University of Kerala

University of Kerala - Four Year Under Graduate Programme (UOK-FYUGP)

Syllabus for
Bachelor of Science in
BIOTECHNOLOGY

2024 April

Aim and objective

The Four Year Degree Programme (FYUGP) in **b**iotechnology as one of the core subjects is designed to develop a scientific temperament to find out technological interface in modern areas of biotechnology to achieve its goal at applied level. It will help the students to become critical and curious in their outlook about modern Biotechnology. The courses are designed to impart the essential basics in biotechnology as well as its advanced fields.

The various courses in the programme is aimed to develop proficiency in the theory as well as practical experiments to achieve the goal of this course in applied as well as research level. The course structure will encompass usage of common equipments, laboratory experiments, individual or group projects along with case study reports and preparation of research proposals at advanced level to exploit the cognitive level of students at its maximum heights. The students will be equipped with knowledge in the modern areas of biotechnology and its application in medical science, agriculture, industry, proteomics, genomics, bioinformatics, nanobiotechnology etc. Apart from understanding biotechnology and its potential in developing the nation, it will create awareness about the socio, ethical and environmental aspects of the course also. This will help in eliminating public fear about the contribution of biotechnology and confusion of this subject at applied levels. Students, who pursue this programme pass out successfully, will surely have an urge to continue higher studies in biotechnology and potential to explore industrial areas to achieve significantly in their career development.

Graduate Attributes

Graduate attributes bridge the gap between academia and the real world, fostering lifelong learning and meaningful contributions. They denote the skills, competencies and high-level qualities that a student should acquire during their university education. Apart from gathering content knowledge, these attributes go beyond the assimilation of information to its application in various contexts throughout a graduate's life. It aims in inculcating the art of critical thinking, problem solving, professionalism, leadership readiness, teamwork, communication skills and intellectual breadth of knowledge. The University of Kerala envisages to pave the path in guiding the student's journey to shape these attributes uniquely, making them integral to personal growth and success in various spheres of life. The University strives to ensure that these graduate attributes are not just checkboxes, but they play a pivotal role in shaping the students into capable, compassionate and responsible individuals with a high degree of social responsibility.

Programme Outcomes (PO)

No.	Programme Outcomes (POs)
PO-1	**Critical thinking** ○ analyze information objectively and make a reasoned judgment ○ draw reasonable conclusions from a set of information, and discriminate between useful and less useful details to solve problems or make decisions ○ identify logical flaws in the arguments of others ○ evaluate data, facts, observable phenomena, and research findings to draw valid and relevant results that are domain-specific
PO-2	**Complex problem-solving** ○ solve different kinds of problems in familiar and no-familiar contexts and apply the learning to real-life situations ○ analyze a problem, generate and implement a solution and to assess the success of the plan ○ understand how the solution will affect both the people involved and the surrounding environment
PO-3	**Creativity** ○ produce or develop original work, theories and techniques ○ think in multiple ways for making connections between seemingly unrelated concepts or phenomena ○ add a unique perspective or improve existing ideas or solutions ○ generate, develop and express original ideas that are useful or have values
PO-4	**Communication skills** ○ convey or share ideas or feelings effectively ○ use words in delivering the intended message with utmost clarity ○ engage the audience effectively ○ be a good listener who are able to understand, respond and empathize with the speaker ○ confidently share views and express himself/herself
PO-5	**Leadership qualities** ○ work effectively and lead respectfully with diverse teams ○ build a team working towards a common goal ○ motivate a group of people and make them achieve the best possible solution. ○ help and support others in their difficult times to tide over the adverse situations with courage

PO-6	**Learning 'how to learn' skills** ○ acquire new knowledge and skills, including 'learning how to learn skills, that are necessary for pursuing learning activities throughout life, through self-paced and self-directed learning ○ work independently, identify appropriate resources required for further learning ○ acquire organizational skills and time management to set self-defined goals and targets with timelines ○ inculcate a healthy attitude to be a lifelong learner
PO-7	**Digital and technological skills** ○ use ICT in a variety of learning and work situations, access, evaluate, and use a variety of relevant information sources ○ use appropriate software for analysis of data ○ understand the pitfalls in the digital world and keep safe from them
PO-8	**Value inculcation** ○ embrace and practice constitutional, humanistic, ethical, and moral values in life including universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values ○ formulate a position/argument about an ethical issue from multiple perspectives ○ identify ethical issues related to work, and follow ethical practices, including avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data, or committing plagiarism, and adhering to intellectual property rights ○ adopt an objective, unbiased, and truthful actions in all aspects of work

Program Specific Outcomes (PSO)

After successfully completing the course students will be able to:-

Programme Specific Outcomes (PSO)

Upon completion of the programme the graduate will be able to

No.	PO	PO No.
PSO-1	Develop basic understanding of the various streams of biotechnology. Apply the knowledge in the modern areas of biotechnology such as medical science, environment, agriculture, industry, proteomics, genomics, computational biology, bioinformatics, nanobiotechnology etc.	
PSO-2	Understand biotechnology and its power to develop scientific temperament, ethical and social responsibilities in students.	
PSO-3	As biotechnology is an interdisciplinary course students acquire technological skilfulness by connecting disciplinary and interdisciplinary aspects of Biotechnology. Student project helps in creating analytical thinking and interpreting the inference. Enhance practical skills and competency in students to conduct experiments in Biotechnology	
PSO4	Pursue higher studies in Biotechnology and contribute significantly in its development. Inculcate skill to organize scientific events and effective communication. Ascertain their area of interest in research	
PSO5	Be able to address challenges in industrial and research areas with socio-ethical responsibilities. Inculcate entrepreneurial skills to explore possibilities in Biotechnology with social outlook	

The University of Kerala FYUGP has a student centric approach in which the student can choose their pathway for learning. On successful attainment of minimum credits of 133 in a three year period, a student shall be awarded an Undergraduate Degree. Ina four year period , the student can successfully attain 177 credits and shall be awarded with either Undergarduate Honours Degree or Undergraduate Honours with Research Degree. The student can acquire credits through the following categories of courses.

1. **Discipline Specific Core courses(DSC)**
2. **Discipline Specific Elective Courses)DSE)**
3. **General Foundation Courses**
   1.Multidisciplinary courses(MDC)
   Ability Enhancement course (AEC)
   Value addition course(VAC)
   Skill enhancement courses(SEC)

DSC courses are the core credit courses in a particular discipline. Student may choose DSC courses as their major or Minor course of study

Credit means the value assigned to a course which indicate the level of instruction. One hour lecturer per week equals 1 credit, 2 hours practical class per week equals 1 credit

Students who secure at least 75% of marks in all six semesters can choose Under graduate Honours with Research stream in the fourth year.

It is mandatory for all the students who enrol for a four year UG programme to acquire 39 credit from 13 general foundation courses. It should be completed within first three years of FYUGP.

The various courses and its corresponding credits are depicted in the following table.

Summary of courses

SI No	Subject Specific Coded	study components	credits/ course	Theory hours/tutorial week	Mode of Study	Practical	
						Essential experiments/ week	Individual/Group work /week
SEMESTER I							
Discipline Specific Core 100-199 Level-A1(P)							
1	UK1DSCBIT100	**Essentials of Biotechnology**	4	3	Offline	1	1
2	UK1DSCBIT101	Environmental Studies	4	3	Offline	1	1
3	UK1DSCBIT102	IT for Biological science	4	3	Offline	1	1
4	UK1DSCBIT103	Fundamentals of Biotechnology	4	3	Offline	1	1
5	UK1DSCBIT104	Food and nutrition	4	3	Offline	1	1
6	UK1DSCBIT105	Chemistry for life sciences-I	4	3	offline	1	1
Multidisciplinary Courses 100-199							
1	UK1MDCBIT100	Emerging pandemics & infectious diseases	3	3	Offline	-	-
2	UK1MDCBIT101	Innovations in Biotechnology	3	3	Offline	-	-
3	UK1MDCBIT102	Nutrition and Health	3	3	Offline	-	-
SEMESTER 2-A2(P)							
Discipline Specific Core 100-199 Level							
1	UK2DSCBIT106	**Biomolecules**	4	3	Offline	1	1
2	UK2DSCBIT107	Elements of biology	4	3	Offline	1	1
3	UK2DSCBIT108	Chemistry for life sciences-II	4	3	Offline	1	1
4	UK2DSCBIT109	Fundamentals of Microbiology	4	3	Offline	1	1
5	UK2DSCBIT110	Basics of Cell biology	4	3	Offline	1	1
6	UK2DSCBIT111	Environmental microbiology, biodiversity and conservation	4	3	Offline	1	1

7	UK2DSCBIT112	Biomathematics	4	4	Online-NPTEL		
Multidisciplinary Courses 100-199							
1	UK2MDCBIT103	Biofuel technology	3	3	Offline	-	-
2	UK2MDCBIT104	Food safety, preservation and quality management	3	3	Offline	-	-
3	UK2MDCBIT105	Life style disease and management	3	3	Offline	-	-
SEMESTER 3							
Discipline Specific Core 200-299 Level A3(P)							
1	UK3DSCBIT200	Biomolecules and metabolism	4	3	Offline	1	1
2	UK3DSCBIT201	**Microbiology**	4	3	Offline	1	1
3	UK3DSCBIT202	Basics of Enzymology	4	3	Offline	1	1
4	UK3DSCBIT203	Microbial Metabolism	4	3	Offline	1	1
5	UK3DSCBIT204	plant physiology	4	3	Offline	1	1
6	UK3DSCBIT205	Animal Physiology	4	3	Offline	1	1
Discipline Specific Elective courses 200-299 DSE-1							
1	UK3DSEBIT200	**Biophysics and instrumentation**	4	4	Offline	-	-
2	UK3DSEBIT201	Enzyme engineering	4	4	offline		
3	UK3DSEBIT202	Introduction to marine Biotechnology	4	4	Offline		
4	UK3DSEBIT203	Biomolecular interactions and cell signalling	4	4	offline		
Value Added Courses 200-299							
1	UK3VACBIT200	IPR,Bioethics and Biosafety	3	3	Offline	-	-
SEMESTER 4							
Discipline Specific Core 200-299 Level A4(P),A5(P)							
1	UK4DSCBIT206	**Cell biology & Genetics**	4	3	Offline	1	1
2	UK4DSCBIT207	**Molecular Biology**	4	3	Offline	1	1
3	UK4DSCBIT208	Developmental Biology	4	3	Offline	1	1
4	UK4DSCBIT209	Metabolism and Energetics	4	3	Offline	1	1
Discipline Specific Elective courses 200-299, DSE2							
1	UK4DSEBIT204	Bioinformatics	4	3	Offline	1	1
2	UK4DSEBIT205	Microbial Metabolism	4	3	Offline	1	1
Value Added Courses 200-299							
1	UK4VACBIT201	Good Laboratory Practices and Quality	3	3	Offline	-	-

		Control in Biotechnology					
2	UK4VACBIT202	Environmental Monitoring and Assessment	3	3	Offline	-	-
Skill Enhancement Courses 200-299							
1	UK4SECBIT200	**B**ioassessment and Biomonitoring	3	3	Offline	-	-
2	UK4SECBIT201	Basics of phytochemistry and medicinal plant-based industry	3	3	Offline	-	-
UK4INTBIT200 Summer Inernship -3 credit							
SEMESTER 5							
Discipline Specific Core Level 300-399- A6(P),A7,A8							
1	UK5DSCBIT300	Recombinant DNA technology	4	3	Offline	1	1
2	UK5DSCBIT301	Food and Industrial Biotechnology	4	4	Offline	-	-
3	UK5DSCBIT302	Immunology	4	4	Offline	-	-
	UK5DSCBIT303	Ethnobotany and medicinal botany	4	3	Offline	1	1
Discipline Specific Elective courses 300-399, DSE3(P), DSE4							
1	UK5DSEBIT300	Genomics and proteomics	4	4	offline		-
2	UK5DSEBIT301	Molecular diagnostics	4	3	Offline	1	1
3	UK5DSEBIT302	Nanobiotechnology	4	3	Offline	1	1
4	UK5DSEBIT303	Cancer biology	4	3	Offline	1	1
5	UK5DSEBIT304	Microbial metabolism	4	3	Offline	1	1
6	UK5DSEBIT305	General virology	4	3	Offline	1	1
7	UK5DSEBIT306	Food microbiology	4	3	Offline	1	1
8	UK5DSEBIT307	Marine biotechnology	4	3	Offline	1	1
9	UK5DSEBIT308	Agriculture biotechnology	4	3	Offline	1	1
10	UK5DSEBIT309	Microbial diversity and phytopathology	4	3	Offline	1	1
11	UK5DSEBIT310	Pharmaceutica lbiotechnology - -	4	3	Offline	1	1
Skill enhancement Courses 300-399							
1	UK5SECBIT300	Plant Tissue Culture Entrepreneurship	3	3	Offline	-	-
2	UK5SECBIT301	Entrepreneurship in Biotechnology	3	3	Offline	-	-
SEMESTER 6							

