduates will acquire practical skills in molecular biology, genetic engineering, microbiology, and bioinformatics, enabling them to design experiments, analyze data, and interpret results effectively in research and industry settings.
PSO-3	Entrepreneurship and Sustainable Development: Graduates will demonstrate the ability to identify opportunities in biotechnology for entrepreneurship and contribute to sustainable development by designing eco-friendly and socially responsible biotechnological solutions

Programme Outcomes (POs)

PO-01	Fundamental knowledge: Graduates will acquire a strong foundational understanding of core concepts in biotechnology and other related subjects.
PO-02	Problem analysis: Identify, formulate, review literature and analyse Biotechnology problems to design, conduct experiments, analyse data and interpret data.
PO-03	Design /development of solutions: Design solution for Biotechnology problems and design system component of processes that meet the desired needs with appropriate consideration for the public health and safety, and the cultural, societal and the environmental considerations
PO-04	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in Biotechnology.
PO-05	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to Biotechnology activities with an understanding of the limitations.
PO-06	Biotechnology and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to Biotechnology practice.
PO-07	Environment and sustainability: Understand the impact of the Biotechnology Engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development.
PO-08	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the Biotechnology practice.

PO-09	Individual and team work: Function affectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings in Biotechnology.
PO-10	Communication: Communicate effectively on complex engineering activities with the engineering committee and with society at large, such as, being able to comprehend and write affective reports and design documentation, make effective presentations in Biotechnology.
PO-11	Project Management and finance: Demonstrate knowledge & understanding of the Biotechnology engineering principles and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments in Biotechnology.
PO-12	Life- long learning: Recognize the need for, and the preparation and ability to engage in independent research and lifelong learning in the broadest contest of technological changes in Biotechnology.

Academic Regulations for 4 Years Undergraduate Programme

School of Biotechnology

Centurion University of Technology and Management

2024

1. Introduction

This Programme provides flexibility to students to choose a single discipline or a combination of disciplines/ streams as an academic career path. The Programme envisages a competency-based, multi-disciplinary, holistic academic programme with a creative combination of disciplines/ skills/ Domain/ Research of study with multiple entry and exit options.

The curriculum emphasizes a flexible combination of a wide range of courses with a focus on analytical and critical thinking, computational skills, use of cutting-edge technology, innovation, creativity, experiential learning including the development of a competency-based skilling ecosystem and holistic development of students leading to specific career prospects.

The university follows a dynamic curriculum development approach. Hence, it reserves the rights to revise / modify the syllabus, structure, credits etc. as deemed fit.

2. Objective

- To provide basic knowledge and laboratory skills of the subjects.
- To create and apply appropriate techniques, resources, and modern instruments for biochemical estimation, animal tissue culture and plant tissue culture experiments, environment insults measurements, genetics, bioinformatics, cellular, molecular and physiological activities of all living organisms with an understanding of the application and limitations.
- To introduce with the area of research as per the recent outbreaks or demand in the society.
- To train and enhance skills using biological principles and systems to create new products.
- To practice biotechnological research, its importance for society, health, safety, legal and environmental issues and the consequent responsibilities relevant to the biodiversity conservation practice.
- To foster innovation and entrepreneurship skills, enabling students to identify opportunities, drive positive change and contribute to the growth of biotechnology field.
- To prepare students to adapt to evolving technologies and methodologies, emphasizing the importance of continuous learning and professional development.

3. Eligibility

A student who has passed the Higher Secondary (12th grade) or its equivalent examination with subjects - Physics, Biology and Chemistry as core subjects with minimum 50% overall (45% for SC/ST candidates) is eligible to take admission to the 1st year of B.Sc. Biotechnology programme.

4. Programme duration and multiple exits

The 4 years programme at CUTM is designed to offer two types of Bachelor's Degrees to the students at the end of the successful completion of the programme — (i) Bachelor's Degree in a Stream and (ii) Bachelor's Degree in a Discipline. The word stream here refers to Arts, Science, Commerce and Business Administration. In case of a degree in a stream, the student studies a multitude of different subjects, usually mixing different disciplines, which leads to a truly multidisciplinary degree. While in case of a degree in a discipline, the student is confined to a certain set of disciplines. However, in both cases, the student earns equal number of credit points.

UG Certificate: Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG certificate if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

UG Diploma: Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma if, in addition, they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

3-years UG Degree: Students who wish to undergo a 3-years UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 120

credits and satisfying the minimum credit requirement as given in the semester wise credit breakup (section-9).

4-years UG Degree (Honours): A four-years UG Honours degree in the major discipline will be awarded to those who complete a four-year degree programme with 160 credits and have satisfied the credit requirements as given in the semester wise credit breakup (section-9).

4-years UG Degree (Honours with Research): Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

UG Degree Programmes with Single Major: A student has to secure a minimum of 50% credits from the major discipline for the 3-years/4-years UG degree to be awarded a single major. For example, in a 3-year UG programme, if the total number of credits to be earned is 120, a student of Physics with a minimum of 60 credits will be awarded a B.Sc. in Physics with a single major. Similarly, in a 4-years UG programme, if the total number of credits to be earned is 160, a student of Physics with a minimum of 80 credits will be awarded a B.Sc. (Hons./Hon. With Research) in Physics in a 4-years UG programme with single major.

UG Degree Programmes with Double Major: A student has to secure a minimum of 40% credits from the second major discipline for the 3-years/4-years UG degree to be awarded a double major. For example, in a 3-years UG programme, if the total number of credits to be earned is 120, a student of Physics with a minimum of 48 credits will be awarded a B.Sc. in Physics with a double major. Similarly, in a 4-years UG programme, if the total number of credits to be earned is 160, a student of Physics with a minimum of 64 credits will be awarded a B.Sc. (Hons./Hon. With Research) in Physics in a 4-years UG programme with double major.

Interdisciplinary UG Programmes: The credits for core courses shall be distributed among the constituent disciplines/subjects so as to get core competence in the interdisciplinary programme. For example, a degree in Econometrics requires courses in economics, statistics

and mathematics. The total credits to core courses shall be distributed so that the student gets full competence in Econometrics upon completion of the programme. The degree for such students will be awarded as B.Sc. in Econometrics for a 3-years UG programme or B.Sc. (Honours) / B.Sc. (Honours with Research) in Econometrics for a 4-years UG programme.

Multidisciplinary UG Programmes: In the case of students pursuing a multidisciplinary programme of study, the credits to core courses will be distributed among the broad disciplines such as Life sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc., For example, a student who opts for a UG programme in Life sciences will have the total credits to core courses distributed across Botany, Zoology and Human biology disciplines. The degree will be awarded as B.Sc. in Life Sciences for a 3-years programme and B.Sc. (Honours) in Life Sciences or B.Sc. (Honours with Research) for a 4-years programme without or with a research component respectively.

5. Programme structure

Basket	Type of Course	Minimum Credit Requirement			
		4 years UG		3 years UG	
		Credit	Approx. Weightage	Credit	Approx. Weightage
I	Major (Core) Courses	80	50 %	60	50 %
II	Minor (Domain) Courses	32	20 %	24	20 %
III	Multi-Disciplinary Courses	9	5.6 %	9	7.5 %
IV	Skill Courses	9	5.6 %	9	7.5 %
	Ability Enhancement Courses	8	5 %	8	7 %
	Value Added Courses	6	3.8 %	6	5 %
V	Summer Internship / Dissertation	16	10 %	4	3 %
TOTAL		160	100 %	120	100 %

6. Types of courses

6.1 Major (Core) courses

Major (Core) Courses are the foundational and specialized courses directly related to a student's chosen major discipline. These courses form the core of the academic programme and provide in-depth knowledge and skills in the chosen field of study.

Major (Core) Courses aim to build a strong theoretical and practical foundation in the chosen major discipline. They equip students with the specialized knowledge and expertise required to excel in their field of study and future careers.

Please refer to Annexure-1 for courses offered in major (core) discipline.

6.2 Domain (Minor), Multi-Disciplinary and Skill Courses

Minor (Domain) Courses: These are courses from a chosen minor discipline, providing students with a secondary area of expertise. There are several domains offered by the university for the academic year 2023-24. Please refer to Annexure-2 for courses offered under this basket.

6.3 Multi-Disciplinary Courses

Multi-Disciplinary Courses: These are courses that broaden a student's knowledge beyond their major and minor disciplines. Students can opt for any discipline other than their selected major discipline under this basket or category. These courses aim to provide students with a well-rounded education. Minor courses enhance their knowledge in a secondary area, domain courses encourage multidisciplinary thinking and skill enhancement courses equip them with practical skills relevant to their field of study.

6.4 Ability Enhancement, Skill and Value Added Courses

Ability Enhancement Courses typically focus on language skills. These courses aim to enhance students' proficiency in communication, both in written and oral forms, which is essential for academic success and future career prospects. Please refer to Annexure-4 for courses offered under this basket.

Ability Enhancement Courses help students improve their communication skills, enabling them to effectively convey their ideas, research findings and insights. Strong communication skills are valuable in academic, professional and personal contexts.

Skill Courses: These courses focus on developing practical skills and competencies that are valuable in various professional contexts. Please refer to Annexure-3 for courses offered under this basket.

Value Added Courses are additional courses that provide students with extra skills and knowledge beyond their major and minor disciplines. These courses are typically designed to enhance employability and provide a competitive edge in the job market.

Value Added Courses aim to make students more versatile and marketable by equipping them with skills that are in high demand in various industries. These courses enhance their career prospects and adaptability. Please refer to Annexure-4 for courses offered under this basket.

6.5 Summer Internship

Summer Internship or Community Engagement programmes involve students participating in real-world work experiences, either in industry or within the community, during the summer break. These experiences can be credit-bearing and provide practical exposure to their chosen field of study.

Summer Internship and Community Engagement experiences bridge the gap between theoretical knowledge and practical application. They offer students an opportunity to apply what they have learned in a real-world context, gain hands-on experience and develop professional networks.

6.6 Research Project / Dissertation / Production Action Learning

These are in-depth, research-oriented components of the academic programme. Students engage in original research, dissertation writing, or production action learning, depending on the programme's requirements. Research projects are typically carried out under the guidance of faculty members.

These components aim to develop students' research skills, critical thinking abilities and problem-solving capabilities. They encourage students to explore, analyze and contribute to the knowledge base of their major discipline, preparing them for careers in research, academia, or industry leadership roles.