Discipline Specific Core Level 300-399- A9(P),A10,A11							
1	UK6DSCBIT304	Animal Biotechnology	4	4	Offline	-	-
2	UK6DSCBIT305	Plant Biotechnology	4	3	Offline	1	1
3	UK6DSCBIT306	Environmental Biotechnology	4	4	Offline	-	-
Discipline Specific Elective courses 300-399, DSE5(P), DSE6							
1	UK6DSEBIT311	Industrial Regulatory Affairs	4	3	Offline	1	1
2	UK6DSEBIT312	Food safety, Preservation and Quality management	4	3	Offline	1	1
3	UK6DSEBIT313	Microbiome Studies	4	3	Offline	1	1
4	UK6DSEBIT314	Microbial metabolites	4	4	Offline	-	-
5	UK6DSEBIT315	Cancer therapeutics	4	4	Offline	-	-
6	UK6DSEBIT316	Tumour immunotherapy	4	3	Offline	1	1
7	UK6DSEBIT317	Pharmacogenomics and Pharmacovigilence	4	4	Offline	-	-
8	UK6DSEBIT318	Pharmabiologics	4	3	Offline	1	1
9	UK6DSEBIT319	Marine biodiversity	4	4	offline	-	-
10	UK6DSEBIT320	Marine natural products	4	4	offline	-	-
11	UK6DSEBIT321	Marine bioremediation	4	3	Offline	1	1
12	UK6DSEBIT322	Vaccine technology	4	4	offline	-	-
13	UK6DSEBIT323	Advanced studies in antivirals	4	3	Offline	1	1
14	UK6DSEBIT324	Advanced food preservation technology	4	4	offline	-	-
15	UK6DSEBIT325	Functional foods, Neutraceuticals and Neutrigenomics	4	4	Offline	-	-
16	UK6DSEBIT326	Datascience and biotechnology	4	4	Online	-	-
17	UK6DSEBIT327	Clinical research and data management	4	3	Offline	1	1
18	UK6DSEBIT328	Introduction to Forensic biotechnology	4	3	Offline	1	1
19	UK6DSEBIT329	Chemical ecology	4	3	Offline	1	1
Skill enhancement Courses 300-399							
1	UK6SECBIT302	Datascience and biotechnology	3	3	Offline	--	-

2	UK6SECBIT303	Clinical research and data management	3	3	Offline	-	-
3	UK6SECBIT304	Biopolymer Technology	3	3	Offline	-	-
4	UK6SECBIT305	Python programming	3	3	Online NPTEL	-	-
5	UK7SECBIT306	Industrial Regulatory Affairs	3	3	Offline	-	-
SEMESTER 7							
Discipline Specific Core Level 400-499- A12(P),A13(P) capstone							
1	UK7DSCBIT400	stem cell technology and regenerative medicine	4	3	Offline	1	1
2	UK7DSCBIT401	Introduction to metabolic engineering	4	3	Offline	1	1
3	UK7DSCBIT402	Gene Therapy and gene editing Technolgies	4	3	Offline	1	1
Discipline Specific Elective courses 400-499, DSE7							
1	UK7DSEBIT400	Research methodology and Biostatistics	4	4	offline	-	-
SEMESTER 8							
MOOC Courses A-14, A-15							
1	UK8DSCBIT403				online		
2	UK8DSCBIT404				online		
Project							
1	UK8CIPBIT400	Internship Project for UG Honours					
2	UK8RPHBIT400	Research Project for UG Honours with Research					
SPECIALIZATIONS IN BIOTECHNOLGY							
	PharmaBiologics						
	UK5DSEBIT301	Genomics and proteomics	4	3	1	-	-
	UK5DSEBIT310	Pharmaceutical biotechnology	4	2	1	1	1
	UK6DSEBIT328	pharmacogenomics and pharmacovigilence	4	3	1	-	-
	UK6DSEBIT318	PharmaBiologics	4	2	1	1	1
	Clinical research and data management						

	UK4DSEBIT204	Bioinformatics	4	3	1	1	1
	UK5DSEBIT301	Genomics and proteomics	4	3	1	-	-
	UK6SECBIT302	Datascience and biotechnology	4	3	2	-	-
	UK6DSEBIT327	Clinical research and data management	4	2	1	1	1
	Marine Bioproducts						
	UK4DSEBIT204	Biophysics and instrumentation	4	3	1	-	-
	UK5DSEBIT307	Marine biotechnology	4	2	1	1	1
	UK6DSEBIT319	Marine Biodiversity	4	3	1	-	-
	UK6DSEBIT320	Marine Bioproducts	4	2	1	1	1
	Cancer Therapeutics						
	UK5DSEBIT300	Genomics and proteomics	4	3	1	-	-
	UK5DSEBIT303	Cancer biology	4	2	1	1	1
	UK6DSEBIT315	Cancer Therapeutics	4	3	1	-	-
	UK6DSEBIT316	Tumour Immunotherapy	4	3	1	-	-
	Molecular diagnostics and Therapeutics						
	UK5DSEBIT301	Genomics and proteomics	4	3	1	-	-
	UK5DSEBIT300	Molecular diagnostics	4	3	1	-	-
	UK6DSEBIT315	Cancer Therapeutics	4	2	1	1	1
	UK6DSEBIT322	Vaccine Technology	4	3	1	-	-
	UK6DSEBIT323	Advanced Studies in Antivirals	4	2	1	1	1
	Functional foods, neutraceuticals and neutrigenomics						
	UK5DSEBIT301	Genomics and proteomics	4	3	1	-	-
	UK5DSEBIT306	Food microbiology	4	2	1	1	1
	UK6DSEBIT324	Advanced food preservation technology	4	2	1	1	1
	UK6DSEBIT312	Food safety, Preservation and Quality management	4	2	1	1	1
	UK6DSEBIT325	Functional foods, neutraceuticals and neutrigenomics	4	3	1	-	-

SEMESTER I

Discipline Specific Core 100-199 Level-A1(P)

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<table>
<tr><td>Discipline</td><td colspan="5">BIOTECHNOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK1DSCBIT100</td></tr>
<tr><td>Course Title</td><td colspan="5">ESSENTIALS OF BIOTECHNOLOGY</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">I</td></tr>
<tr><td>Academic Level</td><td colspan="5">100 - 199.</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>2 hours</td><td>1</td><td>2 hours</td><td>5</td></tr>
</table>

Pre-requisites	Basic knowledge in life sciences
Course Summary	This course provides a summary of the essential concepts, methodologies, applications, and implications of biotechnology. Students will comprehend the fundamental principles underlying various domains like plant, animal, environmental, food, and industrial biotechnology and their significance in advancing scientific understanding, technological innovation, and societal progress.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Overview of Biotechnology**	**5**
	1	Historical perspectives and Milestones, Scope and significance of Biotechnology, Major Areas of Biotechnology (Red, White, Green and Blue Biotechnology),	
	2	Commercial potential of Biotechnology, Biotechnology in India, and its global trends	
	3	Major Biotechnology institutes and companies in India.GenenTech , Bocon case study	
II		**Gene & Genetic Engineering**	**9**
	4	DNA as genetic material, Central dogma, Concept of Gene	
	5	Genetic Engineering: Definition, Steps involved, A brief account on Tools - Restriction Enzymes, DNA Ligases, Plasmid as vectors (pBR 322).prediction of biological phenomena-Alfa fold2 case study	
III		**Plant, Animal and Environmental Biotechnology**	**12**
	6	Transgenic Plants – Agricultural Applications -Herbicide tolerant crops (Glyphosate resistant), Insect resistant crops (Bt cotton), Nutritionally improved crops (Golden Rice), Shelf-life improved crop (Flavr Savr) and Non-agricultural Applications - Bio-Pharming	
	7	Transgenic Animals - Applications - Production of therapeutic proteins (ATryn Cow), Environment friendly Farm animals (Enviro pigs), Production of silk (Spider goat)	
	8	Bioremediation - Bacteria for oil spill clean-up, Heavy metal remediation Bioenergy Production -Biogas, Bioethanol, Biodiesel Bioplastics – PHB and its applications	
	9	Overview – synthetic genome,Biomimetics,Artificial Life,Unconventional Molecular Biology	
	10	Brief- Insilico Biology, SciFi Foods,Cellular agriculture, Artificial Intelligence in Biotechnology,Space exploration biology	
IV		**Food and Industrial Biotechnology**	**10**

	11	Microbial Fermentation in Food Production: Fermented Foods (Yogurt, Cheese) and Beverages (Beer, Wine), SCP-	
	12	Microbial production of Antibiotics (Penicillin), Vitamins (B12), Amino acids (Glutamic acid), Organic acids (Citric acid), Enzymes (Protease and Amylase), Applications of Hybridoma technology	
V		**Ethical issues in Biotechnology**	**9**
	13	Ethical considerations in biotechnological research and applications, Public perception and acceptance of Biotechnology, Regulatory frameworks, and implications, Dark Biotechnology	

Practicum (30 Hours)-[Essential Experiments(15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1) Awareness on safety Precautions and Good Laboratory Practices
2)Introducing Laboratory Instruments: Microscope, pH meter, Colorimeter, Centrifuge, Incubator, Shaker and Stirrer, Autoclave, Water Bath, LAF, Gel Electrophoresis Systems
3)Preparation of agarose gel for gel electrophoresis.
4)Set up small-scale fermentation experiments using yeast cultures and appropriate growth media.
5) Produce fermented food products such as yogurt using starter cultures

Suggested Readings:

1. Introduction to Genetic Engineering & Biotechnology (2008), Nair, A.J., Infinity Science Press.
2. Biotechnology Expanding Horizons (5^{th} edn. 2023), B.D. Singh, MedTech Science Pres
3. Principles of gene manipulation (6^{th} edn.), S.B. Primrose, R.M. Twyman & R.W. Old, Blackwell pub.
4. Gene Cloning & DNA Analysis: An introduction (8^{th} edn), T.A. Brown, Wiley Blackwell pub
5. Advanced Biotechnology (2014), R.C. Dubey, S. Chand Publication
6. Plant Biotechnology: The genetic manipulation of plants (2^{nd} edn), Adrian Slater, Nigel Scott & Mark Fowler, Oxford pub.
7. Biotechnology (2005), U. Satyanarayana & U. Chakrapani, Books & Allied Pub Pvt.Ltd
8. Introduction to Biotechnology & Genetic engineering (2010), Nair, AJ, Johns & Bartlett Pub, Boston USA.
9. Industrial Microbiology (2^{nd} edn.), L.E.J.R. Casida, New Age International P.
10. X) Principles and techniques of Biochemistry & Molecular Biology (7^{th} edn.) edited by Keith Wilson & John Walker, Cambridge University Press.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Understand the history and scope of biotechnology and differentiate among the classes of biotechnology	U	PSO-1,2
CO-2	Describe the various tools, techniques used in genetic engineering and understand the molecular basis of life	R, U	PSO-1,4
CO-3	Understand the applications of biotechnology in environment, and associate with applications of transgenic plants and animals	U, E	PSO-1,2,3
CO-4	Identify the various tools and techniques used for basic biotechnological studies and applications	U, Ap	PSO-3,5
CO-5	Compare and contrast the various bioprocess technologies in manufacturing of industrial products and understands ethical implications of biotechnology	U	PSO-1,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Essentials of Biotechnology
Credits: 2:1:2 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	Understand the history and scope of biotechnology and differentiate among the classes of biotechnology	PO-1 PSO-1,2	U	F	L	
2	Describe the various tools, techniques used in genetic engineering and understand the molecular basis of life	PO-3 PSO-1,4	R, U	F, C	T	
3	Understand the applications of biotechnology in environment, and associate with applications of transgenic plants and animals	PO-1,2 PSO-1,2,3	U, E	F, C	L	

4	Identify the various tools and techniques used for basic biotechnological studies and applications	PO-6 PSO-3,5	U, Ap	F, P		P
5	Compare and contrast the various bioprocess technologies in manufacturing of industrial products and understands ethical implications of biotechnology	PO-3,8 PSO-1,5	U	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	-	-	-	3	-	-	-	-	-	-	-
CO 2	2	-	-	1	-	-	-	2	-	-	-	-	-
CO 3	2	3	1	-	-	2	1	-	-	-	-	-	-
CO 4	-	-	1	-	5	-	-	-	-	-	2	-	-
CO 5	1	-	-	-	3	2	-	1	-	-	-	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium

3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

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Discipline	BIOTECHNOLOGY				
Course Code	UK1DSCBIT101				
Course Title	ENVIRONMENTAL STUDIES				
Type of Course	DSC				
Semester	I				
Academic Level	100 - 199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in Life sciences				
Course Summary	Students should acquire a basic understanding about the structure function of the environment and its interaction with the living systems. It will impart the				

	geographical distribution of plants and the impact of human intervention in the environment and the delicate balance of various factors in the environment. It gives an idea about the various types of biodiversity and the influence of environmental pollution on the biodiversity

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Society and Environment**		**6**
	1	Definition and scope of environmental studies, Historical perspectives and milestones in environmental awareness, Interdisciplinary nature of environmental science, Ethics and values in environmental decision-making.	
	2	Natural Resources- Renewable and non-renewable resources. Forest resources: Use and over exploitation. Deforestation, Mineral resources: Use and exploitation, Environmental effects of extracting and using mineral resources , Water resources	
	3	Causes and consequences of climate change,Greenhouse gas emissions and their sources, Mitigation and adaptation strategies	
	4	International agreements and policies on climate change (discussions)	
II	**Ecosystems-Concept of an ecosystem**		**10**
	5	Types,structure and function of an ecosystem, Biotic and abiotic components- Energy flow in an ecosystem.,Ecological succession- Definition & types. Food chains -Food web & ecological Pyramids	
	6	anatomical & physiological adaptations of –Hydrophytes, Xerophytes, Halophytes, Epiphytes, Parasites.	
III	**Biodiversity and its conservation-**		**10**
	7	Introduction – Definition: genetic, species and ecosystem diversity. / Bio-geographical classification of India	
	8	[illegible]	
	9	Case studies on habitat loss, species extinction, and ecosystem degradation	
IV	**Environmental pollution**		**10**

	10	Types of pollution: air, water, soil, noise, and light, Sources and effects of pollution on human health and ecosystems, Waste generation, disposal, and recycling, Environmental legislation and regulations.	
	11	Solid waste Management	
	12	Scientific methods in environmental studies,-Environmental monitoring and assessment techniques, Remote sensing and GIS applications in environmental research	
V	**Sustainable Development-**		**9**
	13	Principles of sustainable development,Sustainable resource management: energy, water, land, Sustainable agriculture and food systems, Green technologies and innovations	
	14	Environmental Policy and Governance- Policy-making processes and stakeholders, Environmental law and regulations,Environmental impact assessment Case studies on successful environmental policies and initiatives	

Practicum (30 Hours)-[Essential Experiments (15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Study of ecological and anatomical modifications of Xerophytes, Hydrophytes, halophytes, epiphytes and Parasites.
2. Study of plant community by quadrat method.
3. Observation and study of different ecosystems mentioned in the syllabus
4. Determination of frequency and density constituent of plant species in a terrestrial community through quadrate and transect (line, belt).
5. Phytogeographical regions of India.