7. Assessment

7.1 Evaluation for Theory Components

i. End semester theory examinations (50% weightage):

- a. Duration – 3 hrs
- b. Full Mark – 100. During result processing, it will be proportionately added.
- c. Distribution of marks (should cover all COs)
 - i. 10 short questions x 2 marks = 20 marks
 - ii. 5 long questions x 12 marks = 60 marks
 - iii. 4 short notes x 5 marks = 20 marks

ii. Continuous assessments: Details are as indicated in the table below:

Sl. No.	Continuous Assessment	Score
1	Individual / Group Presentation <i>Rubric is as under:</i> <ul style="list-style-type: none"> • Content & creativity – 05 • Presentation & Discussion – 05 	10
2	Mid-semester (Written Examination) <i>Mark Distribution:</i> <ul style="list-style-type: none"> • 5 short questions x 1 marks = 5 marks • 2 long questions x 5 marks = 10 marks • 2 short notes x 2.5 marks = 5 marks 	20
3	Assignment (2 assignments x 5 marks each)	10
4	Learning Record (<i>Based on the parameters indicated in the learning record format, course faculty to evaluate and award score</i>)	10
Total		50

7.2 Evaluation of Practice/ Laboratory Components

The evaluation of the practice component will be carried out 50% by concerned faculty and 50% by the external examiner and will be conducted as per the present policy. Details are as under:

Internal

A	Concept	10
B	Planning & Execution/ Practical/ Simulation/ Programming	10
C	Result and Interpretation	10
D	Record/ Report	10
E	Viva	10
Total		50

External

A	Execution & Result	20
B	Record of Applied and Action Learning	10
C	Viva	20
Total		50

7.3 Evaluation of Project Component

The evaluation of the project component will be completed 50% by concerned faculty and 50% by the external examiner and will be conducted as per the present policy. Following guideline may be referred during evaluation of internal and external components:

Internal

A	Understanding the relevance, scope and dimension of the project	10
B	Methodology	10
C	Quality of Analysis and Results	10
D	Interpretations and Conclusions	10

E	Report	10
Total		50

External

A	Understanding the relevance, scope and dimension of the project	10
B	Report	20
C	Viva	20
Total		50

7.4 Evaluation of Internship

The evaluation of the internship will be completed 50% by concerned faculty and 50% by the industry guide. Following guideline may be referred during evaluation of internal and external components:

Internal

A	Daily Diary & Log Report	20
B	Periodical (Weekly/Monthly) Report	10
C	Presentation & Viva	20
Total		50

External

A	Completion of the task / project assigned	30
B	Feedback of the industry supervisor	20
Total		50

7.5 Evaluation of Workshop Component

The evaluation of the workshop component will be completed 100% by concerned faculty as per the present policy. Following guideline may be referred during evaluation:

A	Critical Thinking/ Simulation/ Field work & Report	50
B	Presentation & Viva	50

Total	50
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8. Pass criteria

- A. **Theory papers**: students must secure a minimum of **30% in individual components** (both continuous assessment & end-semester theory) **along with 40% in aggregate.**
- B. **Theory & practice papers**
- i. Theory component: minimum of 30% in individual components (both continuous assessment & end-semester theory) along with 40% in aggregate
 - ii. Practice component: minimum of 50% marks both in internal & external
- C. **Theory & project type papers**
- i. Theory component: minimum of 30% in individual components (both continuous assessment & end-semester theory) along with 40% in aggregate
 - ii. Project component: minimum of 50% marks both in internal & external
- D. **Theory, practice & project type papers**
- i. Theory component: minimum of 30% in individual components (both continuous assessment & end-semester theory) along with 40% in aggregate
 - ii. Practice component: minimum of 50% marks both in internal & external
 - iii. Project component: minimum of 50% marks both in internal & external
- E. **Practice & project type papers**
- i. Practice component: minimum of 50% marks both in internal & external
 - ii. Project component: minimum of 50% marks both in internal & external
- F. **Workshop or Internship type papers**: 50% in aggregate

9. Grading

CUTM follows “Absolute” grading system / Grade point or marks scheme applicable for different programmes. Under absolute grading system, a Ten Point grading system on base of 10 shall be followed in CUTM. Categorization of these grades and their correlation shall be as under:

Qualification	Grade	Score on 100 Percentage Points	Point
Outstanding	O	90 and above up to 100	10
Excellent	E	80 and above but less than 90	9
Very Good	A	70 and above but less than 80	8
Good	B	60 and above but less than 70	7
Fair	C	50 and above but less than 60	6
Pass	D	40 and above but less than 50	5
Failed	F	Below 40	2
Malpractice	NOT APPLICABLE	NOT APPLICABLE	0
Absent	NOT APPLICABLE	NOT APPLICABLE	0

N.B. Grade C shall be considered as average, Grade D shall be the passing Grade for theory and Grade C shall be the Pass Grade for Practical/ Project/ Workshop mode paper.

10. Attendance

Attendance will be calculated from the date of commencement of classes or date of admission, whichever is later.

- a. A student attending at least 75% of the total number of classes held shall be allowed to sit for the concerned Semester Examinations subject to fulfilment of other conditions laid down in the regulation.
- b. A student attending at least 60% but less than 75% of the total number of classes held shall be allowed to sit for the concerned Semester Examinations subject to the payment of prescribed fees and fulfilment of other conditions laid down in the regulations.
- c. A student attending less than 60% of the total number of classes held shall not be allowed to sit for the concerned Semester Examinations and he /she has to take admission to the same Semester in the very next year for attending the classes and appearing at the said Semester Examination.

Details of the Courses for B.Sc. Biotechnology Choice-based Credit System (CBCS) Structure

Basket	Type of Course	Minimum Credit Requirement			
		4 years UG		3 years UG	
		Credit	Approx. Weightage	Credit	Approx. Weightage
I	Major (Core) Courses	80	50 %	60	50 %
II	Minor (Domain) Courses	32	20 %	24	20 %
III	Multi-Disciplinary Courses	9	5.6 %	9	7.5 %
IV	Skill Courses	9	5.6 %	9	7.5 %
	Ability Enhancement Courses	8	5 %	8	7 %
	Value Added Courses	6	3.8 %	6	5 %
V	Summer Internship / Dissertation	16	10 %	4	3 %
TOTAL		160	100 %	120	100 %

Basket- I

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Major (Core)	CUTM4115	Cell Biology	4	3+1+0
2	Major (Core)	CUTM4116	Molecular Biology	4	3+1+0
3	Major (Core)	CUTM4117	Microbial Biotechnology	4	3+1+0
4	Major (Core)	CUBOT205	Basics of Genetics	4	3+1+0
5	Major (Core)	CUTM4119	Biochemistry	4	3+1+0
6	Major (Core)	CUTM4352	Immunology	4	3+1+0
7	Major (Core)	CUTM1430	Developmental Biology and Phytotomy	4	3+1+0
8	Major (Core)	CUBOT304	Plant Physiology	4	3+1+0
9	Major (Core)	CUTM4121	Bioanalytical Techniques	4	3+1+0
10	Major (Core)	CUTM4353	Metabolic Engineering	4	3+1+0
11	Major (Core)	CUTM4351	Genetic Engineering	4	3+1+0
12	Major (Core)	CUTM4350	Fermentation Biotechnology	4	3+1+0
13	Major (Core)	CUTM1569	IPR, Biosafety and Bio-entrepreneurship	4	2+0+2
14	Major (Core)	CUTM4355	Cancer Biology	4	3+1+0
15	Major (Core)	CUTM1565	Biostatistics and Bioinformatics	4	2+2+0
16	Major (Core)	MPC203T	Computer Aided Drug Designing	4	4+0+0
17	Major (Core)	CUTM1567	Frontiers in Genomics	4	3+1+0
18	Major (Core)	CUTM4120	Animal Biotechnology	4	2+1+1
19	Major (Core)	CUTM1439	Plant Biotechnology	4	3+1+0
20	Major (Core)	CUTM1674	Environmental Science	4	3+0+1

Credits to be completed from Basket I ≥ 60 for 3 years exit and 80 for 4 years exit.

Basket- II

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Domain (29 Credits) [Genetics and Genomics]	CUGE2270	Computational Biology	3	1+2+0
2		CUGE2271	Genetic Engineering and its applications	3	1+2+0
3		CUGE2277	Genetics and Genomics	3	1+2+0
4		CUGE2273	Molecular Genomics	3	0+3+0
5		CUGE2274	Plant Tissue Culture Technologies	3	0+3+0
6		CUGE2275	Techniques in Molecular Biology	3	0+3+0

7		CUGE2276	AELP Project	11	0+0+11
8	Domain (29 Credits) [Nutraceuticals]	CUNU2280	Introduction to Nutraceuticals	3	1+2+0
9		CUNU2281	Functional Food	3	1+2+0
10		CUNU2282	Nutrigenetics	3	1+2+0
11		CUNU2283	Development of Personalized Food and Medicine	3	0+1+2
12		CUNU2284	Development of Biopesticides and Biofertilizers	3	0+1+2
13		CUNU2285	Development of Immune Boosters	3	0+1+2
14		CUNU2286	AELP Project	11	11
15	Minor Stream	CUTM4332	Medical Microbiology	3	2+1+0
16	Minor Stream	CUTM2375	Nanobiotechnology	3	2+0+1
17	Minor Stream	CUTM1171	Phyto-Pharmacology	4	2+1+1

Credits to be completed from Basket II \geq 24 for 3 years exit and 32 for 4 years exit.

Basket- III

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Multidisciplinary	CUTM1005	Probability & Statistics	3	2+0+1
2	Multidisciplinary	CUTM1400	Bio and Biomimetic Nanomaterials	4	3+0+1
3	Multidisciplinary	CUTM1008	Applied Analytical Chemistry	3	2+1+0

Credits to be completed from Basket III \geq 09 for 3 years and 4 years exit.

Basket- IV

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Ability Enhancement Courses (AEC)	CUTM1021	Design Thinking	2	0+0+2
2	Ability Enhancement Courses (AEC)	CUTM1016	Job Readiness	6	0+6+0
3	Skill Enhancement Courses (SEC)	CUTMXXXX	Skill I	4	0+3+1

4	Skill Enhancement Courses (SEC)	CUTMXXXX	Skill II	4	0+2+2
5	Skill Enhancement Courses (SEC)	CUTMXXXX	Skill III	4	0+2+2
6	Value Added Courses (VAC)	CUTM1013	Project Management	3	2+0+1
7	Value Added Courses (VAC)	CUVA4063	Introduction to Indian Knowledge System	3	2+0+1
8	Value Added Courses (VAC)	CUTM1015	Climate Change, Sustainability and Organisation	3	2+0+1

For AEC, Credits to be completed ≥ 08 for 3 years and 4 years exit.

For SEC, Credits to be completed ≥ 09 for 3 years and 4 years exit.

For VAC, Credits to be completed ≥ 06 for 3 years and 4 years exit.

Basket- V

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Summer Internship	CUTM1578	Summer Internship I	2	0+0+2
2	Summer Internship	CUTM1579	Summer Internship II	2	0+0+2
3	Project	CUTM1849	Project	12	0+0+12

For Internships, Credits to be completed $\geq 02-04$ for 3 years and 4 years exit.

For Research Project / Dissertation, Credits to be completed ≥ 12 4 years exit. Not applicable for 3rd year exit.

Semester-wise course distribution

Semester I

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM4115	Cell Biology	4	3+1+0
CUTM4116	Molecular Biology	4	3+1+0
CUTM4117	Microbial Biotechnology	4	3+1+0
CUTM1400	Bio and Biomimetic Nanomaterials	4	3+0+1
CUTM1015	Climate Change, Sustainability and Organisation	3	2+0+1
CUTM1016	Job Readiness	6	0+6+0

Semester II

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM1008	Applied Analytical Chemistry	3	2+1+0
CUBOT205	Basics of Genetics	4	3+1+0
CUTM1430	Developmental Biology and Phytotomy	4	3+1+0
CUVA4063	Introduction to Indian Knowledge System	3	2+0+1
CUTM1674	Environmental Science	4	3+0+1
CUTMXXXX	Skill I	4	0+2+2

Semester III

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM1013	Project Management	3	2+0+1
CUBOT304	Plant Physiology	4	3+1+0
CUTM4119	Biochemistry	4	3+1+0
CUTM1005	Probability & Statistics	3	2+0+1
CUTM4121	Bioanalytical Techniques	4	3+1+0
CUTM1021	Design Thinking	2	0+0+2

Semester IV

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM4352	Immunology	4	3+1+0
CUTM1569	IPR, Biosafety and Bioentrepreneurship	3	2+0+2
CUTM1565	Biostatistics and Bioinformatics	3	2+2+0
CUTM4350	Fermentation Biotechnology	3	3+1+0
CUTMXXXX	Skill II	4	0+2+2
CUTM1578	Summer Internship I	2	0+0+2

Semester V

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTMXXXX	Domain Subject I	4	1+2+0
CUTMXXXX	Domain Subject II	4	1+2+0
CUTMXXXX	Domain Subject III	4	1+2+0
CUTM4120	Animal Biotechnology	4	2+1+1
CUTM1439	Plant Biotechnology	4	3+1+0
CUTMXXXX	Elective I	4/3	

Semester VI

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTMXXXX	Domain Subject IV	3	0+0+3
CUTMXXXX	Domain Subject V	3	0+0+3
CUTMXXXX	Domain Subject VI	3	0+0+3
CUTMXXXX	Domain Project	11	0+0+11
CUTM1579	Summer Internship II	2	0+0+2

Semester VII

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM4353	Metabolic Engineering	4	3+1+0
CUTM4351	Genetic Engineering	4	3+1+0
CUTM1567	Frontiers in Genomics	4	3+1+0
CUTM4355	Cancer Biology	4	3+1+0
MPC203T	Computer Aided Drug Designing	4	4+0+0
CUTMXXXX	Skill IV	4	0+2+2

Semester VIII

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM1849	Project	12	0+0+12
CUTM1579	Summer Internship II	2	0+0+2

Core Courses

Cell Biology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4115	Cell Biology	4	3-1-0	Nil

Course Objectives

- To study structure and functions of cell organelles.
- Exposure on transportations through cell membrane.
- To introduce the concept of cell signaling.