Suggested Readings:

1.Misra SP and Pandey SN, 2009, Essential Environmental studies, Ane Books Pvt. Ltd.

2. Erach Bharucha – Text book of environmental Studies for undergraduate Courses, Universities Press, University Grants Commission

3.Ahluwalia VK and Sunitha Malhotra 2009, Environmental science, Ane Books Pvt. Ltd.

4.Chapman J.L. (2006) Ecology-Principles and Application. Cambridge University Press India Pvt. Ltd

5.Chandoco.S Weaver and Clements – Plant Ecology, McGraw Hill Publications, New York.

6.Verma, P. S. and V. K. Agrawal. 2004. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand & Company Ltd., New Delhi.
7.Prithipal Singh 2007- An Introduction to Biodiversity. Ane Books Pvt. Ltd
8. Verma and Agarwal – Principles of Ecology, S. Chand and Co.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Identify the Scope and relevance to society and human on environment	U	PSO-,2
CO-2	Identify the concept of an ecosystem its structure and function	R, U	PSO2
CO3	Identify the importance of Biodiversity and its conservation	U	PSO-,2
CO4	Evaluate the effect of anthropogenic effect on Environmental pollution	U,Ev	PSO-,2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Environmental studies,Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Identify the Scope and relevance to society and human on environment	PSO-,2	U	F, C	L	

CO-2	Identify the concept of an ecosystem its structure and function	PSO2	R, U	F	L	
CO3	Identify the importance of Biodiversity and its conservation-	PSO-,2	U	F	L	P
CO4	Evaluate the effect of anthropogenic effect on Environmental pollution	PSO-,2	U,Ev	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	-	-	3	-	-		-	-	-	-	-	-	-	2
CO2	-	-	3	-	-		-	-	-	-	-	-	-	

CO 3	-	-	3-	-	-	-	-	-	-	-	-	-	-	3
CO 4	-	-	3	-	-	-	-	-	-	-	-	-	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK1DSCBIT102
Course Title	IT FOR BIOLOGICAL SCIENCE
Type of Course	DSC
Semester	I
Academic Level	100 - 199.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5

Pre-requisites	Basic knowledge in Life sciences
Course Summary	This course introduces fundamental computer science principles and their applications in biological research. The course will explore how information technology is revolutionizing fields like education and biology

Detailed Syllabus:

Module	Unit	Content	Hrs

I	**Overview of Information of Technology**		**6**
	1	Features of modern personal computers and peripherals computer networks and Internet, Internet as knowledge repository. Web page & web designing	
II	**Introduction to wireless Technology**		**10**
	2	Introduction to mobile phone technology and ATM. Overview of Operating systems Major application software- MS OFFICE. Major system software- Compiler Basic concepts of programming: variables, data types, control flow, functions. Introduction to high level languages- Python, SQL, Java	
III	**IT in education & biology**		**10**
	3	Academic Search Techniques Use of IT in teaching and learning- educational softwares, Google scholar, Science direct, INFLIBNET, NICNET, BRNET Academic services- MOOC, SWAYAM. Introduction to major biological databases: GenBank, UniProt, PDB, KEGG Techniques for searching and retrieving biological data from online resources. Data formats and standards for representing biological information (e.g., FASTA, GenBank, PDB formats).	
IV	**Applications of IT**		**10**
	4	IT and Society, Creating your cyber presence, Cyber ethics, Cyber crime, security & privacy issues, Application in medicine, healthcare, Business, Commerce, Industry, Defense, Law, crime detection, publishing, communication, resource management, weather forecasting, film and media, Introduction to Scilab and Matlab	
V	**AI and Data Science**		**9**
	5	Introduction to Artificial Intelligence and Data Science Applications of Data Science in Academics, Biological science	

Practicum (30 Hours)-[Essential Experiments(15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. MS WORD
2. EXCEL
3. PPT
4. AI in EXCEL

Suggested Readings:

1. Bioinformatics Concepts Skills And Applications (2019), Rastogi S. C.,CBS publishers and distributors pvt. ltd
2. Introduction to Computers (2009), Alexis Leon , Mathews Leon , Vikas Publishing
3. Conceptual Integrated Science (2013), Paul G. Hewitt, Suzanne A Lyons, John A. Suchocki, Pearson.
4. Fundamentals of Information Technology (2009), Alexis Leon, Mathews Leon. Tata McGraw Hill Education.
5. Introduction to Information Technology (2018), V. Rajaraman, PHI Learning.
6. Learning Computer Fundamentals PB (2005), Khanna Book Publishing Co. (P) Ltd.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand how the internet works	R, U	PSO-1,2,3
CO-2	Differentiate the types of softwares and basic concept of programming	R, U	PSO -3
CO3	Application of Information technology in education and biology	U, Ap	PSO- 3,4
CO4	How Information technology is utilised in different fields	An, Ap	PSO 3
CO5	Get a basic idea about Data science	U	PSO 4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: IT for Biological Science
Credits: 2:1:2 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	Understand how the internet works	PSO-1,2,3	R, U	F, C	L	
2	Differentiate the types of softwares and their	PSO 3	R, U	P	L	

	application with examples					
3	Application of Information technology in education	PSO 3, 4	U, Ap	F	L	
4	How Information technology is utilised in different fields	PSO 3	An, Ap	F	L	
5	Get a basic idea about Data science	PSO 4	U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	1	1	1	-	-		1	1	-	-	-	-
CO 2	-	-	2	-	-		1	-	1	-	-	-
CO 3	-	-	1	1	-	-	-	1	-	-	-	-
CO 4	-	-	2	-	-	-	1	2	-	-	-	-
CO 5	-	-	-	1	-	-	1	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK1DSCBIT103				
Course Title	FUNDAMENTALS OF BIOTECHNOLOGY				
Type of Course	DSC				
Semester	1				
Academic Level	100 -199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in life sciences				
Course Summary	This course explores the applications of Biotechnology in promoting human welfare. Students will gain a comprehensive understanding about the role of Biotechnology in healthcare, agriculture, environmental conservation, and energy production.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Biotechnology**		6
	1	Biotechnology- Definition, Scope, Historical Development & Milestones	
	2	Key Concepts – Genetic Engineering, Recombinant DNA Technology, Bioprocessing and Fermentation,	
II	**Biotechnology in Agriculture and Food Technology**		10
	3	Biotechnology in Crop improvement, GMOs, Biofertilizer, Biopesticide, Biofortification, Livestock Biotechnology	
	4	Fermentation and Food Processing – Brewing, Baking, Cheese making, Alcoholic Fermentation, Acetic Acid Fermentation, Vitamin Synthesis	
	5	Microbial biotechnology in food preservation and flavour enhancement	
III	**Biotechnology for Environment**		10
	6	Bioremediation- Chlorinated and Non-chlorinated pollutants, Hydrocarbons, Heavy metals, Agricultural wastes Conservation Biotechnology- Cryopreservation of genetic material and Genetic rescue programs	
	7	Bioenergy production- Ethanol, Bio-diesel & Methane Biodegradable Polymer- PHB- Properties, Applications and Production	
IV	**Biotechnology in Forensic Sciences and Health**		10
	8	DNA Profiling/DNA Fingerprinting, Biological Evidence analysis, Forensic Toxicology	
	9	Overview of: Molecular Diagnostics, Gene Therapy, Development of monoclonal antibodies, Recombinant proteins, Vaccines, Overview – synthetic genome,Biomimetics,Artificial Life,Unconventional Molecular Biology Insilico Biology, SciFi Foods,Cellular agriculture, Artificial Intelligence in Biotechnology,Space exploration biology	
V	**Biotechnology in Day-to-day life**		9
	10	Brief account on: Food processing enzymes, Biopharmaceuticals, Personalized medicines, Biodegradable plastics, Biotech Fibres, Enzymatic cleaners	

Practicum (30 Hours)-[Essential Experiments(15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Traditional fermented food production (Pickle/Yogurt)
2. Value added products from Milk (Yogurt/Buttermilk/Condensed milk)
3. Alcoholic fermentation-Demonstration (Wine Production)
4. Design and implement composting for bioremediation of agricultural wastes
5. Field visit (Research institute/Industry) and report submission
6. Organize a Public awareness session on applications of Biotechnology in agriculture
7. Production of Monoclonal Antibody- Virtual Lab
8. DNA Fingerprinting – Virtual Lab

Suggested Readings:

1. Biotechnology Expanding Horizons (2021), B D Singh, Kalyani Publishers
2. Basic Biotechnology (2006, 3rd Edn.), Colin Ratledge and Bjorn Kristiansen, Cambridge
3. Textbook of Biotechnology (2010, 4th Edn.), H K Das, Wiley India
4. Bioethics and Biosafety in Biotechnology (2007,1st Edn.), V Sree Krishna, New Age International Publishers
5. Introduction to Biotechnology (2014, 3rd Edn.), William J Thieman, Michael A Palladino, Pearson
6. Biotechnology in Medical sciences (2017), Firdos Alam Khan, CRC Press
7. Molecular biotechnology: Principles and applications of Recombinant DNA (2009), Bernard R Glick, Jack J Pasternak, and Cheryl L Pattern, ASM Press
8. Biotechnology for beginners (2008), Reinhard Renneberg, Arnold L Demain and Dieter Antranikian, Academic Press.

Course outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the scope of Biotechnology for human welfare and develop an idea about key concepts of Biotechnology	U	PSO-1,2
CO-2	Identify applications and impact of biotechnology on agricultural productivity and food technology	R, U	PSO-1, 4
CO-3	Awareness about the intricate interplay between biotechnological advancements and environmental conservation.	E	PSO-3,5
CO-4	Apply principles of molecular biology, genetics etc to the field of forensic sciences to evaluate and solve real world forensic cases. To address production strategies of value-added milk products and bioremediation of agricultural wastes.	Ap	PSO-3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Biotechnology for Human Welfare

Credits: 2:1:2 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	Understand the scope of Biotechnology for human welfare	PO-1 PSO-1,2	U	F	L	
2	Identify applications and impact of biotechnology on agricultural productivity	PO-3 PSO-1,4	R, U	F, C	L	
3	Awareness about environmental conservation and Biotechnology	PO-6 PSO-3,5	E	C, P	T	
4	Apply principles of molecular biology, genetics etc to the field of forensic sciences	PO-2,6 PSO-3,5	Ap	F, C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	1	-	-	-	2	-	-	-	-	-	-	-
CO 2	1	-	-	3	-	-	-	2	-	-	-	-	-
CO 3	-	-	3	-	3	-	-	-	-	-	1	-	-
CO 4	-	-	2	-	3	-	2	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

.

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK1DSCBIT104				
Course Title	FOOD AND NUTRITION				
Type of Course	DSC				
Semester	I				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in Life sciences				
Course Summary	Introduces food science & inculcates knowledge on the relation between nutrition and health. This course emphasises on the importance of fermented food & promotes the idea of entrepreneurship by implementing various marketing strategies.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to food Science:**	**6**
	1	Importance and scope of food science, Components of food – Carbohydrates, Proteins, Fats, Vitamins, Minerals, Fibre, Water.	
	2	Perishable food types- Milk, Meat, Fish, Poultry	
	3	Semi perishable food types- Fruits, vegetables, fats, oils	
	4	Non perishable food – Cereals, Pulses, Legumes	
II		**Properties of Food:**	**10**
	5	Physicochemical and functional properties of food-	
	6	Colour, Structure, Texture, Rheology and interfacial properties, Thermal properties, pH, acidity, Fat content.	
	7	Characterisation of Food: Analysis of Fatty acids, Oil fat indices	
	8	Characterisation of Proteins, Amino acid Composition and analysis (LC MS)	
III		**Nutrition, Malnutrition and Health:**	**10**
	9	Definition and Scope of Nutrition.	
	10	Minimum Nutritional Requirement: RDA, Factors affecting RDA, formulation of RDA and Dietary Guidelines, Adult consumption unit.	
	11	Energy in Human Nutrition: Idea of Energy and its unit, Energy Balance, Assessment of Energy Requirements—deficiency and excess, Determination of Energy in food, B.M.R. and its regulation, S.D.A.	
	12	Importance of Nutrition for ensuring adequate development	
	13	Growth monitoring and promotion: Use of growth charts and standards, Prevention of growth faltering.	
IV		**Nutritional Benefits of fermented food:**	**10**
	14	Microbiome of food- Milk, Vegetables, Fruits, Meat.	
	15	Role of microbes in food fermentation-	
	16	Fermented foods: Milk- Cheese, Yogurt, Kefir, Koumiss, Kombucha,	
	17	Vegetables- Tempeh, Sauerkraut, Kimchi, Pickles, Miso, Natto	
	18	Beverages- Kvass, Wine, Beer, Apple cider vinegar, Nutritional benefits of fermented foods- prebiotic, probiotic and post biotic.	
V		**Marketing and Management of fermented foods:**	**9**
	19	Entrepreneurship and food service management- Business requirements for food products	
	20	Government requirements and marketing.	

Practicum (30 Hours)-[Essential Experiments (15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Calculation of BMR
2. Chart preparation of 1week dietary intakes
3. Preparation of Balanced Diet for different ages
4. Preparation of Growth charts
5. Production of fermented foods
6. Analysis of Fats and Oils using Calorimetry

Suggested Readings:

1. Food Microbiology- M R Adams and Moss, 4th edition, Royal Society of Chemistry,2015
2. Food Microbiology – William C Frazier, 5th edition, McGraw Hill Education, 2017
3. Basic Food Microbiology, 2nd edition, George J. Banwart, CBS Publishers and Distributors, New Delhi,2012
4. A modern Introduction to food microbiology – Board R G., Blackwell Scientific Publishers, Oxford,1983
5. Fundamentals of Food, Nutrition & Diet therapy- Mudambi S R and Rajagopal M V, New age international publishers,2022
6. Dietetics- B Srilakshmi, New Age International Pvt Ltd, 2003
7. Text book of food science and Nutrition Sunitha Roy Chowdhury and Bani Tamber Aeri, Aarahan Publishers, 2023
8. Food and Beverage Management, Partho Pratim Seal, Oxford University Press

https://draxe.com/nutrition/fermented-foods/
https://onlinelibrary.wiley.com/journal/20487177

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO 1	Understand the basic components of food.	U	PSO-1,2
CO 2	Categorize food and understand different types of food	R, U	PSO-1,2
CO 3	Identify and analyse the properties of food and correlate the importance of these properties in the formation of different food items	U, AN	PSO-1,2
CO 4	Understand the concept of nutrition and evaluate the importance of nutrition in development	U	PSO-1
CO 5	Understand the need to balance and maintain the energy through nutrition	U, AP	PSO-1
CO 6	Differentiate the microorganisms present in different food. Analyse how these microorganisms improve the nutritional quality of food	R, U, AN	PSO-3
CO 7	To get an idea about the preparation of various fermented food products	AP	PSO-4
CO 8	To get the basic idea to start a business with food products	C	PSO-5

Course Outcomes

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Food and Nutrition, Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	Understand the basic components of food.	PSO-1,2 PO-1	U	F, C	L	
2	Categorise food and understand different types of food	PSO-1,2 PO-1	R, U	C	L	
3	Identify and analyse the properties of food	PSO-1,2 PO-1	U, AN	F, C	L	
4	Understand the concept of nutrition	PSO-1	U	C	L	
5	Understand the need to balance energy through nutrition	PSO-1	U, AP	C	L	
6	Differentiate the microorganisms present in different foods.	PSO-3, P O-3	R, U, AN	M	L	
7	To get an idea about fermented food products	PSO-4, PO-3	AP	P		P
8	To get the basic idea to start a business with food products	PSO-5, PO-6	C	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	2	-	-	-	-	1	-	-	-	-	-
CO 2	2	3	-	-	-	-	1	-	-	-	-	-
CO 3	2	2	-	-	-	-	1	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	3	-	-	-	-	-	1	-	-	-
CO7	-	-	-	2	-	-	-	-	1	-	-	-
CO8	-	-	-	-	2	-	-	-	-	-	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar,Midterm Exam
- Programming Assignments ,Final Exam

Mapping of COs to Assessment Rubrics:

Internal Exam	Assignment	Project Evaluation	End Semester Examinations
✓			✓
✓			✓
✓			✓
✓			✓
✓			✓
✓	✓		✓
✓	✓	✓	✓
✓		✓	

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK1DSCBIT105				
Course Title	CHEMISTRY FOR LIFE SCIENCES-I				
Type of Course	DSC				
Semester	I				
Academic Level	100 –199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in chemistry and life science				
Course Summary	This course provides students with the understanding of basics of chemical principles in biological systems. It also provides an insight into biophysical chemistry and application of green chemistry.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Fundamentals of biophysical chemistry**	**6**
	1	Normality, molarity, molality, percentage solutions	
	2	Concept of pH, pOH (Henderson-Hasselbalch equation)	
	3	Meaning of ka and pKa values	
	4	Buffers-buffer action, buffers in biological systems.	
II		**Colloids and its properties**	**10**
	5	True solution, colloidal solution, and suspension	
	6	Classification of colloids: Lyophilic, lyophobic, with examples	
	7	Properties of colloids: Brownian movement – Tyndall effect	
	8	Application of colloids in biological system.	
III		**Thermodynamics**	**10**
	9	Types of thermodynamic system- Open, closed, isolated.	
	10	Properties of thermodynamics –intensive & extensive, entropy and enthalpy.	
	11	Laws of Thermodynamics- Zeroth, First, Second & Third law Thermodynamics.	
	12	Thermodynamic processes- Isothermal, isobaric, isochoric, adiabatic, reversible & cyclic with biological examples.	
IV		**Applied Chemistry**	**10**
	13	Nature of environmental threats and role of chemistry-Greenhouse effect, ozone layer and its depletion	
	14	Agricultural pollutants - pesticides, fertilizers, detergents	
	15	Water pollution: Various factors affecting purity of water, sewage water, industrial waste	
	16	Treatment of industrial waste water using activated charcoal, synthetic resins, reverse osmosis, electrodialysis	
V		**Application of chemistry in bio-systems**	**9**
	16	Bio inorganic compounds: Metalloporphyrin	
	18	Cytochromes and Chlorophyll in Photosynthesis	
	19	Haemoglobin and myoglobin	
	20	Respiration – mechanism of O_2 – CO_2 transportation	

Practicum (30 Hours)- [Essential Experiments (15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Introduction to Safety and Security while using chemicals in lab
2. Working and Weighing in Chemical balance
3. Working of pH meter
4. Preparation of solutes at different pH
5. Determination of pH using indicators and pH meter
6. Calculation and Preparation of solutions by percentage, normality, molality and molarity
7. Preparation of stock solutions and dilution from stock solution

8. Dissociation of weak acids and bases
9. Acid - base titrations: Strong Acid-Strong Base, Strong acid-weak base, Weak acid Strong base and weak acid-strong base Plotting titration curves

Suggested Readings:

1. Principles of inorganic chemistry (2019), Puri, Sharma and Kalia, Vishal Publishing.
2. Principles of Physical Chemistry (2020), Puri, Sharma and Pathania, Vishal Publishing.
3. Biophysical chemistry Principles and techniques Upadhyay (2016), Upadhyay and Nath, Himalaya Publishing House.
4. Biophysical chemistry (2021), Jaidev Kumar, Nation Press.
5. Concise Inorganic Chemistry (2022), J D Lee, Wiley India Edition.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamentals of biophysical chemistry	U	PSO-1,2
CO-2	Define Colloids and its properties	R, U	PSO-1
CO-3	Define Thermodynamics and explain its applications in bio-systems.	U, Ap	PSO-1
CO-4	Summarize the applications of chemistry for green environmental	Ap, E	PSO-3
CO-5	Explain the chemistry of biosystems- photosynthesis and respiration	U, An	PSO-1,2
CO-6	Handle chemicals, prepare solutions of different pH, normality, molality, and molarity and perform acid-base titration	An, Ap	PSO-3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Chemistry for Life Sciences-I

Credits: 2:1:2 (Lecture: Tutorial: Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	Understand the fundamentals of biophysical chemistry	PO-1, PSO-1,2	U	F, C	L	
2	Define Colloids and its properties	PO-1, PSO-1	R, U	F, C	L	
3	Define Thermodynamics and explain its applications in bio-systems.	PO-2, PSO-1	U, Ap	F	L	
4	Summarize the applications of chemistry for green environmental	PO-3, PSO-3	Ap, E	C	L	
5	Explain the chemistry of biosystems-photosynthesis and respiration	PO-1 PSO-1,2	U, An	C	L	
6	Handle chemicals, prepare solutions of different pH, normality, molality, and molarity and perform acid-base titration	PO-6, PSO-3	An, Ap	C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	-	-	-	-	2	-	-	-	-	-
CO 2	2	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	-	1	-	-	-	-	1	-	-	-	-
CO 4	-	-	2	3	-	-	-	-	-	2	-	-
CO 5	-	1	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	3	-	-	-	-	-	-	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Multidisciplinary Courses 100-199

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK1MDCBIT100				
Course Title	EMERGING PANDEMICS & INFECTIOUS DISEASES				
Type of Course	MDC				
Semester	I				
Academic Level	100 - 199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3
Pre-requisites	Basic Microbiology, Lifescience				
Course Summary	Infectious disease pandemics are a rising threat in our globalizing world. This course explore the documented history of pandemics and various epidemics that have the potential of turning into pandemics. Imparts skill on the management and prevention of emerging and re-emerging diseases. This course also give knowledge regarding various bacterial and viral infectious diseases.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**History of outbreaks**	9
	1	History of out breaks-Plague, Cholera, Small pox, Spanish flu, SARS, Ebola. Epidemics, Endemic & Pandemics	
	2	Infection control practice-Hand washing, decontamination, disinfection, sterilization, using of PPE, face mask, social distance, aseptic handling, quarantine and isolation. Concept of Antibiotic resistance	
II		**Emerging Pandemics**	9
	5	Emergence & re-emergence of infectious disease- COVID 19, Monkey pox, Spanish flu, Ebola virus, SARS, ZIKA, H1N1, Dengue, Chikungunya, plague, cholera,	
	6	Factors affecting emergence and re-emergence. , Environmental factors and habitat destruction,Globalization, travel, and trade	
	7	Early identification and control measures. Principles of disease surveillance, Outbreak investigation and response	
III		**Infectious Bacterial Diseases**	9
	8	Air borne (streptococcal diseases, Tuberculosis),	

	9	Food &Water Borne Diseases; Food & Water borne Intoxication-Botulism; Food & Water borne infections-Typhoid fever, Cholera, Shigellosis, E.coli diarrhoea	
	10	Soil borne bacterial diseases- Anthrax, Tetanus, Leptospirosis	
IV		**Infectious Viral Diseases**	9
	11	Pneumotropic Viral Diseases- Influenza, Adenoviral infection, Rhino viral infection,	
	12	Dermatotrophic Viral Diseases- Herpes simplex, Chickenpox, Measles, Rubella, Small pox	
	13	Viscerotropic Viral Diseases- Yellow fever, Dengue fever	
	14	Neurotropic Viral Diseases-Rabies, Polio, NIPAH	
V		**Prevention and Control Strategies**	9
	15	Vaccines: Development, types, and challenges Antimicrobial therapies: Antibiotics, antivirals, and antifungals Public health measures: Quarantine, isolation, and social distancing	

Suggested Readings

1. Emerging Epidemics, Management and Control., Prakash S. Bisen, Ruchika Raghuvanshi., 2013., Publisher: Wiley.
2. Outbreaks and Epidemics, Battling Infection from Measles to Coronavirus., Meera Senthilingam., 2020., Publisher: Icon Books.
3. Pandemics and Emerging Infectious Diseases Karen Staniland, Lily M. Hoffman, Robert Dingwall., 2013., Publisher: Wiley.
4. Microbiology – L M Prescott,2011, Brown Publishers, Australia.
5. Microbiology., - Prescott L. M., Harley, J. P., and Klein D. A., 2017., Publisher: Mc Graw Hill, New York

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand key concepts and current issue related to pandemics and infectious diseases.	R, U	PSO-1,2
CO-2	Identifying the main challenges in the management of emerging pandemics.	R, U	PSO-2, 5

CO3	Identify the symptoms and mode of transmission of various infectious diseases.	U, Ap	PSO-1
CO4	Practice healthy habits and develop skills for managing the spread of communicable diseases.	U, Ap, C	PSO-3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Emerging pandemics & infectious diseases

Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand key concepts of pandemics.	PO-1, 2	R, U	F, C	L/T	
CO-2	Identifying the main challenges in the management of pandemics	PO-1, 2	R, U	F, C	L/T	
CO3	Identify the symptoms and mode of transmission	PO-1, 2	U, Ap	F, C	L/T	
CO4	Practice healthy habits to manage communicable diseases.	PO-2, 6, 8	U, Ap, C	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8

CO1	2	2	-	-	-	-	3	3						
CO2		3	-	-	3	-	3	3						
CO3	2	-		-	-	-	3	3						
CO4	-	-	3		-	-		3				3		

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓

CO 3	✓	✓		✓
CO 4	✓			✓
CO 5				
CO 6				

1. .

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK1MDCBIT101				
Course Title	INNOVATIONS IN BIOTECHNOLOGY				
Type of Course	MDC				
Semester	I				
Academic Level	100 – 199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3
Pre-requisites	Essentials of Biotechnology, Basic Molecular Biology				
Course Summary	Bio innovation refers to the application of innovative techniques , technologies and principles to biological systems with the aim of solving challenges in the fields such as Healthcare, Agriculture, Environmental sustainability etc.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction and Concepts**	**9**
	1	Introduction: Basics and importance of Bio Innovations,	
	2	Innovative concepts in research and development	
	3	Major industries in Biotechnology.	
II		**Major areas of Innovations I**	**9**
	4	Innovations in Genetic Engineering: CRISPR/Cas9 and other genome editing technologies	
	5	Synthetic biology principles and applications, Bioactuators, Cell free Bioprocessing.	
	6	Designing and engineering biological systems,. Green and sustainable bioprocess. High-throughput sequencing platforms and methodologies	
	7	**Protein Engineering**: computational protein design, protein engineering for biomaterials, Enzyme engineering and Biocatalysis and multi specific and bi specific antibodies. Recombinant protein production techniques Monoclonal antibody technology	
III		**Major areas of Innovations II**	**9**
	8	**Omics Technology**: Next Generation Sequencing, Single Cell omics, Spatial omics and Metagenomics and Microbiomics	
	9	**Gene synthesis**: High throughput synthesis platforms, Error correction and quality control, Codon optimization and customization and Multi fragment assembly	
	10	**Metabolic Engineering**: computational tools and algorithm to design and predict metabolic pathways for production of target compounds	
IV		**Industrial aspects of Biotechnology**	
	11	A brief overview in Bioproduct research and commercialisatiion Nanomaterials in biotechnology applications Targeted drug delivery systems Nanoscale imaging and diagnostics	9
V		**Importance of Bio Innovations**	
	12	Genetically modified organisms (GMOs) and crop improvement Precision agriculture and smart farming technologies Biofuels and sustainable agriculture Case study reports about new innovations in Biotechnology and industrial visit	9

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	understand the basics and significance of biotechnological innovations, in the development of society	U	PSO-1,4,5
CO-2	Understand principles of genetic engineering, and learn to utilize various Biotechnology tools for sustainable development and green bioprocessing.	R, U	PSO1,3
CO-3	Understand application of Omics approaches to analyze industrial and environmental applications of biotechnological processes.	U,	PSO2,5
CO-4	understand the fundamental theory and practices in bioproduct research and commercialization	U,An	PSO4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Innovations in biotechnology Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	understand the basics and significance of biotechnological innovations	PSO-1,4,5	U	F, C	L	
CO-2	understand principles of genetic engineering	PSO1,3	R, U	P	L	
CO-3	Evaluate industrial and environmental applications of biotechnology	PSO2,5	U,	C	L	
CO-4	Assess fundamentals of practicing bioproduct research	PSO-1,4,5	U,An	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	1	2	-						
CO 2	2	-	1	-	-	-						
CO 3	-	2	-	-	2	-						
CO 4	2	-	-	2	2	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK1MDCBIT102

Course Title	NUTRITION AND HEALTH
Type of Course	MDC
Semester	I
Academic Level	100 – 199.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3

Pre-requisites	Microbiology, Biochemistry, General Physiology
Course Summary	This graduate-level course explores the intricate relationship between nutrition and health, with a focus on understanding the physiological, biochemical, and epidemiological aspects of nutrition and their impact on human health. Through a multidisciplinary approach, students will examine the role of various nutrients, dietary patterns, and lifestyle factors in preventing chronic diseases and promoting overall well-being. Emphasis will be placed on critical analysis of current research, dietary guidelines, and public health strategies aimed at addressing nutrition-related health challenges.