Course Outcomes

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To memorize the features of prokaryote and eukaryote cells, cell organelles, the composition and spatial organization of the cell.	PO1 (3), PO2 (3), PO3 (2), PO8 (3), PSO1 (2), PSO2 (2) PSO3 (3)
CO2	To identify the molecular mechanisms regulating and controlling cell division and the cell cycle.	PO1 (3), PO2 (1), PO3 (2), PO4 (1), PSO1 (3) PSO3 (2)
CO3	To compare and relate the different principles related to extracellular signals, signal amplification, transmission, and termination.	PO1 (3), PO2 (2), PO3 (2), PO4 (1) PSO1 (3) PSO3 (2)
CO4	To outline the ways in which cell biology throws light on cell junctions, signaling, programmed cell death.	PO1 (3), PO2 (1), PO3 (1), PO4 (1), PO9 (1), PO10 (1), PO11 (1) PSO1 (1), PSO3 (2)
CO5	To predict the development of cancer and summarize different types of onco genes.	PO1 (3), PO2 (2), PO3 (3), PO4 (3), PO6 (2), PO8 (1), PSO1 (1), PSO2 (3), PSO (2)

Course Contents

Module I

An Overview of Cells: History, Cell theory, Structure and Function of Cell and its Organelles: Biological membranes – architecture, Cell types: prokaryotes vs. eukaryotes; from single cell to multi-cellular organism; Different molecules of cell- water, salt and mineral ions etc.

Module II

Nucleus - Nuclear envelope, transport across nuclear membrane, Nucleolus, Mitochondria, Chloroplasts, Lysosomes, Glyoxysomes and Peroxisomes, endoplasmic reticulum, ribosomes, Golgi complex (Structural organization, function, marker enzymes of the above organelles).

Module III

Cell cycle and its regulation, Cellular communication and cell mobility: Cell cycle: G₀/G₁, S, G₂ and M phases (Cell Division: Mitosis, meiosis and cytokinesis); regulation of cell cycle.

Module IV

Cell adhesion and roles of different adhesion molecules, gap junctions, Extra- Cellular Matrix (ECM), Cell-cell interaction and cell- ECM interaction, The cytoskeleton, Microtubule- based movement and microfilament -based movement.

Module V

Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors (GPCR), Tyrosine Kinase, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, bacterial chemotaxis, Programmed Cell Death (Apoptosis), Intrinsic and Extrinsic apoptotic pathway, Caspase enzyme; Biology and elementary knowledge of development and causes of cancer; Tumor viruses, Oncogenes and tumor suppressor genes.

Practice

1. Demonstration of the technique of microscopy.
2. Study of the electron micrographs of bacterial cell.
3. Study of the different fungal cells.
4. Study of different stages of mitosis using plant root tips.
5. Study of the structure of cell organelles through electron micrographs.
6. Identification and study of cancer cells by photomicrographs.

Text Books

1. Geoffrey M.Cooper, The Cell: A molecular approach, Sixth edition.
2. Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA

Reference Books

1. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley- Blackwell.
2. Benjamin Lewin, Gene IX, 9thEdition, Jones and Barlett Publishers.
3. Becker's World of the Cell. 8th edition. Pearson, Hardin J, Bertoni G and Kleinsmith L. J. (2010).
4. Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc. Karp G. (2010).
5. Cell and Molecular Biology. 8th edition. Lipincott, Williams and Wilkins, Philadelphia. De Robertis, EDP and De Robertis EMF. (2006).

Molecular Biology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4116	Molecular Biology	4	3-1-0	Nil

Course Objectives

- To provide depth knowledge of biological or medicinal processes through the investigation of the underlying molecular mechanisms.
- Understanding of chemical and molecular processes that occur in and between cells.
- Understanding of gene expression and protein functions.

Course Outcomes

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To learn the molecular structure of cell, cell cycle and transport system.	PO1 (3), PO3 (1), PO4 (1), PO5 (1), PO12 (1), PSO1 (2), PSO2 (2) PSO3 (3)
CO2	To discuss molecular nature of genetic material and evolution of DNA and RNA, gene and genetic codes.	PO1 (3), PO2 (1), PO3 (2), PO4 (2), PO5 (1), PO12 (1), PSO1 (2), PSO3 (3)
CO3	To compare and relate the regulation of gene expression, DNA replication and post-replication modification of DNA.	PO1 (3), PO2 (1), PO3 (2), PO4 (2), PO5 (1), PSO1 (3), PSO3 (2)
CO4	To outline the process of protein biosynthesis.	PO1 (3), PO3 (1), PO5 (1), PO12 (1), PSO1 (2)
CO5	To examine DNA amplification by PCR technique and quantitative analysis of protein via project mode.	PO1 (3), PO2 (2), PO3 (3), PO4 (3), PO5 (3), PO8 (3), PO9 (3), PO10 (2), PO11 (3) PSO2 (2) PSO3 (3)

Course content

Module I

Introduction to molecular biology, Evolution and Molecular structure of cell and its organelles. Types of cells. Including different kinds of prokaryotic and eukaryotic cells. Cell growth, Cell adhesion, cell junctions and extra cellular matrix organelles, Cell cycle, Cell membrane and its structure (fluid-mosaic model). Factors influencing on membrane fluidity, asymmetry of membrane and membrane transport (active and passive)

Module II

Molecular Nature of the Genetic Material in Prokaryotic and Eukaryotic Cells: Molecular biology of Genes, DNA: Molecular structure, types: Primary, secondary and tertiary, Double helix, types, Transferring information from DNA to RNA, Synthesis of RNA, Translation RNA: Molecular structure, types. Evolution of DNA and RNA, Gene and genetic codes

Module III

General Concept on Regulation of the Gene Expression, Regulating the Metabolism: The Lac-Operon system, Catabolic repression, Trp Operon system: regulating the biosynthesis of the tryptophan, Gene expression in Eukaryotic cells, Plasmids: types, maintenance and functions. DNA Replication and Gene Expression: DNA Replication: Semi conservative Nature of DNA Replication, DNA Replication in prokaryotic Cells, DNA Replication in Eukaryotic cell, Enzymes involved in DNA Replication: DNA polymerases, Proofreading, post-replication Modification of DNA.

Module IV

Transferring information from DNA to RNA, Synthesis of RNA(Transcription), RNA polymerase, Initiation and Termination of Transcription, Post and co- transcription modification of the RNA.

Module V

Protein Biosynthesis: Translation of the genetic code, Translation of m RNA, Role of r-RNA in protein synthesis, Forming the polypeptides- elongation, Termination of the protein biosynthesis.

Practice

1. Isolation of genomic DNA from plant/animal tissue.
2. Quantification of isolated DNA via electrophoresis method.
3. Quantification of isolated DNA via spectrophotometry method.
4. DNA amplification by PCR technique.
5. Analysis of PCR amplification via agarose gel electrophoresis.

Text Books

1. Molecular Biology of the gene (7th Ed) by James D. Watson.
E-book link-<https://www.pdfdrive.com/molecular-biology-of-the-gene-e158278674.html>
2. Genes XII by Lewin's.
E-book link- <https://www.pdfdrive.com/lewins-genes-xii-e168024578.html>
3. Molecular cell biology (5th Ed) by Lodish H.
E-book link-<https://www.pdfdrive.com/molecular-cell-biology-lodish-5th-ed-e15674865.html>

Reference Books

1. Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008).
2. The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009).

Microbial Biotechnology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4117	Microbial Biotechnology	4	3-1-0	Cell Biology

Objectives

<ul style="list-style-type: none">• To impart knowledge on the basic concept of cell organization in microorganisms.• To study in detail the growth, genetic organization of microorganisms and impact of environment on their growth.• To highlight the roles and characteristics of microorganisms in field of Biotechnology.

Course outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To learn classification, characteristics, growth conditions and cultural characteristics of different microorganisms.	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (3), PO10 (1), PSO1 (2), PSO2 (1) PSO3 (1)
CO2	To discuss on the importance of different microorganisms for environment and their Genome organization.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO6 (1), PO7 (3), PO8 (1), PO9 (2), PO10 (1), PSO1 (3), PSO2 (1) PSO3 (3)
CO3	To apply the knowledge on classification of microbes using genome mapping and microbial metabolism.	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (2), PSO1 (2), PSO3 (3)
CO4	To design experiments on isolation and identification of different microorganisms and their growth kinetics.	PO1 (1), PO2 (2), PO3 (3), PO4 (3), PO5 (2), PSO1 (3), PSO2 (2), PSO3 (3)
CO5	To summarize the roles and application of different microbes in Biotechnology.	PO1 (3), PO2 (2), PO5 (1), PO6 (3), PO7 (1), PO8 (2) PSO1 (2), PSO3 (3)

Course contents

Module I

Microbial World; Microscope and its types, Phase contrast microscope, Electron microscope, SEM, TEM, STEM; Microscopic examination of microorganisms: Gram and acid-fast staining, negative-staining.

Module II

Classification and Identification of microorganisms; Bacteria, morphology and fine structure of bacteria, cultivation of bacteria, reproduction & growth, pure cultures and cultural characteristics - nutritional types in bacteria; Culture media types; Phases of growth.

Module III

General characteristics-Morphology and structure of Virus, Classification- isolation and identification-fatal diseases associated with viruses in animals. Algae, Fungi, molds and Protozoa – importance, characteristics, morphology, reproduction, physiology cultivation & their association with other organisms. Genome organization of bacteria, virus, algae and fungi.

Module IV

DNA and RNA present as genetic material in microbes. Types and division of microbes according to their genetic organization. Classification of microbes according to genotyping. Enzymes and their regulation, Microbial metabolism energy production (EMP, ED, Pentose phosphate pathway, TCA cycle, Electron transport chain: components of respiratory chain, anaerobic respiration with special reference to dissimilatory nitrate reduction), utilization of energy & biosynthesis (Peptidoglycan), Bacterial Genetics.

Module V

Application of microbes in fuel industry; agriculture, aquatic microbiology; Study of domestic water and waste water.

Practice

1. Study of the principle and applications of important instruments (Autoclave, incubator, Colony counter, digital balance, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
2. Preparation of culture media and sterilization of medium using autoclave and assessment for sterility.
3. Sterilization of glassware using Hot Air Oven and assessment for sterility.
4. Demonstration of the presence of microbes by exposing nutrient agar plates to air.
5. Isolation of fungus.
6. Isolation of bacteria.
7. Bacterial and fungal staining techniques.

Text Books

1. R.K. Sahoo: Introduction to Microbiology, Year 2020, Kindle publication, Amazon, 1st Edition.
2. B. Ray, A. Bhunia: Fundamental food microbiology, CRC press, 5th Edition.
3. Microbiology: An Introduction. 9th edition. Pearson Education. Tortora GJ, Funke BR and Case CL. (2008).

Reference Books

1. Brock Biology of Microorganisms. 14th edition. Pearson International Edition. Madigan MT, Martinko J.M, Dunlap P.V and Clark D.P. (2014).
2. Prescott's Microbiology. 9th Edition. McGraw Hill International.

Basics of Genetics

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUBOT205	Basics of Genetics	4	3-1-0	Molecular Biology

Course Objective

- To understand history and principles of Mendelian inheritance, including the laws of segregation and independent assortment.
- To role of natural selection, mutation, and genetic drift in population genetics.
- To analyze different types of gene mutations and understand their molecular basis and role of mutagens.

Course Outcomes

After completion of the course the students will be able to:

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Learn the concept of concept of inheritance and its correlation with the chromosome theory. and understand lethal alleles, pleiotropy, and the distinction between dominant and recessive traits.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PSO1 (3), PSO2 (1) PSO3 (2)
CO2	Understand the concepts of interference, coincidence, and numerical gene mapping. and analyze recombination frequency and apply it to gene mapping.	PO1(3), PO11(1), PSO1(2), PSO2(1), PSO3(2), PSO1 (3), PSO3 (2)
CO3	Acquire the knowledge on probability and pedigree analysis to solve genetic problems common to the local context.	PO1(2), PO4 (3), PSO1(2), PSO3(2), PSO1 (3), PSO3 (3)
CO4	Acquire the knowledge and understanding on relationship between genetic variation and speciation and to interpret allele and genotype frequencies using the Hardy-Weinberg Law.	PO1(3), PSO1(2), PSO3(2), PSO1 (3), PSO2 (2) PSO3 (3)
CO5	Know classical and molecular concepts of genes and assess their functional allelism, able to apply the knowledge on maintenance of diverse genomes for biodiversity sustainability for higher studies to get employability opportunity	PO1(3), PSO1(2), PSO3(2), PSO1 (3), PSO2 (3) PSO3 (3)

Course Contents

Module-I

Mendelian genetics and its extension: Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis

Module-II

Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Extrachromosomal Inheritance: Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in Paramecium.

Module-III

Linkage, crossing over and chromosome mapping: Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numerical based on gene mapping; Sex Linkage.

Module-IV

Variation in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, Euploidy and Aneuploidy.

Module-V

Gene mutations: Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CIB method. Role of Transposons in mutation. DNA repair mechanisms.

Module-VI

Fine structure of gene: Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

Module-VII

Population and Evolutionary Genetics: Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Practice

1. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
2. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
3. Chromosome mapping using point test cross data.
4. Blood Typing: ABO groups & Rh factor.
5. Study of human genetic traits: Widow's peak and Rolling of tongue
6. Study of human genetic traits: Hitchhiker's thumb and attached ear lobe

Text Books:

1. Genetics: A Conceptual Approach (7th Edition, 2021) – Benjamin A. Pierce
2. Genetics: Analysis and Principles (7th Edition, 2021) – Robert J. Brooker
3. Genetics: From Genes to Genomes (6th Edition, 2021) – Leland Hartwell, Michael Goldberg, Janice Fischer, Leroy Hood

Reference Books:

1. Concepts of Genetics (12th Edition, 2021) – William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, Darrell Killian
2. Chromosomes, Genes, and Traits: An Introduction to Genetics (Revised Edition, 2025) – Amanda Simons
3. Textbook of Medical Genetics: A CBME Approach (1st Edition, 2025) – Anjali S. Sabnis

Biochemistry

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4119	Biochemistry	4	3-1-0	Cell Biology

Course Objectives

- To understand the fundamental principles and concepts of plant biochemistry.
- To understand the structure and function of biological macromolecules such as proteins, carbohydrates, lipids, and nucleic acids.
- To understand the enzyme kinetics and role of enzymes in metabolic processes.

Course Outcomes

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Knowledge on carbohydrates, their classifications and biomedical importance.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5(2), PSO1 (3), PSO2 (1) PSO3 (2)
CO2	Discuss the basic concepts of amino acids, proteins, and their metabolisms.	PO1 (3), PO2 (3), PO3 (3), PO5 (3), PO9 (2), PO10 (2), PO11 (2), PSO1 (3)
CO3	Illustrate the chemistry, structure, and metabolisms of lipids.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO9 (2), PO10 (2), PO11 (2), PSO1 (1), PSO2 (3) PSO3 (2)
CO4	Analyze the structure, mechanism, and diagnostic values of enzymes.	PO1 (3), PO2 (2), PO3 (2), PO5 (3), PO6 (1), PSO1 (3), PSO2 (1) PSO3 (2)
CO5	Estimate the carbohydrate metabolisms and their role in regulating cell respiration and blood glucose levels.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO8 (2), PO9 (2), PO10 (2), PO11 (2), PSO1 (3), PSO3 (3)

Course Contents

Module I

Biomedical importance & properties of Carbohydrates, Classification, Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo isomerism of monosaccharides, epimers, Haworth projection formulae for glucose; chair and boat forms of glucose.

Module II

Overview of proteins and protein structures, Classification, essential & non-essential amino acids. Chemistry of Proteins & their related metabolism, Classification, biomedical importance. Metabolism: Ammonia formation & transport, Transamination, Decarboxylation, Urea cycle, metabolic disorders in urea cycle, catabolism of amino acids.

Module III

Classification, biomedical importance, essential lipids. Brief outline of metabolism: Beta oxidation of fatty acids, Ketogenesis, Cholesterol & its clinical significance, Lipoproteins in the blood composition & their functions in brief.

Module IV

Apoenzyme and cofactors, prosthetic group, coenzymes, metal cofactors, Classification of enzymes. Active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis. Enzyme inhibition, enzyme kinetics.

Module V

Glycogenesis & glycogenolysis, Glycolysis, citric acid cycle & its significance, Components of respiratory chain, energy relationships during cell respiration, types of respiration. HMP shunt & Gluconeogenesis, regulation of blood glucose level, Diabetes mellitus: its types, features, hypoglycaemia & its causes.

Practice

1. Preparation of solution, pH & buffers.
2. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars.
3. Quantitative tests for carbohydrates.
4. Qualitative/Quantitative tests for proteins.

Reference Books

1. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
2. Biochemistry by U. Satyanarayana.

Immunology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4352	Immunology	4	3-1-0	Cell Biology

Course Objective

<ul style="list-style-type: none">• To provide students with a detailed understanding of the structure, components, and functions of the immune system, including innate and adaptive immunity, and their roles in maintaining health and combating diseases.• To equip students with knowledge of immunological processes such as antigen recognition, immune cell activation, and signaling pathways, along with an understanding of immunological disorders and immune evasion strategies by pathogens.• To develop the ability to apply immunological principles in designing vaccines, diagnostics, and immunotherapies, with an emphasis on addressing real-world challenges in medicine and biotechnology.

Course Outcomes

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To recognize and learn the theoretical understanding of the classification of immunological processes and types of antigens.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PSO1 (3), PSO2 (1) PSO3 (2)
CO2	To identify the difference between innate and adaptive immunity and understand the antigen-antibody interactions.	PO1(3), PO11(1), PSO1(2), PSO2(1), PSO3(2), PSO1 (3), PSO3 (2)
CO3	To interpret different types of research-based knowledge, contextual experiments and concept on production of antibodies, cell-mediated immune responses, and hypersensitivity reactions.	PO1(2), PO4 (3), PSO1(2), PSO3(2), PSO1 (3), PSO3 (3)
CO4	To examine the types of hypersensitivity reactions.	PO1(3), PSO1(2), PSO3(2), PSO1 (3), PSO2 (2) PSO3 (3)
CO5	To design different types of vaccines and their production.	PO1(3), PSO1(2), PSO3(2), PSO1 (3), PSO2 (3) PSO3 (3)

Course Contents

Module I

Immunity: Classification, Measurement of immunity, Local immunity, Herd immunity.

Module II

Antigens: Types of antigens, Antigenic Determinant or Epitope, Tolerogens, Biological Classes of antigens, Superantigens. Immunoglobulins: Antibody structure, Immunoglobulin classes, Antigenic Determinants on Immunoglobulins.

Module III

Principal pathways of Complement activation, Quantitation of Complement (C) and its Components. Biosynthesis of complement, Complement Deficiencies. Antigen-Antibody Reactions, Antigen-Antibody measurement. Serological Reactions and their parameters.

Module IV

Immune Response: Types of Immune response, Humoral immunity, Production of Antibodies, Cell-mediated Immune Responses, Hypersensitivity Reactions and its Classification.

Module V

Cytokines, Immunological tolerance, Vaccines, Types and their production

Practice

1. Blood grouping
2. Preparation of O and H antigen
3. Quantitative VIDAL test
4. ASO, C-Reactive Protein
5. Rheumatoid factor (RF)
6. ELISA- qualitative
7. Agglutination
8. Precipitation
9. Neutralization and flocculation

Text Books

1. N. Arumugam, Dulsy Fatima, Immunology, Saras Publication, First Edition
2. Sunil Kumar Mohanty, Textbook Of Immunology, Jaypee Brothers Medical Publishers 2nd Edition

Reference Books

Kuby Immunology by Richard A. Golds by Tharmas J. kindt Sixth edition Barbara Osborne. W.H.freeman and company.
Fundamental Immunology 7th Edition by Paul, Wolters Kluwer | Lippincott Williams and Wilkins.

Developmental Biology and Phytotomy

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM1430	Developmental Biology and Phytotomy	4	3-1-0	Cell Biology

Course objectives

- The student will be able to know the relationship between the internal structure, function, taxonomy, physiology, ecology and developmental genetics of the organism.
- Evolutionary history and taxonomic variation of vascular plant anatomy
- They will understand the morphology and development of reproductive parts

Course outcome

At the end of the course the student will be able to:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understand and remember the internal structure, tissues involved in developmental stages of plants.	PO1 (3), PO2 (2), PO4 (2), PO5 (3), PO6 (1), PO7 (3), PSO 1 (3), PSO 2 (2), PSO 3 (1)
CO2	Identify the secondary growth, gametophyte development, molecular mechanisms of fruit and seed development.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO6 (1), PO7 (3), PO8 (1), PO9 (2), PO10 (1), PSO 1 (3), PSO 2 (2)
CO3	Interpret different plants by studying the anatomical features and make use of the knowledge for studying the deviations	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (2), PSO 1 (3), PSO 2 (3)
CO4	Analyze the gametogenesis and pollen-pistil interaction mechanisms.	PO1 (1), PO2 (2), PO3 (3), PO4 (3), PO5 (2), PSO 1 (2), PSO 2 (2)
CO5	Examine the pollen viability and differential behaviour of sperms.	PO1 (3), PO2 (2), PO5 (1), PO6 (3), PO7 (1), PO8 (2), PSO 1 (3), PSO 2 (2)

Module I

Importance in plant development, taxonomy and identification, ecology and pharmacognosy, Simple tissues, complex tissues and their function; Secondary xylem, secondary phloem in angiosperms and gymnosperms (conifers), structure and functions; Meristematic tissue: Structure, classification, distribution and function

Module II

Secondary growth in stem and root; Anomalous secondary growth in dicot and monocot stems; Cambial types: Vascular cambium and phellogen, structure and functions, cambial activity in grafting and wound healing

Module III

Macro and micro structure and composition, chemical composition and properties of wood, bark and bark products, Apo tracheal and para tracheal parenchyma; Hard wood anatomy, organization of wood, sap wood, heard wood; Axial Parenchyma fibers and ray parenchyma and their value in wood identification'; Nodal anatomy.

Module IV

Shoot systems and its derivatives, Theories of organization of meristem in stem, Root systems and its derivatives, Theories of organization of meristem in root, Quiescent center, Coordination of shoot and root development; Root-shoot transition, Ontogeny and phylogeny of vessels, Ontogeny of dorsiventral leaf, arrangement of leaves (Phyllotaxy)

Module V

Meristem tissue in Flower Development, Genetic Control of Flower Development, Anther wall, endothelium, middle layer, tapetum, tapetum-Structure, types and function, Pollen tetrad development and Pollen wall proteins, Pollen viability and Storage, Male gametophyte development, Differential behavior of sperms.