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Introduction to Nutrition and Health**	**9**
	1	Overview of Macronutrients:s -Carbohydrates,Proteins and Fats – Functions, types, sources, health implications and recommended daily intake.	
	2	Micronutrients and Their Importance: Vitamins - Fat-soluble vitamins, water-soluble vitamins, functions, and food sources	
	3	Minerals - Major and trace minerals, functions, and sources.Water and Dietary Fibers- Functions and impact on health	
	4	Digestion & Absorption: Mechanical digestion, Chemical Digestion, Mention enzymes involved with digestion of specific nutrients	

II		**Nutrition and Health Across the Lifespan**	**9**
	5	Nutrition During Pregnancy and Lactation- Nutritional needs during pregnancy and lactation. Common nutritional challenges during pregnancy, Impact of maternal nutrition on fetal development	
	6	Infant and Child Nutrition- Nutritional needs of infants and children, Breastfeeding, formula feeding, Benefits, challenges, and proper feeding techniques	
	7	Nutrition and Aging- Nutritional challenges associated with aging,Changes in nutrient requirements with aging (Protein, calcium, vitamin D)	
	8	Addressing nutrition-related concerns in older adults (Malnutrition, sarcopenia), Strategies for promoting healthy aging through nutrition	
III		**Nutrition-Related Health Conditions And Management**	**9**
	9	**Obesity**: Causes and consequences of obesity- Genetic, environmental, and behavioral factors. Strategies for weight management: BMI, Dietary modifications, physical activity, and behavior change.	
	10	**Diabetes**: Type 1, Type 2, gestational diabetes, and Prediabetes. Strategies for diabetes management: Carbohydrate counting, glycemic index/load, and meal planning	
	11	**Heart Health**: Risk factors for heart disease- Hypertension, dyslipidemia, obesity, etc. Dietary approaches to prevent and manage heart disease: DASH diet, Mediterranean diet	
IV		**Public Health Nutrition**	**9**
	12	Nutritional Deficiency Diseases: Vitamin Deficiencies- Night blindness, Megaloblastic Anemia, Scurvy, Rickets, Osteomalacia	
	13	Mineral Deficiencies- Osteoporosis, Iodine deficiency diseases, Anemia, Fluorosis, Zinc deficiency	
	14	Protein-Energy Malnutrition- Kwashiorkor, Marasmus Social health Problems: Smoking, Alcoholism, Drug Addiction	

	15	**Nutrition security**: National Nutrition Policy and Programs (ICDS, MDMP), Nutritional Supplements- Multivitamins, Protein supplements, Probiotics, Prebiotics, Nutraceuticals, Sport supplements, biologically engineered supplements, general awareness on nutrigenomics	
V	**Nutrition and Fitness**		**9**
	16	Role of Nutrition in Fitness: Importance and benefits of Physical Activity, Methods of Nutritional assessment-direct and indirect	
	17	Diet Therapy: Basic concepts, therapeutic adaptations of normal diet, principles, and classifications of therapeutic diets	

References

1. Srilakshmi B. Nutrition science; 2012; New age international (P)
2. Fundamentals of Food and Nutrition; Mudambi S R and Rajagopal M Y, 1983 Willey Eastern Ltd
3. Nutrition: Concepts and Controversies, Frances Sizer, and Ellie Whitney, 2013,Wadsworth Cengage Learning
4. Nutrition, Health, and disease: A Lifespan Approach, Simon Langley- Evans ,2021, Willey Publishers
5. Encyclopedia of Nutritional Supplements, Michael T Murray, N.D, 1996,Harmony /Rodales
6. Clinical Dietetics and Nutrition, F P Antia, and Philip Abraham,1997,Oxford University Press
7. The essential pocket guide for clinical nutrition,3rd edition,2020, Width and Reinhard
8. Food safety and Quality control, Pulkit Mathur,2018,Orient Black Swan

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understands macronutrients, micronutrients, water, dietary fibres, digestion, absorption processes and health implications of these nutrients.	U, R	PSO1
CO-2	Analyse the nutritional demands and obstacles across pivotal life stages including pregnancy and lactation, infancy and childhood, and aging.	AN, U	PSO1

CO-3	Summarize the multifaceted interplay between nutrition, lifestyle, and health outcomes.	U, R	PSO1,3
CO-4	Understands implementation of nutrition security through supplements, nutrigenomics, and government programmes.	U, R	PSO2,PSOO4
CO-5	Instantiate various nutritional deficiency diseases, and develops a knowledge on social health problems.	U, R	PSO2,PSO3
CO-6	Explain the role of nutrition in fitness, benefits of physical activity, nutritional assessment, nutrition policies and programs.	U, R	PSO2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Nutrition and health Credits: 2:1:0 (Lecture: Tutorial: Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understands macronutrients, micronutrients on health	PSO1	U, R	F, C	L	
CO-2	Analyse the nutritional demands and obstacles	PSO1	AN, U	P	L	
CO-3	Summarize the multifaceted factors in health outcomes.	PSO1,3	U, R	F	L	
CO-4	Understands implementation of nutrition security	PSO2,PSOO4	U, R	C	L	
CO-5	Instantiate various nutritional deficiency diseases	PSO2,PSO3	U, R	F	L	

CO-6	Explain the role of nutrition in fitness, benefits of physical activity	PSO2	U, R	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	-						
CO 2	3	-	-	-	-	-						
CO 3	2	-	2	-	-	-						
CO 4	3	-	-	3	-	-						
CO 5	-	1	-	2	-	-						
CO 6	-	2	-	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

SEMESTER II

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK2DSCBIT106
Course Title	BIOMOLECULES
Type of Course	DSC
Semester	II
Academic Level	100 - 199.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Fundamentals of Biochemistry, cell biology				
Course Summary	This course delves into the intricate world of biomolecules and the fundamental processes governing metabolism in living organisms. It provides an advanced understanding of the structure, function, and interplay of various biomolecules such as proteins, carbohydrates, lipids, and nucleic acids, as well as the metabolic pathways that govern energy production, biosynthesis, and cellular regulation.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Basic constituents of Life -Overview**	**6**
	1	Chemical Constituents of Life, Importance of water and physiological buffer system	
	2	Carbohydrates : Classification,mono,di,and polysaccharides with special emphasis on starch, glycogen, cellulose, and chitin	
	3	Glycosidic linkages and carbohydrate metabolism. Glycoconjugates and its biological significance. glycosides, deoxy sugars, amino sugars, sugar alcohols and sugar acids (Lectins-CS),Lectins Overview of Anaplerotic pathways in bacteris for carbohydrate metabolism	
II		**Lipids**	8
	4	Classification of lipids, Lipid metabolism , Lipidomics: analysis and applications.	
	5	Fatty Acids,Triglycerides ,Phospholipids ,Sphingolipids - structure, properties and reactions	
	6	Role of lipids in membrane structure and function, and signaling–cholesterol (CS) and ergosterol, phosphatidyl choline and phosphatidyl ethanolamine, cerebrosides and gangliosides	
III		**Amino Acids and Proteins**	10
	7	Classification of amino acids, Physical properties, Chemical reactions of amino acids	
	8	Elementary study of primary, secondary, tertiary and quaternary structure of proteins;(CS-motifs) oligopeptides-glutathione; Hemoglobin- structure and functions ,conjugated proteins(CS)	
	9	Proteins- Protein folding and stability	

	10	Nucleic acids: Base compositions, structure of purines and pyrimidines, ribose and deoxyribose, nucleoside structure , nucleotides- nomenclature, structure of polynucleotide – DNA,RNA primary structure and inter nucleotide linkage	
	11	Enzymes: catalysis, kinetics, and regulation. Protein engineering and design	
IV		**Metabolism of Biomolecules**	**12**
	12	Metabolism basic concepts- Energy rich compounds-ATP, Common types of reaction in metabolism-Oxidation, reduction, phosphorylation, hydrolysis, hydroxylation, carboxylation. High energy compounds with structures (ATP, ADP, Creatine phosphate, 1, 3 bisphosphoglycerate, PEP), role of high energy phosphate groups.	
	13	Metabolism of carbohydrates Glycolysis. Gluconeogenesis, Glycogen metabolism- glycogenesis, glycogenolysis. Regulation (Only pathway outlines, structures not required**).**	
	14	Metabolism of Lipids. Scheme of β- oxidation, ATP yield in β oxidation (stearate, palmitate as examples) and regulation. Basics of α- and ω- oxidation, ketone body formation, cytoplasmic system of fatty acid biosynthesis and regulation of the pathway, outline study of biosynthesis of cholesterol and bile acids (Only pathway outlines, structures not required**).**	
	15	Metabolism of amino acids. Reactions involved in the metabolism of amino acids- deamination, transamination and decarboxylation; coenzymes involved in these reactions. Urea cycle (structure not required). Metabolism of Nucleic Acids- De Novo & Salvage Pathway.	
V		**Biomolecular Techniques**	**9**
	15	Protein purification techniques. Enzyme assays and kinetics. Nucleic acid extraction and analysis (PCR, sequencing, etc.). Chromatography and electrophoresis methods. Structural biology techniques (X-ray crystallography, NMR, etc.).	

<u>Practicals 30 hrs</u>

Essential Experiments (15 hrs) , Group Work (15 hrs)

1. Tests for amino acids: Solubility, ninhydrin reaction, xanthoproteic reaction, Millons test, Morners test, glyoxalic acid test, Ehrlich's test, nitroprusside test, lead acetate, test for methionine, aldehyde test, Sakaguchi reaction and isatintes
2. Tests for proteins: Solubility, Ninhydrin reaction, Xanthoproteic reaction, Folin's test, Lowry's test, Biuret test, Heat denaturation, TCA precipitation, Alcohol precipitation.
3. Demonstration of Kinetics of Urease / Trypsin (Effect of pH, substrate Concentration, enzyme concentration• and temperature) .
4. Progress curve of Urease/Trypsin•
5. Digestion of carbohydrates –action of salivary amylase•

Suggested Readings:

1. Lehninger Principles of Biochemistry, 4th Edition by David L. Nelson David L. Nelson (Author)
2. Biochemistry (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc
3. TextBook of Biochemistry, 5th edition by DM Vasudevan and Sreekumar S, JAYPEE Publishers, New Delhi
4. Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi .
5. Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi,
6. Standard Methods of Biochemical Analysis, S. K. Thimmaiah (Ed), Kalyani Publishers, Ludhiana.
7. ES West, WR Todd, HS Mason and JT van Bruggen. A text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974.
8. E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
9. Principles and Techniques of Practical Biochemistry by Keith M. Wilson, John M. Walker Cambridge University Press

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understanding how chemical constituents of life in a biotechnological perspective	U	PSO-1,2
CO-2	Explain biomolecule modifications and biological significance of various bioconjugates	R, U,Ap	PSO3,4

CO3	Understand complex metabolic pathways in living cells	R , U	PSO3
CO4	Evaluate various tests for presence of amino acids, carbohydrates on the basis of qualitative tests	U, Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

name of the course:Biomolecules credits: 2:1:2 (lecture:tutorial:practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the basic constituents of Life	PSO-1,2	U	F, C	L	
CO-2	Explain how biomolecules function and its various structural and functional modifications	PSO3,4	R, U,Ap	P	L	
CO3	Understand the basics of metabolic networks	PSO3	R , U	F	L	
CO4	Evaluate the tests for important biomolecules	PSO3,4	U, Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6

CO1	2	2	-	-	-	-						
CO2	-	-	3	3	-	-						
CO3	-	-	2	-	-	-						
CO4	-	-	2	3	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

End Semester Examination

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4			✓	✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">BIOTECHNOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK2DSCBIT107</td></tr>
<tr><td>Course Title</td><td colspan="5">ELEMENTS OF BIOLOGY</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">II</td></tr>
<tr><td>Academic Level</td><td colspan="5">100 – 199</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>2 hours</td><td>1</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic knowledge in life sciences</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course provides an overview of the origin of life, diverse forms of life, biomolecules and basic cellular processes. It lays the foundation for students to understand more about cellular and molecular processes of life. This course also provides a brief account of science and experimentation.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Origin & Evolution of Life**	**6**
	1	Life – Fundamental properties of life	
	2	Origin of life - Hypotheses about the Origin of life –Spontaneous origin, Chemical evolution,	
	3	Experiments - Redi's experiments with maggots, Pasteur's experiment, The Miller-Urey experiment	
	4	RNA world, Protein world, Nucleoprotein world (progene) hypotheses	
II		**Evolution of Life and Diversity**	**10**
	5	Evolutionary history of life – Geological time scale and evolution of Kingdoms of life, Significance of evolution of photosynthesis and molecular oxygen in the diversification of life	
	6	Cell as basic unit of life – Prokaryotes and Eukaryotes – Endosymbiotic theory	
	7	Biological classification – Two kingdom, Three Kingdom, Four Kingdom, Five kingdom classification	
	8	Microbial diversity - archaea, eubacteria, protists, fungi – Major features, Features of plant and animal cells	
III		**Biomolecules**	**10**
	9	Carbohydrate: Monosaccharides, Disaccharides, Oligosaccharides and Polysaccharides – basic structure and functions	
	10	Protein: amino acids, structural hierarchy of proteins	
	11	Lipids – Glycolipids and sphingolipids, Simple lipids and compound lipids	