Module VI

Female gametophyte development, Organization of the embryo sac and different types of it. Pollination-pollination mechanism, biotic and abiotic pollination and floral attractants, the stigma-Types and structure, stigmatic exudates, style transmitting tissue, canal cell. Stigma receptivity (recognition and rejection reaction) pollen adhesion, pollen hydration, pollen germination and pollen tube growth and guide, sexual incompatibility (both homorphic and heteromorphic), Double fertilization and In vitro fertilization.

Module VII

Anther culture, Intra-ovarian pollination, Gynogenesis, Types of endosperms, ruminant endosperm, Embryo development in dicot and monocot, polyembryony; apomixes, agamospermy and parthenocarpy, Development and diversity of fruit dispersal.

Practice

1. Study of anatomical details through permanent slides preparation
2. T.S of plants showing secondary growth
3. T.S of plants showing anomalous secondary growth
4. T.S of anthers of angiospermic plants

5. Pollen Viability
6. T.S of ovary of flower showing placentation

Text Books:

1. Pandey S N, Ajanta Chadha (2009) Plant Anatomy and Embryology, Vikas Publishing House
2. Raghavan, V. (1999). Developmental Biology of Flowering Plants. Springer-Verlag, New York
3. Bhojwani, S. S., Bhatnagar, S. P. and Dantu, P.K. (2014). The Embryology of Angiosperms. Vikas Publishing House, New Delhi.

Reference Books:

1. Eames. A.J. and Macdaniels, L.H, 1947, An Introduction to Plant Anatomy, McGraw- Hill, N.Y and London.
2. Easu, K, 2017 Esaus Plant Anatomy: Meristems Cells and Tissues Of The Plant Body Their Structure Function And Development, 3Rd Edn by Evert R.F., Wiley India.
3. Richard Crang , Sheila Lyons-Sobaski , Robert Wise, 2018, Plant Anatomy, A Concept-Based Approach to the Structure of Seed Plants, Springer, 978-3-319-77208-0

Plant Physiology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUBOT304	Plant Physiology	4	3-1-0	Cell Biology

Course objectives

<ul style="list-style-type: none"> To understand concept of water potential and its components. To understand the role of ATP and carrier systems in nutrient absorption and analyze the concept of source-sink relationship in nutrient transport. To analyze the effects of plant growth regulators on plant growth and development and to identify and differentiate between abiotic stresses, including drought, salinity, cold and heat.
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Course outcome

At the end of the course the student will be able to:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Learn the concept of water potential and its components and relate it to water movement in plants and understand root pressure, guttation, and their implications in plant water balance.	PO1 (3), PO2 (2), PO4 (2), PO5 (3), PO6 (1), PO7 (3), PSO 1 (3), PSO 2 (2), PSO 3 (1)
CO2	Understand the Cohesion-Tension Theory and its role in water transport within plants and to evaluate the use of antitranspirants and their applications in plant water conservation.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO6 (1), PO7 (3), PO8 (1), PO9 (2), PO10 (1), PSO 1 (3), PSO 2 (2)
CO3	Acquire the role of soil as a nutrient source and the mechanisms of ion transport across membranes.	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (2), PSO 1 (3), PSO 2 (3)
CO4	Acquire the knowledge of impact of biotic stressors on plant health and growth and to understand the mechanisms of plant adaptation to stress conditions.	PO1 (1), PO2 (2), PO3 (3), PO4 (3), PO5 (2), PSO 1 (2), PSO 2 (2)
CO5	Know photoperiodism, florigen concept, vernalization, and seed dormancy in relation to flowering and apply the knowledge on the molecular mechanisms of photoperiodic and	PO1 (3), PO2 (2), PO5 (1), PO6 (3), PO7 (1), PO8 (2), PSO 1 (3), PSO 2 (2)

	vernalization responses and can pursue higher studies and can get employment opportunity	
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Module I

Plant-water relations: Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation

Module II

Ascent of sap: Cohesion-tension Theory; Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Minerals: Mineral nutrition; Macro and micronutrient; Essential and beneficial elements, methods of study and use of nutrient solutions; criteria for essentiality, mineral deficiency symptoms and their solution, roles of essential elements, chelating agents

Module III

Nutrient Uptake: Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems

Module IV

Translocation in The Phloem: Experimental evidence in support of phloem as the site of sugar translocation, Pressure–Flow Model; Phloem loading and unloading, Source–sink relationship

Module V

Plant Growth Regulator: Discovery, chemical nature (basic structure), bioassay and physiological role of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid

Module VI

Stress Physiology: Abiotic stress on plant; drought, salinity, cold, heat, submergence etc. Biotic stress on plant

Module VII

Physiology of Flowering: Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. Phytochrome, Cryptochromes and Phototropins:

Discovery, chemical nature, role in photo morphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action

Practice

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
3. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
4. Calculation of the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces)
5. Study of the phenomenon of seed germination (effect of light)
6. Fruit ripening/Rooting from cuttings (Demonstration)

Text Books:

1. Plant Physiology and Development (6th Edition) by Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy (2014)
2. A Textbook of Plant Physiology by Dr. A.S. Gontia (2017)
3. Abiotic Stress Signaling in Plants: Functional Genomic Intervention edited by G.K. Pandey, M. Prasad, A. Pandey, and M. Boehmer (2016)

Reference Books:

1. Elucidation of Biotic Stress Signaling in Plants: Functional Genomics Perspective (Volumes 1 & 2) edited by G.K. Pandey (2015)
2. MicroRNAs in Plant Development and Stress Responses edited by S. Sinha and G.K. Pandey (2015)
3. Light and Its Many Wonders by N. Burman, A. Bhatnagar, and J.P. Khurana (2015)

Bioanalytical Techniques

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4121	Bioanalytical Techniques	4	3-1-0	Biochemistry

Course Objectives

<ul style="list-style-type: none">• To understand the principle and concepts of biological instruments.• To emphasize on the application of instrumentation.• To quantify and identify biological compounds using biological instruments.

Course Outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To demonstrate a comprehensive understanding of the principles and theories behind key bioanalytical techniques.	PO1(2), PO2 (3), PO3 (2), PO6 (1), PO8 (2), PSO1(2), PSO3(2)
CO2	To understand the principles and applications of various spectroscopy techniques such as UV-Vis, IR, NMR, and Mass Spectrometry.	PO1(3), PO2(2), PO4(2), PO5 (1), PO6 (2), PO12 (2) PSO1(2), PSO3(2)
CO3	To perform and interpret data from spectroscopic analyses and explain the principles of different chromatography techniques including HPLC, GC, and TLC.	PO1(2), PO2(3), PO5(2), PO8 (1), PO11 (1), PO12 (3), PSO1(2), PSO3(2)
CO4	To apply the knowledge of chromatographic methods for the separation and analysis of biomolecules.	PO1(3), PO2(2), PO4(1), PO5 (2), PO7 (2), PO9 (1), PO12 (2) PSO1(2), PSO3(2)
CO5	To analyse and develop skills in the quantitative and qualitative analysis of bioanalytical data.	PO1(3), PO2 (2), PO4 (2), PO9 (1), PO11 (2), PO12 (2), PSO1(2), PSO3(2)

Course Contents

Module I

Introduction to microscope, Principles, optics, Types of microscope, Bright field, Dark field, Phase contrast, Fluorescence microscopes, SEM, TEM, and Application

Module II

Introduction to absorption and elimination spectroscopy-UV and visible and absorption method, fluorescence and phosphorescence spectrophotometry, Infrared spectrometers.

Module III

Theory of NMR-environmental effects on NMR spectra-chemical shift-NMR spectrometers, applications of ^1H and ^{13}C NMR, Molecular mass spectra, Ion sources. Applications of molecular mass-electron paramagnetic resonance-g values-instrumentation

Module IV

General description of chromatography, Band broadening and optimization of column performance, Adsorption chromatography, Partition Chromatography, Liquid chromatography, Paper chromatography, GC chromatography, Ion exchange chromatography, Affinity chromatography, Size exclusion chromatography, HPLC

Module V

Principle, Procedure, components of centrifugation, Preparative and Analytical centrifuge, Types of centrifugations, and application of centrifugation, principle, procedure and application of gel electrophoresis (Native PAGE, SDS-PAGE, 2D-GE)

Practice

1. Study of Microscope
2. Electrophoresis of macromolecules
3. Centrifugation of blood-blood separation
4. UV and visible spectrophotometry
5. Chromatography of leaf pigments

Text books

1. Keith Wilson and John walker, "Practical Biochemistry Principles and Techniques", 8th Edition, 2018.
2. Lehninger A.L., Nelson D.L. and M.M. Principles of Biochemistry. CBS publishers and distributors.

Reference Books

1. Kamaraj.P & Arthanareeswari.M, Applied Chemistry, 2nd Edition, Sudhandhira Publication, 2003.
2. Pranab Kumar Banerjee. "Introduction to Biophysics" S chand and company Publication, 2008
3. Friefelder, David. "Molecular Biology". Narosa Publications, 2004.

Metabolic Engineering

Subject Name	Code	T-P-Pr (Credit)	Prerequisite
Metabolic Engineering	CUTM4353	3-1-0 (04)	Bioanalytical techniques

Course objectives

- To develop the skill to understand the theory and practice of bioanalytical techniques
- To provide scientific understanding of analytical techniques and detailed implementation of results
- To understand different types of data using appropriate statistical software

Course outcome

At the end of the course the student will be able to:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Comprehend and explain basic cellular uptake and metabolism of amino acids, nucleotides.	PO1(2), PO3 (3), PO5 (2), PO10(2), PSO1(2), PSO3(2),
CO2	Identify the metabolic flux by using quantification tools and models associated with metabolic flux.	PO1(3), PO2(2), PO3 (1) PO4(2), PO12(1), PSO1(2), PSO3(2)
CO3	Explain the role of enzymes at the level of production and their kinetic regulation.	PO1(2), PO2(3), PO3(1), PO5(2), PO7(1), PSO1(2), PSO3(2)
CO4	Analyze different phyto-constituents using different instruments.	PO1(3), PO2(2), PO5(2), PO8 (2), PSO1(2), PSO3(2), PO11(1)
CO5	Apply 'Omics' technologies in the metabolic engineering area and describe it's role	PO1(3), PO3 (3), PO9 (2), PO10 (1) PSO1(2), PSO3(2)

Module I

Overview of metabolism, Basic concepts of metabolic engineering, Cellular metabolism, Transport processes-Active and passive transports, Biosynthetic and degradation pathways of amino acids, nucleotides, fats. Metabolic flux, Methods for metabolic flux analysis, Application of metabolic flux analysis, Amino acid production by bacteria.

Module II

Metabolic flux analysis for glutamic acid and lysine biosynthetic networks, Fluxes in mammalian cell cultures, Flux analysis and design of culture media. Regulation of metabolic pathways, Regulation of enzymatic activities.

Module III

Enzyme kinetics, Reversible and irreversible inhibitions, Regulatory enzymes, Allosteric enzymes, Cooperativity, Control of enzyme production at transcription, and translation levels, Regulation of metabolic networks.

Module IV

Metabolic control analysis, Control coefficient and elasticity, Functional genomics, proteomics, metabolomics, systems biology.

Module V

Application of metabolic engineering, Enhancement of product yield, Alteration of nitrogen metabolism, Production of antibiotics, vitamins, polyketides etc., Bioconversions.

References Books

1. G. N. Stephanopoulos, A. A. Aristidou, and J. Nielson, *Metabolic Engineering: Principles and Methodologies*, 1st Edn., Academic Press, 1998.
2. N. V. Torres and E. O. Voit, *Pathway Analysis and Optimization in Metabolic Engineering*, 1st Edn., Cambridge University Press, 2002.
3. B. Kholodenko, *Metabolic Engineering in the Post Genomic Era*, New edition Edn., Taylor & Francis, 2004.
4. S. Cortassa, M.A. Aon, A.A. Iglesias, and D. Lloyd, *An Introduction to Metabolic and Cellular Engineering*, 1st Edn., World Scientific Pub. Co., 2002.

Genetic Engineering

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4351	Genetic Engineering	4	3-1-0	Molecular biology

Objective

- To strengthen the knowledge on various cloning and expression vectors
- To impart the importance of vectors in genetic engineering experiments
- To strengthen the knowledge on various Strategies of gene cloning

Course outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To learn the concepts of vectors, gene cloning, and gene manipulation.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5(2), PSO1 (3), PSO2 (1) PSO3 (2)
CO2	To describe the different methods of DNA sequencing and their applications.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO9 (2), PO10 (2), PO11 (2), PSO1 (2), PSO3 (2)
CO3	To apply the concepts of PCR, primer designing, PCR-based genotyping and their applications in biotechnology.	PO1 (3), PO2 (3), PO3 (3), PO5 (3), PO9 (2), PO10 (2), PO11 (2), PSO1 (2), PSO2 (3) PSO3 (3)
CO4	To analyze the concepts of gene expression, expression estimation, and recombinant proteins.	PO1 (3), PO2 (2), PO3 (2), PO5 (3), PO6 (1), PSO1 (2), PSO3 (1)
CO5	To design the methods of gene manipulations and gene cloning towards gene silencing and product generation.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO8 (2), PO9 (2), PO10 (2), PO11 (2), PSO1 (2), PSO3 (3)

Course content

Module I

Purification and Separation of Nucleic Acids, Restriction Endonucleases- types, function, and applications, DNA modifying enzymes, Linkers and adaptors, Overview of Cloning- cutting and joining of DNA and vector, Recombinant DNA

Module II

Vectors- Plasmid vectors, phage vectors, cosmids, Construction of genomic library- cDNA library Characteristics of cloning and expression vectors, Vectors for yeast, plant, and mammalian systems, Prokaryotic and eukaryotic expression host systems.

Module III

PCR technology – concept, types, and applications (DNA-finger printing, Genotyping, Marker-assisted selection, Marker development, etc.), Overview of DNA sequencing, Maxam-Gilbert-Sanger methods, Automated DNA sequencing, and Next Generation Sequencing

Module IV

Analysis of gene expression, Real-time PCR, SYBR green assay, Taqman assay, Molecular beacons, Analysis of gene function, Site Directed Mutagenesis, Transposon Mutagenesis, Strategies for the production of recombinant proteins - insulin- human growth hormone- industrially important proteins.

Module V

RNA interference technology, Small double stranded RNAs; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing. Application of genetic engineering – vaccines – human and genetic diseases – transgenics.

Practice

1. Restriction enzyme digestion of Genomic DNA/ Lambda DNA
2. Isolation of gene of interest/DNA fragment by PCR/Gel elution method.
3. Ligation of DNA with cloning vector.
4. Competent cells preparation and transformation into *E.coli*.
5. Screening of positive and negative transformants by blue-white screening.
6. Confirmation of positive transformants by colony PCR.

Text Books

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL,

Reference Books

1. Brown T. A. Gene Cloning, Blackwell Science Publishers.
2. Ernst L and Winnacker. Genes to Clones, Panima Publishing House, New Delhi.

Fermentation Biotechnology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4350	Fermentation Biotechnology	4	3-1-0	Biochemistry

Objectives

- To study the design and construction of fermenter.
- To study the cell growth and product formation.
- To evaluate the kinetics and mechanism of microbial growth.

Course outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To recognize and learn the fermentation technology, its types and the associated kinetics.	PO1 (3), PO2 (3), PO3 (2), PO4 (1), PO5 (1), PO8 (1), PSO1 (2), PSO2 (2) PSO3 (3)
CO2	To identify the bioreactor configurations and measurement of different parameters.	PO1 (3), PO2 (2), PO3 (3), PO4 (1), PO5 (3), PO9 (1), PO10 (1), PO 11 (2), PO12 (1), PSO1 (2), PSO3 (3)
CO3	To interpret different types of fermentation process and its application in biotechnology.	PO1 (3), PO3 (3), PO4 (1), PO5 (2), PO11 (1), PO12 (1), PSO1 (2), PSO3 (1)
CO4	To examine preparation of different fermented products.	PO1 (2), PO2 (3), PO3 (3), PO4 (3), PO5 (3), PO6 (2), PO7 (1), PO8 (2), PO9 (2), PO10 (1), PO11 (2), PO12 (1), PSO1 (2)
CO5	To design different fermentation processes by using microorganisms for development of industrial products.	PO1 (2), PO2 (2), PO3 (3), PO4 (2), PO5 (2), PSO1 (2), PSO2 (2) PSO3 (3)

Course contents

Module I

Introduction to fermentation; History and development of fermentation industry; General requirements of fermentation processes; Crude and synthetic media: molasses, corn-steep liquor, sulphite waste liquor, whey; Isolation, preservation and improvement of industrially important micro-organisms.

Module II

Development of inoculum for industrial fermentations; Kinetics of microbial growth and death; Air and media sterilization; An overview of aerobic and anaerobic fermentation processes and their application in the biotechnology industry; Types of fermentation processes – batch and continuous fermentations, solid-substrate, submerged fermentation and its applications.

Module III

Fermentor; Basic design and construction of fermentor and ancillaries; Fermentation parameters - pH, temperature, foaming and aeration; Measurement and control of bioprocess parameters Bioreactor configuration - batch, continuous stirred-tank, tubular, plug flow, packed bed, air lift, fluidized bed, photobioreactors.

Module IV

Processes involving microbial flocs; Bioreactors containing microbial films; Basic concept of scale-up of bioreactors. Residence time distribution, Concentration distribution and Temperature distribution; Downstream processing - cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying.

Module V

Microbial production: Citric acid, glutamic acid, ethanol, penicillin, Vaccine, Vitamin B12, Enzymes (amylase, protease), steroid; Enzyme immobilization: Definition, Methods of immobilization, advantages and applications of immobilization.

Practice

1. Study of different parts of fermenter by photograph/field visit to an industry.
2. Antibiotic Assay - Antimicrobial Sensitivity Test (Disc Diffusion Method).
3. Growth Kinetics Study (Bacterial Growth Curve).
4. Microbial activity study on (qualitative) analysis of: Enzymes: Amylase.
5. Microbial activity study on (qualitative) analysis of: Enzymes: Protease.
6. Microbial activity study on (qualitative) analysis of: Amino acid: Tryptophan utilization.
7. Microbial activity study on (qualitative) analysis of: Substrate: Citrate test (carbon).
8. A visit to any educational institute/industry to see industrial fermenter and other downstream processing operations (Assignment).

Text Books

1. Microbes & Fermentation, A. Lel and Kotlers Richard J. Mickey, Oriffin Publication
2. Industrial Fermentations- Leland, N. Y. Chemical Publishers.

Reference Books

1. Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited. USA. Okafor N. (2007).
2. Industrial Microbiology: An Introduction. 1st edition. Wiley – Blackwell Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001).

IPR, Biosafety and Bioentrepreneurship

SubjectName	Code	Type of course	T-P-Pr (Credit)
IPR, Biosafety and Bioentrepreneurship	CUTM1569	Theory+ practice	2-0-2 (04)

Course Objective

<ul style="list-style-type: none">• The risks of handling chemical and biological materials and hazardous, toxic, explosive, inflammable, infective effects of some chemical and biological substances.• To become familiar with ethical issues in biological research.• To teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.
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Course outcome

At the end of the course the student will be able to:

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Learn the ethical aspects related to biological, and biotechnology research.	PO1 (3) , PO2 (2), PO3 (1), PO4 (1), PO5 (3), PSO1 (3), PSO2 (2), PSO3 (1)
CO2	Understand ethical aspects related to biomedical and health care and biotechnology research.	PO1 (1) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1 (3), PSO2 (3)
CO3	Make use of the entrepreneurial skill and the schemes promoted through knowledge centers and various agencies.	PO1 (2) , PO2 (2), PO3 (1), PO4 (3), PO5 (3), PSO1 (1), PSO2 (2), PSO3 (1)
CO4	Discover the scope for entrepreneurship in biosciences.	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (2), PSO1 (3), PSO2 (2), PSO3 (3)
CO5	Evaluate the various operations involved in venture creation.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (3), PSO1 (3), PSO2 (2)

Module I

Types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; plant variety protection and farmers rights; Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; filing of a patent application; role of a Country Patent Office; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications.

Module II

Introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants; risk – environmental risk assessment and food and feed safety assessment; risk assessment of transgenic crops, RNAi, genome edited crops

Module III

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India.

Module IV

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities,

Project: Preparation of proposals for entrepreneurship development programs of public and private agencies (MSME, DBT and BIRAC).

Test Books:

1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
2. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.

Cancer Biology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4355	Cancer Biology	4	3-1-0	Cell Biology

Course Objectives

- To impart basic concepts of cancer biology, various stages in carcinogenesis, molecular cell biology of cancer, cancer metastasis, and cancer therapy.
- Understanding about the biological aspects of cancer.
- Awareness about the therapeutic aspects of cancer.

Course Outcomes

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To understand the difference between normal cell and cancer cell, its principle. Role of cell cycle in cancer. cell culture techniques. knowledge of cancer culture media, cell stock preservation techniques. Relation between diet and cancer.	PO1 (3) , PO2 (2), PO3 (1), PO4 (1), PO5 (3), PSO1 (3), PSO2 (1) PSO3 (2)
CO2	To identify the molecular event of cell cycle, aspect of cancer metabolism, epigenetics, DNA repair pathways.	PO1 (1) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1 (3)
CO3	To interpret the processes of cancer metastasis, dysregulation factors, the role of oncogenes and growth factors.	PO1 (2) , PO2 (2), PO3 (1), PO4 (3), PO5 (3), PSO1 (3), PSO3 (3)
CO4	To examine the significance of carcinogenesis in the development of cancer. Role of tumor microenvironment, angiogenesis in cancer	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (2), PSO1 (2), PSO2 (1) PSO3 (1)
CO5	To apply the concept of the types of cancer treatment, properties of chemotherapeutic drugs, cancer prevention technologies and early detection.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (3), PSO1 (3)

Course Contents

Module I

Introduction to Cancer --Cell cycle—pRb--Tumor suppressor genes--Knudson's two-hit hypothesis--p53--Myconcoprotein--TGF-b --Cell cycle and cancer-- Different forms of cancer-
- Diet and Cancer.

Module II

Stages of Carcinogenesis-Environment, Genetics, and Cancer—Causes of cancer—Classes and Types of Carcinogens—Ecogenetics and Cancer risk— Carcinogen Metabolism—Epigenetics-
- DNA, and Human Cancer.

Module III

Signal Transduction-Growth factor signaling-EGF signaling-Oncogenes—Wnt signaling--
Immune system in cancer—B cell, T cell, and Cytokine signaling— Neuroendcrine system in
cancer-Hormone and Neurotransmitter signaling— Apoptosis—Cancer stem cells

Module IV

Tumor microenvironment in cancer progression—Invasion and Metastasis-Stages in metastasis
and the factors involved in the invasive process—Angiogenesis- VEGF signalling

Module V

Current modalities of treatment-Radiation therapy-Surgery-Chemotherapy- Classification of
properties of chemotherapeutic drugs—Biological therapy-Cancer prevention and early
detection, Imaging and cancer (PET, CT).

Practice

1. Tumor cell isolation using MACS
2. Tumor cell growth in different media.
3. Tumor cell growth with different proteins
4. Tumor cell regression using plan extract.
5. Morphological analysis of different cancer cell lines.

Text Books

1. Robert A. Weinberg, "The Biology of Cancer," Garland Science; 1 Cdr Edition, 2010.

Reference Books

1. Lauren Pecorino, "Molecular Biology of cancer: Mechanisms, Targets, and
Therapeutics," Oxford University Press. 3rd edition, 2012.

Biostatistics and Bioinformatics

Subject Name	Code	Type of course	T-P-P (Credit)
Biostatistics and Bioinformatics	CUTM1565	Theory+Project	2-0-2 (04)

Objective

<ul style="list-style-type: none"> To equip students with the knowledge and skills to apply biostatistical methods such as hypothesis testing, regression analysis, and probability theory to analyze biological data effectively. To train students in using bioinformatics software, databases, and computational techniques to analyze biological sequences, protein structures, and genomic data. To enable students to integrate statistical and bioinformatics methods to solve real-world biological problems, such as identifying biomarkers, analyzing gene expression, and understanding molecular interactions.

Course Outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Recall and describe fundamental concepts of biostatistics and bioinformatics, including statistical methods, biological databases, and computational tools.	PO1(2), PO2 (3), PO3 (2), PO6 (1), PO8 (2), PSO1(2), PSO3(2)
CO2	Explain the applications of statistical techniques in analyzing biological data and the role of bioinformatics in genomics, proteomics, and systems biology.	PO1(3), PO2(2), PO4(2), PO5 (1), PO6 (2), PO12 (2) PSO1(2), PSO3(2)
CO3	Use statistical software and bioinformatics tools to analyze biological datasets, including gene sequences, protein structures, and expression profiles.	PO1(2), PO2(3), PO5(2), PO8 (1), PO11 (1), PO12 (3), PSO1(2), PSO3(2)
CO4	Analyze experimental and computational data to derive meaningful biological interpretations and identify patterns or anomalies.	PO1(3), PO2(2), PO4(1), PO5 (2), PO7 (2), PO9 (1), PO12 (2) PSO1(2), PSO3(2)
CO5	Evaluate the quality and reliability of statistical models and bioinformatics predictions in the context of real-world biological problems.	PO1(3), PO2 (2), PO4 (2), PO9 (1), PO11 (2), PO12 (2), PSO1(2), PSO3(2)

Course Contents

Module I

Sampling methods, concept of Parametric and non-parametric statistics, Measures of central tendency: Mean, Mode & Median, Measures of dispersion: Mean deviations, coefficient of variance (CV), Standard deviations, skewness and kurtosis. Test of hypothesis; Student t-test and paired t-test; chi square test; Probability distribution (normal, binominal and poison distributions), Simple Correlation and Regression, Analysis of variance: one way and two-way classification

Module II

Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification of databases, Data access, retrieval and submission, limitations of existing databases

Module III

Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model, Heuristic approach: BLAST, FASTA.

Module IV

Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, GWAS, ENCODE, HUGO projects; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies, visualization tools such as PyMol

Practice

- Sampling and collection of data (Primary and Secondary).
- Calculate the Mean Median Mode, Standard deviation from the supplied data set.
- Representation and Visualization of the collected data (Table Graph, Heat map).
- Calculation of Paired and Unpaired t Test from the supplied data set.
- Test the goodness of fit.
- Demonstration of biological databases: NCBI, EMBL, Swissprot/TrEMBL, UniProt.
- Data retrieval using Entrez and SRS.
- Pairwise Sequence Alignment using BLAST.
- Aligning Multiple Sequences with CLUSTAL W.
- Identification of gene characteristics using ExPaSy tools.
- Demonstration of gene organization using GSDS tool.
- Functional annotation to genes using DeepGO tool.

Test Books

1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Lesk, A. M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press
3. Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Hoboken, NJ.: Wiley-Blackwell.
4. Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.

Computer Aided Drug Design

Code	Course Title	Credit	T-P-PJ	Prerequisite
MPC203T	Computer Aided Drug Design	4	3-1-0	Biochemistry

Course Objectives

- To provide students with an in-depth understanding of the principles, methodologies, and applications of computer-aided drug design, including structure- and ligand-based approaches.
- To equip students with practical skills in using computational tools and software for molecular modeling, virtual screening, and pharmacokinetic property predictions in drug discovery.
- To enable students to apply computational techniques in the design and optimization of novel therapeutic molecules, considering target specificity, efficacy, and safety.

Course Outcomes

COs	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understand the basics of bioinformatics, chemoinformatics and how useful for drug designing and discovery process.	PO1 (3) , PO2 (2), PO3 (1), PO4 (1), PO5 (3), PSO1 (3), PSO2 (2), PSO3 (1)
CO2	Acquire the knowledge about protein structure prediction methods, structure visualizations and their importance.	PO1 (1) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1 (3), PSO2 (3)
CO3	Understand the principle, types and various applications of computer aided drug designing and discovery process.	PO1 (2) , PO2 (2), PO3 (1), PO4 (3), PO5 (3), PSO1 (1), PSO2 (2), PSO3 (1)
CO4	Explore the concept and SAR, QSAR and their importance in ligand optimization.	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (2), PSO1 (3), PSO2 (2), PSO3 (3)
CO5	Overall understanding the concept and applications for computer aided drug designing and discovery process.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (3), PSO1 (3), PSO2 (2)

Course Contents

Module I

Introduction to Computer Aided Drug Design (CADD) History, different technique sand applications Quantitative Structure Activity Relationships: Basics History and development of QSAR: Physicochemical parameters and methods to calculate physicochemical parameters:

Hammett equation and electronic parameters (σ), lipophilicity effects and parameters ($\log P$, π - substituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physicochemical parameters

Module II

Quantitative Structure Activity Relationships: Applications Hansch analysis, Free Wilson analysis and relationship between them, Advantages and disadvantages; Deriving 2D-QSAR equations 3D-QSAR approaches and contour map analysis, Statistical methods used in QSAR analysis and importance of statistical parameters

Module III

Molecular Modeling and Docking, Molecular and Quantum Mechanics in drug design, Energy Minimization Methods: comparison between global minimum conformation and bioactive conformation, Molecular docking and drug receptor interactions: Rigid docking, flexible docking and extra-precision docking. Agents acting on enzymes such as DHFR, HMG-CoA reductase and HIV protease, choline esterase (AChE & BchE)

Module IV

Molecular Properties and Drug Design, Prediction and analysis of ADMET properties of new molecules and its importance in drug design. De novo drug design: Receptor/enzyme-interaction and its analysis, Receptor/enzyme cavity size prediction, predicting the functional components of cavities, Fragment based drug design. Homology modeling and generation of 3D-structure of protein

Module V

Pharmacophore Mapping and Virtual Screening Concept of pharmacophore, pharmacophore mapping, identification of Pharmacophore features and Pharmacophore modeling; Conformational search used in pharmacophore mapping. In Silico Drug Design and Virtual Screening Techniques Similarity based methods and Pharmacophore based screening, structure based In-silico virtual screening protocols

Reference Books

1. Computational and structural approaches to drug discovery, Robert M Stroud and Janet F Moore, RCS Publishers.
2. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press, Taylor & Francis group.
3. Drug Design by Ariens Volume 1 to 10, Academic Press, 1975, Elsevier Publishers.
4. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis.
5. The Organic Chemistry of the Drug Design and Drug action by Richard B.

Frontiers in Genomics

Subject Name	Code	Type of course	T-P-Pr (Credit)
Frontiers in Genomics	CUTM1567	Theory+ practice	3-1-0 (04)

Objective

<ul style="list-style-type: none"> To provide students with an in-depth understanding of the latest advancements in genomics, including next-generation sequencing and high-throughput genomic analysis techniques. To equip students with the skills to analyze and interpret genomic data using bioinformatics tools and software, with applications in personalized medicine, agriculture, and evolutionary studies. To expose students to cutting-edge topics in genomics such as epigenomics, metagenomics, and functional genomics, highlighting their relevance in modern biological research and their potential for innovation.

Course outcome

At the end of the course the student will be able to:

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Recall key concepts and terminologies in genomics, including genome structure, sequencing technologies, and functional genomics.	PO1 (1) , PO2 (3), PO3 (3), PO4 (3), PO5 (3), PSO1 (3)
CO2	Explain the principles and applications of next-generation sequencing, genome editing tools, and comparative genomics in understanding genetic diversity and evolution.	PO1 (2) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO2(3)
CO3	Use bioinformatics tools to analyze genomic data, interpret genome annotations, and identify genes associated with traits and diseases.	PO1 (3) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO3(2)
CO4	Analyze advancements in genomics, such as epigenomics, metagenomics, and transcriptomics, to explore their implications for personalized medicine and biotechnology.	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO8 (2)
CO5	Design research strategies integrating genomic technologies to address specific biological questions or challenges in healthcare, agriculture, or environmental sustainability.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (1), PSO3(3)

Module I

Introduction to genomics, Brief overview of prokaryotic and eukaryotic genome organization, Extra-chromosomal DNA: bacterial plasmids, Mitochondrial and chloroplast genomes.

Module II

Molecular Mapping of Genome: Genetic mapping- linkage analysis, Choice of mapping populations, markers for genetic mapping; methods and techniques used for genetic mapping; Physical mapping- tools for physical mapping of genes, cytogenetic maps, FISH, radiation hybrid maps, high resolution physical mapping.

Module III

Chemical (Maxim and Gilbert's degradation method) and enzymatic (Sanger's dideoxy synthetic method) methods of DNA sequencing; Genome sequencing strategies- Whole genome, clone-by-clone and hybrid approaches.

Module IV

Next generation sequencing technologies- 454, Illumina, ABI SOLiD, single molecule and nanopore sequencing.

Module V

Whole Genome Assembly and challenges, Gene prediction, Functional annotation, Web based servers for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome.

Module VI

Human Genome Sequencing Project, Genome sequencing projects for microbes (including yeast), Genome sequencing projects for plants (Rice, Arabidopsis).

Module VII

Whole genome comparison; Tandem and segmental duplication; DNA based phylogenetic trees; Identification and classification of organisms using 16S rRNA typing/sequencing.

Practice

- Demonstration of genetic mapping.
- Demonstration of web tools for genome analysis.
- Demonstration of genome browsers- ENSEMBL, VISTA and UCSC Genome Browser.
- Demonstration of genome assembly & alignment using Splign.
- Phylogenetic analysis using genomic tools.
- Genome comparison using MOAV tool.

References

1. Azuaje F & Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics. John Wiley & Sons, US
2. Baxevanis. A. D. and Ouellette. B. F. F. (Eds). 2001. Bioinformatics: A Practical guide to the analysis of genes and proteins. Wiley Interscience. New York. 470p.

Animal Biotechnology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTM4120	Animal Biotechnology	4	3-1-0	Cell Biology

Course Objectives

- To provide the fundamentals of animal cell culture, details of disease and therapy.
- To know the difference between 2D and 3D animal cell culture.
- Acquire the knowledge of gene therapy in biomedical applications.

Course Outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To understand the various techniques required for culturing the animal cell, its characterization, and authentication.	PO1 (1) , PO2 (3), PO3 (3), PO4 (3), PO5 (3), PSO1 (3), PSO2 (1) PSO3 (2)
CO2	To identify contaminations in cell culture and appraise the importance of animal cell culture techniques in the development of drug, cell and gene therapy.	PO1 (2) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1 (3), PSO3 (1)
CO3	To make use of the concept about molecular techniques and tools in animal conservation	PO1 (3) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1 (3), PSO3 (1)
CO4	To examine different methods used to deliver and manipulate genes in desired cells. Knowledge about 2D and 3D culture.	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (3), PSO1 (2), PSO2 (3)
CO5	To apply the principle of gene targeting methods used in the generation of animal models for biomedical research.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (1), PSO1 (2), PSO2 (2)

Course Contents

Module I

Introduction to basic tissue culture techniques; chemically defined and serum free media; animal cell cultures, their maintenance and preservation; various types of cultures; suspension cultures, continuous flow cultures, immobilized cultures. Somatic cell fusion; cell cultures as a source of valuable products.

Module II

Information about organs; culture techniques and preservations. Mammalian cell culture in 2D and 3D. 3D culture platforms (scaffolds, scaffold-free spheroids, gels, bioreactors, and

microchips) and 3D printing techniques (particulate leaching, electro-spinning, etc. are used to prepare various 3D platforms.

Module III

Bacterial and viral diseases in animals; monoclonal antibodies and their use in diagnosis; molecular diagnostic techniques like PCR, in-situ hybridization; northern and southern blotting; RFLP. Recombinant cytokines and their use in the treatment of animal infections; monoclonal antibodies in therapy; vaccines and their application in animal infections; gene therapy for animal diseases.

Module IV

Introduction to stem cell culture, definition, properties, proliferation, culture of stem cells. Types of stem cells, embryonic stem cell, adult stem cell, stem cell biology and therapy. Potential benefits of stem cell technology, medical applications of stem cells, ethical and legal issues in use of stem cells

Module V

What is micromanipulation technology; equipment's used in micromanipulation; enrichment of x and y bearing sperms from semen samples of animals; artificial insemination and germ cell manipulation; invitro fertilization and embryo transfer; micromanipulation technology and breeding of farm animals. Concepts of transgenic animal technology; strategies for the production of transgenic animals and their importance in biotechnology; stem cell cultures in the production of transgenic animals

Practice:

1. Animal handling and care.
2. Drug-induced diabetic study.
3. Liver function test (Alanine transaminase (ALT), Aspartate aminotransferase (AST), Alkaline phosphatase (ALP), Gamma-glutamyltransferase (GGT), Bilirubin, Albumin) between the control and diseased animal.
4. Gel electrophoresis.
5. PCR

Text Books

1. Animal biotechnology by P.Ramadas
2. Embryonic stem cells by Kursad and Turksen. 2002. Humana Press.
3. Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour, Laboratory Press
4. Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler, Jonathan Leo, Springer

Reference Books

1. Louis-Marie Houdebine, Transgenic animals: Generation and Use 7th Edition, CRC Press.
2. Stem Cells Handbook: Stewart Sell, Humana Press; Totowa NJ, USA; Oct. 2003,
3. Human Embryonic Stem Cells: The Practical Handbook by Stephen Sullivan and Chad A Cowan.

Plant Biotechnology

Subject Name	Code	Type of course	T-P-Pr (Credit)
Plant Biotechnology	CUTM1439	Theory+ practice	3-1-0 (04)

Course objectives

<ul style="list-style-type: none"> To understand the basics of tissue culture, its practices and apply knowledge of cellular differentiation and totipotency in plant tissue culture and regeneration. To learn the principles of vector-mediated gene transfer and Agrobacterium-mediated genetic transformation in plants, and to optimize protocols for gene transfer. To develop and apply genetic engineering techniques, for improved plant variety development and to design edible vaccines and long-shelf-life plants.
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Course outcome

At the end of the course the student will be able to:

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Learn to propagate plants, conduct research, develop disease-free germplasm and advance agricultural and horticultural practices	PO1 (1) , PO2 (3), PO3 (3), PO4 (3), PO5 (3), PSO1 (3)
CO2	Understand different genetic manipulation techniques, to create genetically modified plants, enhance crop traits, and address agricultural challenges	PO1 (2) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO2(3)
CO3	Make use of the enhanced agricultural practices, with advanced knowledge in introducing foreign DNA into plant by utilizing a variety of gene transfer techniques for development of an improved variety	PO1 (3) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO3(2)
CO4	Discovering the knowledge and skills in designing, developing, and evaluating genetically modified plants for enhanced disease resistance	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO8 (2)
CO5	Evaluating the gene function, mechanisms and skills to manipulate gene expression using techniques like RNA interference (RNAi) in plants.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (1), PSO3(3)

Module I

History, scope, concept of cellular differentiation and Totipotency, Cell culture media and sterilization techniques, Callus culture, nodal and tip culture, Protoplast and Embryo culture, Embryo culture and embryo rescue, protoplast isolation, culture and plant regeneration

Module II

Applications of Plant Tissue Culture: Somatic embryogenesis, Somaclonal variation and crop improvement, Germplasm conservation, Production of Secondary metabolites through Tissue culture, Industrial applications.

Module III

Recombinant DNA technology: Genomic DNA & plasmid DNA isolation and purification, construction of recombinant DNA and expression cassettes, Transformation (mobilization of vectors into competent bacteria), selection and analysis of recombinant clones, genomic DNA and cDNA libraries.

Module IV

Genetic Engineering in Plants: Vector mediated Gene transfer, Molecular basis of crown gall and hairy root diseases, features of Ti and Ri plasmids, mechanism of T-DNA transfer, role of virulence genes, vectors based on PTi & PRi, binary and co-integrate vectors, optimized protocols for Agrobacterium-mediated genetic transformation, physical and chemical methods of gene transfer.

Module V

Methods of Gene transfer in plants: Direct gene transfer methods (particle bombardment/ micro projectile / biolistic, electroporation, microinjection, liposome mediated, silicon carbide fibers), chemical methods (PEG - mediated, calcium phosphate co-precipitation), transgenic monocots and dicots via direct gene transfer, in plant transformation. Integration and fate of transgene, precision of transgene integration by site-specific.

Module VI

Applications of Genetic Engineering: Transgenic plants for disease resistance, nutritional improvement, herbicide tolerance, Long shelf life, edible vaccines.

Module VII

Gene silencing in plants: Antisense RNA technology: Antisense RNA, construction of antisense vectors, applications of antisense technology. Gene silencing: causes (DNA methylation, homology-dependent suppression by antisense gene), strategies for avoiding gene silencing, methods of inducing gene silencing and its application. Regulatory RNA molecules (si RNA and miRNA), RNAi technology and its applications in plants. CRISPR/Cas technology and its applications in plants.

Practice

1. Preparation of tissue culture media
2. Direct Organogenesis: Shoot tip culture
3. Protoplast isolation
4. Micro propagation of plants
5. *Agrobacterium tumefaciens* mediated transformation of tobacco leaves
6. Demonstration of biolistic method of gene transfer through photographs

Text Books

1. Satyanarayana, U. (2020), Biotechnology, Elsevier
2. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick (2017). Lewin's Genes XII.
3. Jeremy W. Dale , Malcolm von Schantz , Nicholas Plant (2011). From Genes to Genomes: Concepts and Applications of DNA Technology

Reference Books

1. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Human Press, Totowa NJ. 2002.
2. Richard J. Reece. Analysis of Genes and Genomes. 2003.

Environmental Science

Subject Name	Code	T-P-Pr (Credit)	Prerequisite
Environmental Science	CUTM1674	3-0-1 (04)	Nil

Course objectives

- To understand the relationship among human being, natural resource and environment on the historical perspectives.
- To orient students towards the principles of sustainable development goals and train them for conserving Biodiversity and maintaining ecosystem balance.
- To analyze environmental issues and problems critically, and develop strategic environmental management policies and practices.

Course outcome

At the end of the course the student will be able to:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Explain the historical perspectives of human, natural resource and environment interactions.	PO1(2), PO3 (3), PO5 (2), PO10(2), PSO1(2), PSO3(2),
CO2	Identify, classify, and prospect the natural resources integrated with Sustainable Development Goals.	PO1(3), PO2(2), PO3 (1) PO4(2), PO12(1), PSO1(2), PSO3(2)
CO3	Demonstrate their environmental management competency to combat pollution, waste generation and climate change.	PO1(2), PO2(3), PO3(1), PO5(2), PO7(1), PSO1(2), PSO3(2)
CO4	Analyze issues and concerns of Biodiversity conservation and Ecosystem services at local, regional and global scales.	PO1(3), PO2(2), PO5(2), PO8 (2), PSO1(2), PSO3(2), PO11(1)
CO5	Conduct independent project works and address current environmental challenges complying with Environmental agreements, treaties, acts and laws.	PO1(3), PO3 (3), PO9 (2), PO10 (1) PSO1(2), PSO3(2)

Module I

Introduction to Human and the Environment: Overview of human-environment interactions throughout history; Importance of mastery of fire, the origin of agriculture, and the emergence of city-states; Discussion on the impact of ancient civilisations on the environment. Emergence of Environmentalism: Anthropocentric and eco-centric perspectives; Study of significant thinkers and their contributions to environmental philosophy; Environmental movements, Analysis of critical events such as the UN Conference on Human Environment 1972.

Module II

Understanding Natural Resources: Definition and classification of natural resources; Renewable and Non-renewable, Biotic and abiotic resources, Forest, Grasslands, Wildlife, Water, Mineral, Food, Land, Energy; Introduction to sustainable development: Sustainable Development Goals (SDGs), targets and indicators; Discussion on challenges and strategies for achieving sustainability. World commission on Environment and Development.

Module III

Levels and types of Biodiversity, Biodiversity in India and the world, Biodiversity Hotspots, Land Use and Loss of Biodiversity: deforestation, urbanisation, desertification; trends in biodiversity loss; Case studies on the impact of human activities on biodiversity hotspots. Conservation of Biodiversity and Ecosystems: Understanding biodiversity and its distribution; Discussion on major ecosystem types: forests, grasslands, agriculture, coastal and marine and their characteristics; Ecosystem services: Classification and significance; Exploration of threats to biodiversity and ecosystems; in-situ and ex-situ conservation, protected areas, traditional knowledge, sacred groves, community based conservation.

Module IV

Pollution and its impact; Overview of pollution: air, water, soil, noise, solid waste, hazardous waste; Discussion on transboundary pollution and its consequences; Understanding environmental issues at micro, meso, synoptic, and planetary scales; Case studies highlighting the adverse effects of pollution on human health and ecosystems. Addressing Environmental Pollution and Health: Strategies for pollution control and management; Examination of air, water, soil, and noise pollution and their health impacts; Introduction to waste management practices and their significance. Introduction to environmental management systems such as ISO 14001 and the role of organizations like UNEP and IPCC in global environmental governance; Case studies on the implementation of environmental policies and regulations in different contexts.

Module V

Introduction to environmental laws and regulation: Constitutional provisions - Article 48A, Article 51A(g) and other derived environmental rights; Introduction to environmental legislations on the forest, wildlife and pollution control: The Wild Life (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; The Biological Diversity Act, 2002; Noise Pollution (Regulation and Control) Rules, 2000; National Green Tribunal; Climate Change policies, Greenhouse gas emissions and their impact on global climate; Climate change mitigation measures and practices: UNFCCC, Concept of NET ZERO. Environmental Treaties: Major international environmental

agreements, conventions and their significance: CBD, CITES, UNCCD, Analysis of India's status and commitments under these agreements.

Suggested readings

- Rajagopalan, R. (2011). *Environmental Studies: From Crisis to Cure*. India: Oxford University Press.
- Sinha, N. (2020) *Wild and Wilful*. Harper Collins, India.
- Krishnamurthy, K.V. (2003) *Textbook of Biodiversity*, Science Publishers, Plymouth, UK.
- Kanchi Kohli and Manju Menon (2021). *Development of Environment Laws in India*, Cambridge University Press.
- Ministry of Environment, Forest and Climate Change (2019). *A Handbook on International Environment Conventions & Programmes*. <https://moef.gov.in/wpcontent/uploads/2020/02/convention-V-16-CURVE-web.pdf>
- Headrick, Daniel R. (2020). *Humans versus Nature- A Global Environmental History*, Oxford University Press.
- Chiras, D. D and Reganold, J. P. (2010). *Natural Resource Conservation: Management for a Sustainable Future*. 10th edition, Upper Saddle River, N. J. Benjamin/Cummins/Pearson.
- Harper, Charles L. (2017). *Environment and Society, Human Perspectives on Environmental Issues* 6th Edition. Routledge.
- Jackson, A. R., & Jackson, J. M. (2000). *Environmental Science: The Natural Environment and Human Impact*. Pearson Education.
- Pittock, Barrie (2009) *Climate Change: The Science, Impacts and Solutions*. 2nd Edition. Routledge.