	12	Nucleic acid – DNA and RNA, Types of DNA- A, B, and Z forms, Types of RNA – mRNA, rRNA, tRNA, miRNA	
IV	**Basic of cellular Processes (Overview only)**		**10**
	13	Photosynthesis – Dark and light reactions	
	14	Cellular respiration – Glycolysis, Krebs cycle, ETC, ATP synthase	
	15	Cell Cycle – Phases of cell cycle, Mitosis Vs meiosis	
	16	Central dogma of molecular biology, DNA replication – semiconservative replication, Gene expression- Transcription and translation, Reverse transcription	
V	**Science and experimentation**		**9**
	17	Science, non-science and pseudoscience	
	18	Observation - an important skill	
	19	Experimentation- potential to falsify hypothesis, hypothesis testing	
	20	Data Collection & Analysis	
	21	Tools of Biostatistics-Standard Deviation, Standard Error, Variance	
	22	Basics microscopy and staining techniques for observation of cells	

Practicum (30 Hours)-[Essential Experiments (15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Introduction to laboratory safety and good laboratory practices
2. Familiarize with common laboratory equipment and its working
3. Identify an ecosystem and record the observable diversity
4. Staining and observation of bacteria/fungi under microscope
5. Observe various stages of mitosis in onion root tip cells
6. Permanent slide preparation with given samples/sections
7. Estimation of protein by Lowry/Bradford method
8. Estimation and purity checking of nucleic acid by spectrophotometry
9. Agarose gel electrophoresis analysis of DNA
10. Calculation of standard deviation, standard error and variance

Suggested Readings:

1. The Cell: A Molecular Approach, 9th edition (2023) - Geoffrey Cooper, Kenneth Adams, OUP USA
2. Biology, 11th edition (2016) - Peter Raven, George Johnson, Kenneth Mason, McGraw- Hill Education
3. Cell Biology, 4th Edition (2017) - Graham Johnson, Jennifer Lippincott-Schwartz, Thomas D. Pollard, William C. Earnshaw, Elsevier - Health Sciences Division
4. Cell Biology (Cytology, Biomolecules and Molecular Biology), 1st Edition (2016) - P S Verma, and V K Agarwal, S Chand Publishing

5. Biology: A Global Approach, Global Edition, 10th Edition (2014) - Reece / Jackson, Pearson
6. An Introduction to Biostatistics: A Manual for studies in Health Sciences, 3rd Edition (2004)- P. Sundar Rao, and J. Richard, Prentice Hall

<u>Course Outcomes</u>

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Describe how organic evolution happened	U	PSO-1
CO-2	An understanding of microbial diversity and identifying the peculiarity of different microbial class	R, U, An	PSO-1
CO3	Classify biological molecules based on their structure and types	R, U	PSO-1
CO4	Identify basic scientific skills and data generation methods	U	PSO-2, PSO-3
CO-5	Explain basic cellular processes	R, U	PSO-1
CO-6	Collect data and calculate standard deviation, standard error, and variance	U, A	PSO-3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module

Name of the Course: Elements of Biology
Credits: 2:1:2 (Lecture: Tutorial: Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Describe how organic evolution happened	PSO-1	U	F, C	L	
		PO-1				
2	An understanding of microbial diversity and identifying the peculiarity of different microbial class	PSO - 1	R, U, An	F, C	T	
		PO - 3				

3	Classify biological molecules based on their structure and types	PSO - 1 PO-1	R, U	F, C	L	
4	Identify basic scientific skills and data generation methods	PSO-2, PSO-3 PO-1	R, U, A	F, C, P	L	
5	Explain basic cellular processes	PSO -1 PO-1	R, U	F, C	L	
6	Collect data and calculate standard deviation, standard error, and variance	PSO-3 PO-2	U, A	F, P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	3	-	-	-	-	-	1	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	2	-	-	-
CO 3	1	-	-	-	-	-	1	-	-	-	-	-
CO 4	-	2	3	-	-	-	3	-	-	-	-	-
CO 5	2	-	-	-	-	-	1	-	-	-	-	-

CO6	-	-	1	-	-	-	-	1	-	-	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

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University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK2DSCBIT108				
Course Title	CHEMISTRY FOR LIFE SCIENCES-II				
Type of Course	DSC				
Semester	II				
Academic Level	100 –199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in Chemistry and Life science				
Course Summary	This course provides students with the understanding of basics of chemical principles in biological systems. It also provides an insight into biophysical chemistry and application of green chemistry.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Fundamentals of biophysical chemistry**	**9**
	1	Introduction-Wave mechanical concept of the atom-Dual Character of electron- de Broglie equation -matter waves and electromagnetic waves. Heisenberg’s uncertainty principle-Schrodinger's wave equation-Shapes of orbitals.	
	2	Electronic Configuration and Periodicity- Electronic configuration of atoms-classification of elements in to s, p, d, f blocks-atomic radii, ionization, enthalpy, electron gain enthalpy and electronegativity	
	3	Meaning of ka and pKa values	
	4	Acid-base, redox, precipitation and complexometric titrations. Theory of indicators acid-base, redox, Buffers-buffer action, buffers in biological systems.	
II		**Chemical bonding**	**10**
	5	Ionic bond-ionic solids and their coordination number, limitations of Covalent character of ionic bond	
	6	Covalent bond-valence bond theory and its limitations-hybridization, VSEPR theory and its applications- structure of XeF VB theory of H2 molecule, MO theory, LCAO of H2 ion, homo nuclear diatomic molecules-C2, B2, N2, heteronuclear diatomic molecules (HF, NO, and CO)	
	7	Polarity of Covalent bond-dipole moment-percentage ionic character-dipole moment and molecular structure	
	8	Metalic bonding and weak electrical forces, H Bond, Inter-intra molecular Bonds	
III		**Thermodynamics**	**10**
	9	Natural radioactivity, modes of decay, Geiger–Nuttal rule, artificial transmutation and artificial radioactivity-nuclear stability, n\p ratio, mass defect and binding energy	
	10	Nuclear fission and nuclear fusion, elementary idea of subatomic particles like neutrino, antineutrino	
	11	Applications of radioactivity-C14 dating, rock dating, neutron activation analysis and isotope as tracers	
IV		**Applied Chemistry**	**7**
	12	Nature of environmental threats and role of chemistry- Greenhouse effect, ozone layer and its depletion	
	13	Water pollution: Various factors affecting purity of water, sewage water, industrial waste	
	14	Agricultural pollution such as pesticides, fertilizers, detergents	
	15	Treatment of industrial waste water using activated charcoal, synthetic resins, reverse osmosis, electrodialysis	

V	**Application of chemistry in bio-systems**		**9**
	16	Bio inorganic compounds: Metalloporphyrins	
	18	Cytochromes and Chlorophyll in Photosynthesis	
	19	Haemoglobin and myoglobin	
	20	Respiration – mechanism of O_2 – CO_2 transportation	

Practicum (30 Hours)-[Essential Experiments(15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Introduction to Safety and Security while using chemicals in lab
2. Working and Weighing in Chemical balance
3. Working of pH meter and preparation of solutes at different pH
4. Determination of pH using indicators and pH meter
5. Calculation and Preparation of solutions by percentage, normality, molality and molarity of solutions
6. Preparation of stock solutions and dilution from stock solution
7. Dissociation of weak acids and bases
8. Acid - base titrations: Strong Acid-Strong Base, Strong acid-weak base, Weak acid Strong base and weak acid-strong base (Explanation with titration curves)

Suggested Readings:

1. Principles of inorganic chemistry (2019), Puri, Sharma and Kalia, Vishal Publishing
2. Principles of physical Chemistry (2020), Puri, Sharma and Pathania, Vishal Publishing
3. Biophysical chemistry Principles and techniques by Upadhyay (2016), Upadhyay and Nath, Himalaya Publishing House.
4. Biophysical chemistry (2021), Jaidev Kumar, Nation Press.
5. Concise Inorganic Chemistry (2022), J D Lee, Wiley India Edition.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamentals of biophysical chemistry	U	PSO-1,2
CO-2	Understand dual nature of electrons and various theories explains the electronic state of the atoms	R, U	PSO-1
CO-3	Understand how atoms interact with each other for atomic bond formation and subsequent inter- molecular interaction.	U, R	PSO-1
CO-4	Summarize the applications of chemistry for green environmental	Ap, E	PSO-3
CO-5	Explain the chemistry of photosynthesis and respiration	U, An	PSO-1,2
CO-6	Handling chemicals, preparation of solutions of different pH, normality, molality and molarity and acid-base titration	An, Ap	PSO-3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Chemistry for Life Sciences-II
Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
CO-1	Understand the fundamentals of biophysical chemistry	PO-1, PSO-1,2	U	F, C	L	
CO-2	Understand dual nature of electrons and various theories explains the electronic state of the atoms	PO-1, PSO-1	R, U	F, C	L	
CO-3	Understand how atoms interact with each other for atomic bond formation and subsequent inter-molecular interaction.	PO-2, PSO-1	U, Ap	F	L	
CO-4	Summarize the applications of chemistry for green environmental	PO-3, PSO-3	Ap, E	C	L	
CO-5	Explain the chemistry of photosynthesis and respiration	PSO-1,2	U, An	C	L	
CO-6	Handling chemicals, preparation of solutions of different pH, normality, molality and molarity and acid-base titration	PO-6, PSO-3	An, Ap	C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	-	2	-	-	-	-	-
CO 2	2	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	-	1	-	-	-	-	1	-	-	-	-
CO 4	-	-	2	3	-	-	-	-	-	2	-	-
CO 5	-	1	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	3	-	-	-	-	-	-	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

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University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK2DSCBIT109				
Course Title	FUNDAMENTALS OF MICROBIOLOGY				
Type of Course	DSC				
Semester	II				
Academic Level	100 - 199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in life sciences				
Course Summary	This is a graduate level course in microbiology which provides basics in microbiology. This course deals with the history and scope of microbiology and diverse forms of microorganisms. Students can learn about isolation, culture and characterization of bacteria from different sources. Also includes topics on the beneficial role of microorganisms and its applications.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to microbial world**	**6**
	1	History and scope of Microbiology - Establishment of theory of biogenesis, Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch	
	2	Microbial Diversity – Prokaryotic organisms, eukaryotic microorganisms, acellular microorganisms (Viruses, Viroids, Prions, Mycoplasma (PPLO).	
II		**Structure and Classification**	**10**
	3	Ultrastructure of bacteria: Cell wall (Gram positive & Gram negative) and internal organisation, structure of flagella, types of arrangement of flagella, Motility – motile and non-motile bacteria	
	4	**Microbial systematics -** Systems of classification: Binomial Nomenclature, Concept of microbial species & strains,	

		Morphological classification, Nutritional Classification, Introduction to Bergey's Manual	
III		**Principles of microbial control**	**8**
	5	General principles: Removal, inhibition and killing	
	6	Physical methods of microbial control: Heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation	
	7	Chemical methods of microbial control: Types and mode of action of chemical sterilant and disinfectants	
IV		**Microbial culture and identification**	**12**
	8	Bacterial culture media:-Nutritional requirements, Components, and types of culture media	
	9	Bacterial growth and reproduction: Factors affecting growth of microbes, Bacterial reproduction by binary fission and sporulation, Measurement of bacterial growth, Bacterial growth curve Bacterial culture methods: Pure culture techniques (Serial dilution, pour plate, spread plate, streaking techniques, stab, and slant culture) Large scale culture methods of bacteria: Batch, Fed-batch, Continuous culture	
	10	Identification of Bacteria: Motility in bacteria – hanging drop test Staining: Types of stains- Acidic and basic, Types of staining techniques – Simple staining (Direct/positive and Indirect/Negative), Differential staining (Gram staining, Acid-fast staining, Endospore staining) Biochemical test – IMViC tests	
V		**Beneficial Microbes**	**9**
	11	Agricultural: biofertilizer (*Rhizobium)*	
	12	Food & Industrial: *Lactobacillus* (Dairy products), *Saccharomyces* (Bread, Beer, Wine), *Aspergillus (*Citric acid), *Cornebacterium glutamicum (*Glutamic Acid)	
	13	Environment: *Pseudomonas sp.*	
	14	Medical: *Penicillium sp.,*	
	15	Extremophiles & their biotechnological applications – Thermophiles, Acidophiles, Halophiles and Alkalophiles, Methanogenic bacteria	

Practicum (30 Hours)-[Essential Experiments(15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Introduction to Laboratory safety and good laboratory practices in a microbiology laboratory

2. Working with microbiology laboratory instruments - Microscope, Incubator, Autoclave, Centrifuge, LAF, Shaker incubator, pH meter
3. Aseptic handling of microbial cultures
4. Media preparation and sterilization
5. Sampling, isolation, and enumeration of microorganisms from air, soil and water
6. Pure culture techniques - Serial dilution, pour plate, spread plate, Streak plate, Stab and slant culture
7. Identification of microorganisms isolated from specific sample
    a. Staining (simple staining, differential staining)
    b. Test for motility - Hanging drop
    c) Biochemical test (IMViC)

8. Preparation of Bacterial growth curve

Suggested Readings:

1. Microbiology, 5th Edition (2023) - Pelczar M J, Chan E C S and Kreig N R, , Affiliated East West Press Private Limited New Delhi
2. Prescott's microbiology, 12th Edition (2022) - Wood D, Willey J, Sandman K, McGraw-Hill Education
3. Microbiology: An Introduction, 12th Edition (2014) - Tortora G J, Funke B R, Case C L, Prentice-Hall, NY, USA
4. Brock Biology of Microorganisms, Global Edition, 15th Edition (2018) - Michael Madigan, Kelly Bender, Daniel Buckley, W. Sattley, David Stahl, Pearson,
5. Textbook of Microbiology, 1st Edition (2012) - Surinder Kumar, Jaypee Brothers Medical Publishers
6. Modern Concepts of Microbiology, 2nd Edition (2001) - H.D. Kumar, S Kumar, Vikas Publishing House Pvt Ltd
7. Microbiology, 4th Edition (2019) - P D Sharma, Rastogi Publications
8. A TextBook of Microbiology, 3rd Edition (2013)- Chakraborty P, New Central Book Agency
9. A Textbook of Microbiology, 5th Edition (2022) - Dubey R C, D K Maheshwari, S Chand & Company.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Outline the microbial systematic and evolution of microbiology	U	PSO-1
CO-2	Explain the principles of microbial control and various agents involved in controlling microbial growth	R, U	PSO -1
CO3	Describe the basics of microbial physiology and distinguish the structure of bacteria	R, U	PSO -1

CO4	Understand the beneficial role of microbes for human welfare and Explain the applications of microbes	U, An	PSO -3, PSO-5
CO5	Perform Gram staining and identify Gram positive and negative bacteria	U, A	PSO - 3
CO6	Isolate, enumerate and pure culture bacteria isolated from different sources	U, A	PSO - 3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Fundamentals of Microbiology

Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	Outline the microbial systematic and evolution of microbiology	PSO-1 PO -1	U	F, C	L	
2	Explain the principles of microbial control and various agents involved in controlling microbial growth	PSO -1 PO -1	R,U	F, C	L	
3	Describe the basics of microbial physiology and distinguish the structure of bacteria	PSO -1 PO -1	,	F, C	L	

4	Understand the beneficial role of microbes for human welfare and explain the applications of microbes	PSO -3, PSO-5 PO -2, PO -3	U,A	F, C, M	T	
5	Perform Gram staining and identify Gram positive and negative bacteria	PSO – 3 PO -1, PO -6	U,Ap	P		P
6	Isolate, enumerate and pure culture bacteria isolated from different sources	PSO – 3 PO -1, PO -3, PO -6	U,Ap	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs:

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	3	-	-	-	-	-	2					
CO 2	2	-	-	-	-	-	2					
CO 3	3	-	-	-	-	-	2					
CO 4	-	-	1	-	2	-		3	2			
CO 5	-	-	3	-	-	-	3					3
CO 6	-	-	3	-	-	-	3		2			3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

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University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK2DSCBIT110				
Course Title	BASICS OF CELL BIOLOGY				
Type of Course	DSC				
Semester	II				
Academic Level	100 - 199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in life sciences				
Course Summary	This course is a foundation level course in the area of cell biology for graduate students. This course provides an overview of the origin and diversity of life on earth. Through this course, learners can acquire basic ideas about the cellular and molecular processes of life.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I		**Cell as basic unit of life**	**5**
	1	Origin of life – Hypotheses, Experiments to establish the chemical evolution of cell	
	2	RNA world, Protein world, Nucleoprotein world (progene) hypotheses	

	3	Cell as basic unit of life – Prokaryotes and eukaryotes	
	4	Five kingdom classification	
	5	Microbes – general features of archaea, eubacteria, protists, fungi	
	6	Features of plant and animal cell	
II		**Cell Structure**	**10**
	7	Cell Membranes-Structure and Function: Composition of Cell membranes (Membrane lipids, Protein, and Carbohydrates), Fluid Mosaic Model of membrane structure, Membrane transport - Simple diffusion, Facilitated diffusion and Active transport	
	8	Cell organelles- Structure and Functions: Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplast, Ribosomes, Lysosomes, Peroxisomes, Nucleus, Vacuole, Cytosol and Cytoskeleton structures (Microtubules, Microfilaments, and Intermediate filaments).	
	9	Cell Adhesion, Cell Junctions and Extracellular Matrix: Tight Junctions, Adherens Junctions, Desmosomes, and Gap Junctions, ECM- components (Fibrous Proteins, Glycosaminoglycans and Proteoglycans) and its functions	
III		**Genes, Chromosomes and Genomes**	**9**
	10	Genes: Concept and Chemical nature	
	11	Chromosome structure: Chromatid, Chromonema, Chromomeres, Centromere, Telomere, Secondary Constrictions, Nucleolar Organizers, Satellite, Heterochromatin and Euchromatin Chromosomal aberrations (Structural and numerical)	
	12	Genomes: Structure and Composition, Size and Complexity, Genome Packaging, Histones and Nonhistones, Nucleosome and Solenoid Model of Chromatin, Giant Chromosomes	
IV		**Basic cellular processes**	**12**
	13	Photosynthesis – Dark and light reaction, Cellular respiration - Glycolysis, Kreb’s cycle, ETC and ATP synthesis	
	14	Cell cycle, cellular growth and differentiation, cell division – mitosis and meiosis, Programmed cell death	
	15	Gene expression (Brief account only) – Transcription, translation and	
	16	Overview of cell signalling	
V		**Methods and techniques in cell biology**	**9**
	17	Microscopy (Principle and application only)– Light microscopy, fluorescence microscopy, Electron microscopy (SEM, TEM)	
	18	Cell staining techniques	
	19	Cell Lysis, Isolation, purification and detection of proteins and nucleic acids	

Practicum (30 Hours)-[Essential Experiments(15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Light microscope- Identification of its parts and handling
2. Cell counting using haemocytometer
3. Squash preparation of onion root tip and identification of stages of mitosis
4. Calculation of mitotic index
5. Squash preparation of flower buds of *Rhoeo* and identification of stages of meiosis
6. Isolation of genomic DNA
7. Quantification and purity checking of isolated DNA by Spectrophotometry
8. Agarose gel electrophoresis and visualization of DNA bands

Suggested Readings:

1. Karp's Cell and Molecular Biology: Concepts and Experiments, 9th Edition (2020) - Gerald Karp, Gerald Karp, and Wallace Marshall; Wiley Publishers
2. The Cell: A Molecular Approach, 9th edition (2023) - Geoffrey Cooper, Kenneth Adams, OUP USA
3. Molecular Biology of the Cell, 7th Edition (2022) - Bruce Alberts, Rebecca Heald, Alexander Johnson et al.; WW Norton & Co
4. Cell Biology, 4th Edition (2017) - Graham Johnson, Jennifer Lippincott-Schwartz, Thomas D. Pollard, William C. Earnshaw, Elsevier - Health Sciences Division
5. Cell Biology (Cytology, Biomolecules and Molecular Biology), 1st Edition (2016) - P S Verma, and V K Agarwal, S Chand Publishing
6. Biology: A Global Approach, Global Edition, 10th Edition (2014) - Reece / Jackson, Pearson
7. Cell And Molecular Biology, 8th Edition (2017) - De Robertis E.D.P.; Lea & Febiger, U.S.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand common evolutionary history of life and how living things evolve from simplicity to complexity	R	PSO-1
CO-2	Identify cellular components and explain its functions	R, U, A	PSO-1
CO-3	Explain the concepts of gene and genome	R, U	PSO-1
CO-4	Comprehend the basic cellular processes	U, An	PSO-1, PSO -4
CO-5	Demonstrate and identify various stages of cell cycle under a microscope	U, A, An	PSO-3

CO - 6	Isolate genomic DNA and visualize it agarose gel	U, A	PSO-3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module

Name of the Course: Basics of Cell Biology
Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)
1	Understand Common evolutionary history of life	PSO-1, PO-1	R	F, C	L	
2	Identify cellular components and explain its functions	PSO-1 PO-1	R, U, A	P	T	
3	Explain the concepts of gene and genome	PSO-1 PO-1	R, U	F,C	L	
4	Comprehend the basic cellular processes	PSO-1, PSO -4	U, An	M	L, T	
5	Demonstrate and identify various stages of cell cycle under a microscope	PSO-3 PO-6	U, A, An	P		P
6	Isolate genomic DNA and visualize it agarose gel	PSO-3 PO-6	U, A	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6

CO1	3	-	-	-	-	-	2	-	-	-	-	-
CO2	3	-	-	-	-	-	3	-	-	-	-	-
CO3	2	-	-	-	-	-	1	-	-	-	-	-
CO4	2	-	-	1	-	-	2	2	-	-	-	-
CO5	-	-	3	-	-	-	-	-	-	-	-	3
CO6	-	-	3	-	-	-	-	-	-	-	-	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓

CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">BIOTECHNOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK2DSCBIT111</td></tr>
<tr><td>Course Title</td><td colspan="5">ENVIRONMENTAL MICROBIOLOGY, BIODIVERSITY AND CONSERVATION</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">II</td></tr>
<tr><td>Academic Level</td><td colspan="5">100 - 199</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>2 hours</td><td>1</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Fundamental knowledge on Microbiology and Ecology</td></tr>
<tr><td>Course Summary</td><td colspan="5">This graduate-level course explores the intricate relationship between microorganisms, the environment, and biodiversity, with a focus on conservation principles and practices. It delves into the roles of microorganisms in ecological processes, their impact on environmental health, and their significance in maintaining biodiversity. The course also examines various conservation strategies and their application in preserving microbial diversity and ecosystem stability.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Organisms in nature & their importance**		**6**
	1	Principles of microbial ecology	
	2	Microbial interactions and community dynamics	
	3	Factors influencing microbial diversity and distribution, Microbiome studies and their applications	
II	**Microbial processes for bioenergy production**		**10**
	5	Microbial reactors, Genetically modified microbes	
	6	Environmental management and gradation technology	
	7	Microbial processes for bioenergy production (e.g., anaerobic digestion, microbial fuel cells Biogas technology, plant design, construction, operation, biogas from organic wastes	
	8	Water weeds, landfills, microbiology of anaerobic fermentation.	
III	**Microbial ecology and biogeochemical cycles**		**10**
	9	Extremophiles: definition and classification Adaptations of microorganisms to extreme conditions (e.g., temperature, pH, salinity) Biotechnological implications of extremophiles, role of different microbial taxa.	
	10	Overview of biogeochemical cycles- Carbon, nitrogen, sulfur, and phosphorus cycles	
	11	Microbial roles in biogeochemical processes, Impacts of human activities on biogeochemical cycles, Overview of bioremediation Role of microorganisms in soil fertility and plant health Microbial inoculants and biofertilizers	
IV	**Biodiversity and conservation**		**10**
	12	Biodiversity: importance, levels of biodiversity- species, genetic and ecosystem diversity, threats to biodiversity- habitat loss and fragmentation, exotic species, pollution, overexploitation, IUCN categories of threat, Microbial symbiosis and interactions with plants and animals Microbial contributions to ecosystem resilience and stability,	
	13	Endemism and threatened species, red data book, Habitat destruction, pollution, and climate change Invasive species and microbial pathogens Human activities impacting microbial ecosystems	
	14	Molecular Principles and importance of conservation biology; In-situ conservation of biodiversity Sanctuaries, national parks, biosphere reserves Ex-situ conservation of biodiversity: Principles and practices, field gene banks, seed banks and cryopreservation.	
V	**Phytogeography**		**9**
	15	Introduction to phytogeography , Adaptations in plant communities – hydrophytes, xerophytes, epiphytes, parasites and halophytes.	

	16	Vegetational types in India	
	17	Phytogeographical regions in India	

Practicals. - 30 Hrs -Essential Experiments (15 hrs), Group work (15 hrs)

Essential Experiments

1. Perform/demonstrate dissection of hydrophytes
2. Microscopic Examination of Environmental Samples
3. Immunoblotting
4. Sampling Methods for Environmental Microbiology
5. Physiological and Biochemical Characterization of Microorganisms
6. Molecular Biology Techniques in Environmental Microbiology (PCR, DNA sequencing)
7. Agarose gel, PAGE, SDS -PAGE

Suggested Readings:

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker 2. Bioinstrumentation, Webster

2. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic

3. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.

4. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.

5. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.

6. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. AppletonCentuary-Crofts publication.

7. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

8. Microscopic Techniques in Biotechnology, Michael Hoppert Different Levels of Biosafety, Containment

9. Genes IX by B. Lewin, Oxford University Press

10. An Introduction to Genetic Analysis (2000) by A.J.F. Griffiths, J.H. Miller, D.T. Suzuki, R.C. Lewontin and W.M. Gelbart, W.H. Freeman, New York

11. "Environmental Microbiology" by Raina M. Maier, Ian L. Pepper, and Charles P. Gerba

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	To Understand the fundamental principles of microbiology and its applications in environmental science	U	PS-O1
CO-2	Demonstrate proficiency in microbiological techniques for sampling, isolation, and identification of microorganisms from environmental samples.	U, Ap	PSO-3
CO-2	Analyze microbial diversity and community structure in different environmental habitats using molecular biology techniques.	U, Ap	PSO-3, 4
CO-3	Evaluate the role of microorganisms in biogeochemical cycles and ecosystem processes.	Ap, An	PSO-3,4
CO-4	To understand various biodiversity and their conservation strategies	Ap, An	PSO-2, 3
C0-5	To understand various vegetational and phytogeographical regions in India	U	PSO-2, 5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Environmental microbiology, biodiversity and conservation **Credits: 2:1:2 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	To Understand the fundamental principles of microbiology	PSO-1	U	F, C	L	
CO-2	Demonstrate proficiency identification of microorganisms from environmental samples.	PSO-3	U, Ap	P	L	
CO-2	Analyze microbial diversity in environment	PSO-3, 4	U, Ap	C	L	P
CO-3	Evaluate biogeochemical cycles	PSO-3, 4	Ap, An	F	L	
CO-4	To understand biodiversity and their conservation	PSO-2, 5	Ap, An	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	-	-	-	-						
CO 2	-	-	2	-	-	-						
CO 3	-	-	2	2	-	-						
CO 4	-	2		-	3	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

Multidisciplinary Courses 100-199

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK2MDCBIT103				
Course Title	BIOFUEL TECHNOLOGY				
Type of Course	MDC				
Semester	II				
Academic Level	100 - 199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2hours	1	-	3
Pre-requisites	Microbiology, Biochemistry				
Course Summary	Biofuel Technology is a comprehensive graduate-level course that explores the science, technology, and applications of biofuels in the context of sustainable energy production. This course delves into the various aspects of biofuel production, including biomass feedstock selection, conversion processes, and environmental implications.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**sustainable fuel sources**	**9**
	1	Renewable and non renewable energy resources, fossil fuel reserves, fossil fuel usage and its impacts, green house gases, Mitigation of global warming – Kyoto protocol,	
	2	Sequestration of carbon dioxide	
	3	Sustainable energy sources , energy storage,	
II		**Harvesting energy from biochemical reactions**	**9**
	4	Biochemical pathways for various metabolic process involved in biofuel production. Aerobic /anaerobic respiration. Fermentation. Mixed acid fermenations. Lithotrophic and phtotrophic growth and metabolism	
	5	Bioreactor design and operation for biofuel production .biorefinery and current technology	
	6	Microbial Fuel Cells. Fuel cell design	
III		**Liquid biofuels**	**9**
	7	Bioenergy feed stocks – 1st, 2nd and 3rd generation biofuels: starch feedstocks, sugar feedstock, lignocellulosic feedstock, recalcitrance of lignocellulosic materials. plant oils and animal fats, miscellaneous feedstocks. Algal biofuels	
		Ethanol production from sugar and starch feed stocks. Process technology	
IV		**Production of Biodiese**	**9**

	8	Production of Biodiesel. Transesterification, Esterification, Lipase-Catalyzed Interesterification, Supercritical process , microwave/ultrasound assisted process Biodiesel as an ideal engine oil,	
	15	Oil Sources For biodiesel production: Plant Oils, Microbial and Algal Oils, Used Cooking Oils, straight Vegetable Oil. Novel type of biodiesel, Jatropha cultivation	
	9	Gaseous biofuels – biological production of hydrogen, enzymatic, photobiological , fermentative . hydrogen storage, use as transport fuel. methane production using anaerobic digestion process, Microbiology of methane production, biomass sources for methane production, biogas composition and use Nanotech fuels and fuel additives	
V		**The benefits and deficiencies of biofuels**	**9**
	10	The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels.	
	11	National hydrogen energy road map.	

Suggested Reading

1. Biofuels production, application and development. Alan Scragg,2009,CABI
2. Biofuels, Wim Soetaert, Erick J. Vandamme,2011,Wiley Publishers
3. Caye M. Drapcho, Nghiem Phu Nhuan,Terry H. Walker, Biofuels Engineering Process
4. Technology McGrow Hills, 2007
5. 3. Biotol Series, Vch Ellis Horwood, Butterworth-Heinemann, Product Recovery in Bioprocess
6. Technology 1st Edn ,1992

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Learn about production of biological solid fuel.	U	PSO3,5

CO-2	Learn about gaseous biofuel production like methane and hydrogen in detail.	R, U	PSO3,5
CO3	Learn about liquid biofuels	U,Ap	PSO3,5
CO4	Learn about benefits and deficiencies of biofuels, life cycle analysis	U	PSO 3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Biofuel technology Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Learn about production of biological solid fuel.	PSO3,5	U	F, C	L	
CO-2	Learn about gaseous biofuel production like methane and hydrogen in detail.	PSO3,5	R, U	P	L	
CO3	Learn about liquid biofuels	PSO3,5	U,Ap	P	L	P
CO4	Learn about benefits and deficiencies of biofuels, life cycle analysis	PSO 3	U	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	1	-	3	-						
CO 2	-	-	1	-	3	-						

CO 3	-	-	2	-	3	-						
CO 4	-	-	1	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar/Midterm Exam
- Programming Assignments /Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY

Course Code	UK2MDCBIT104				
Course Title	FOOD SAFETY, PRESERVATION AND QUALITY MANAGEMENT				
Type of Course	MDC				
Semester	II				
Academic Level	100 - 199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-s	3
Pre-requisites	Microbiology,Biochemistry, Animal Physiology				
Course Summary	This course provides an in-depth exploration of the principles, practices, and challenges associated with ensuring the safety, preservation, and quality management of food products. It is designed to equip graduate students with advanced knowledge and skills necessary to address complex issues in the food industry, regulatory compliance, and consumer protection.				

Detailed Syllabus:

Module	**Unit**	content	**Hrs**
I		food handling, adulteration and spoilage	**9**
	1	Food hygiene and health: Concepts of personal hygiene in food handling, Modes of disease transmission through food, Good hygienic practices for food handling	
	2	Food adulterants: Types of food adulterants- intentional and incidental, metallic adulteration, Adulteration in important food items (milk, fat and oil, food grains, fruits and vegetables, spices, honey and beverages), food adulteration and public health	
	3	Food spoilage: Types -, physical, chemical and biological spoilage Microbial Food spoilage: Factors affecting microbial growth in food, , Spoilage of canned food	
II		**food borne intoxications and infections**	**9**
	4	Overview of foodborne illnesses: definitions, scope, and significance	
	5	Causes of foodborne illnesses - Physical hazards, Chemical Hazards and Biological Hazards	
	6	Foodborne infections- Cholera, Salmonellosis, Shigellosis, Typhoid fever, Brucellosis, E. coli Diarrhoea	
	7	Foodborne intoxications- Botulism, Staphylococcal food poisoning, Aflatoxins and Mycotoxins. Risk factors for foodborne illness susceptibility and severity	
III		**food additives, preservatives, and packaging**	**9**
	9	Food preservation –Importance and scope Conventional methods of food preservation (Smoking, Sun drying, Pickling/ Salting, Fermentation)	

		Physical Methods of food preservation- High temperature, Low temperature, dehydration and Concentration, Cold pressing (Fruits, Oils), Ionizing radiation and microwave heating Chemical methods of food preservation – Classification of preservatives- Class I and Class II preservatives ,Food Additives Biological methods of food preservation – Bio-preservation - Fermentation, Use of LAB, Enzymes (e.g. lysozyme)	
	11	Food packaging: GMP, Methods of food packaging, Types of food packaging materials, bio-packaging materials	
IV		**food quality management**	**9**
	13	Total Quality Management (TQM) principles, Quality control and assurance methodologies	
	14	Indicator organisms: Food and water quality	
	15	Food labelling: Purpose and types of food labels	
	16	Food safety and quality control: Food laws and standards (PFA act, Overview of Codex alimentarius, Agmark, ISO, BIS, FSSAI, HACCP) Regulatory frameworks (FDA, USDA, Codex Alimentarius, etc.). HACCP (Hazard Analysis and Critical Control Points) principles and implementation	
V		**Familiarize with General Laboratory Techniques**	**9**
	18	Water quality analysis– MPN method	
	19	Isolation and identification of microbes from spoiled food– spoiled milk, meat, fish, vegetables, grains etc.	
	20	Food preservation techniques: Pickling, salting and drying	
	21	Detection of adulteration in food (e.g. milk)	
	22	Preparation of case study report	
	23	Visit to Food research institutes/ industries	

Suggested reading

1. https://onlinelibrary.wiley.com/doi/full/10.1002/fsn3.3732
2. Food microbiology- MR Adams and MO Moss, 4th edition, Royal Society of Chemistry,2015
3. Industrial microbiology- L E Casida, JR, New Age International Publishers, 2019
4. Basic food microbiology – 2nd edition, George J Banwart, CBS Publishers, 2017
5, Food Microbiology – William C Frazier, 5th edition, McGraw Hill Education, 2017
6. Industrial Microbiology – A H Patel, 2nd edition, Laxmi Publications, 2022
7. Microbiology- L M Prescott, McGraw Hill, 2016

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Understand the vital link between food & health	U	PSO-1
CO-2	Familiarize the microbial diversity associated with food & their role in spoilage/ preservation	R, U	PSO1
CO-3	Develop Knowledge on organisms identified as leading causes of food borne illness	An	PSO1
CO- 4	Learn & implement important methods for food preservation for ensuring quality of processed food	Ap	PSO1,4
CO-5	Impart comprehensive overview of the scientific & technical aspects of food packaging	C,Ap	PSO4
CO- 6	Instill knowledge on packaging systems, testing & regulations of packaging	E,C	PSO4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: F**ood Safety, preservation and quality management Credits: 2:1:0 (Lecture:Tutorial:Practical)**

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understand the vital link between food & health	PSO1	U	F, C	L	
CO-2	Familiarize the microbial diversity of food	PSO1	R, U	P	L	
CO-3	Develop Knowledge on food borne illness	PSO1	An	F	L	
CO- 4	Learn & implement food	PSO1,4	Ap	F	L	

	preservation methods					
CO5	Impart knowledge of food packaging	PSO4	C,Ap		L	
CO6	knowledge on testing & regulations of packaging	PSO4,5	E,C		L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	-	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	-	-	-	-						
CO 4	2	-	-	3	-	-						
CO 5	-	-	-	3	-	-						
CO 6	-	-	-	3	2	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low

2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

Univesity of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK2MDCBIT105				
Course Title	LIFE STYLE DISEASE AND MANAGEMENT				
Type of Course	MDC				
Semester	II				
Academic Level	100-199.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1		3
Pre-requisites	Basic knowledge of human anatomy, physiology, and public health principles				
Course Summary	There is a significant increase in life style disease due to faulty diet and sedentary life style. This course will enhance knowledge and skills towards management of life style by addressing risk factors such as unhealthy diet, physical inactivity and stress towards achieving healthy approach to life				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to life style diseases**	9
	1	Concept of lifestyle diseases, Non Communicable diseases and different types.	
	2	Importance of lifestyle factors in preventing disease development.	
	3	Medical, Physical, nutritional, Psycho-social and behavioural aspects of health.	
	4	Healthy habits- diet, Yoga & meditation, exercise and unhealthy habits- smoking, alcohol, Addiction to technology (Brief description only).	
II		**Major life style diseases**	9
	5	Diabetes- Type 1 and Type2, characteristics, causes, diagnosis, prevention and management (diet, exercise, drugs)	
	6	Obesity - Body mass index, - factors leading to obesity, prevention and management.	
	7	Atherosclerosis and cardiovascular diseases- Myocardial infarction, congestive heart failure, ischemic diseases-Causes, diagnosis and management	

	8	Mental health and happy hormones. Methods to improve mental wellbeing.	
III	**Cancer as lifestyle disease**		9
	9	Cancer: Characteristics, types, Causes, Diagnosis -screening, blood test, Xray, CT Scan & endoscopy brief description	
	10	Prevention-dietary , medication, vaccination, screening-outline only	
	11	Management- surgery, chemotherapy, radiation, palliative care-brief outline	
IV		**Physical Activity and Public Health Approaches**	9
	`11	Benefits of exercise for health, Exercise prescription for different populations, Incorporating physical activity into daily life	
	12	Public Health Approaches to Lifestyle Diseases,Population-based interventions Health promotion campaigns ,Policy initiatives and advocacy	
V		**Lifestyle Modification Techniques**	9
	13	Motivational interviewing, Behavior change theories and models Goal setting and action planning	

Suggested Readings

1. Lifestyle diseases., by surendra g gattani., 2017., publisher: niraliprakashan.
2. Guide to prevention of lifestyle diseases., m. kumar and r. kumar., 2005., deep & deep publications pvt.ltd.
3. A lifetime of health lifestyle diseases., holt, rinehart and winston staff., 2004., publisher: holt mcdougal.
4. Preventing insidious lifestyle diseases. 2022., k v ramani hemlatha ramani, gunjan y trivedi vishwanathan p, lakshmi m and anita verma., publisher: bookventure.
5. Yoga for lifestyle diseases., 2017., dr. a. banerjee., publisher: sports publication.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Create an awareness on lifestyle associated health issue.	U, E	PSO-1,2
CO-2	List and define various life style associated diseases.	R, U	PSO-1,2
CO3	Demonstrate the symptoms and method of diagnosis of lifestyle diseases.	R, U	PSO-1, 4
CO4	Build and Practice healthy habits. Develop skills for the management of life style diseases.	Ap, C	PSO-4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Life style disease and management Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Create an awareness on global health issue.	PO-1 PSO- 1, 2	U, E	C, M	L	
CO-2	List and define various life style associated diseases.	PO-1 PSO- 1, 2	R, U	F, C	L	
CO3	Demonstrate the symptoms and method of diagnosis of lifestyle diseases.	PO-1, 2 PSO- 1, 4	R, U	P	L	
CO4	Build and Practice healthy habits and develop skills for the management of life style diseases.	PO-2, 3, 8 PSO-4	Ap, C	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	-	3					
CO 2	2	2	-	-	-	-	3					
CO 3	2	-		2	-	-	2	3				
CO 4	-	-		2	-	-		3	3			
CO 5	-		-	-	-	-						
CO 6	-	-	-		-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4	✓			✓
CO 5				
CO 6				

SEMESTER III

Discipline Specific Core 200-299 Level A3(P)

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK3DSCBIT200
Course Title	BIOMOLECULES & METABOLISM
Type of Course	DSC
Semester	III
Academic Level	200 - 299.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5

Pre-requisites	Fundamentals of Biochemistry, cell biology
Course Summary	This course delves into the intricate world of biomolecules and the fundamental processes governing metabolism in living organisms. It provides an advanced understanding of the structure, function, and interplay of various biomolecules such as proteins, carbohydrates, lipids, and nucleic acids, as well as the metabolic pathways that govern energy production, biosynthesis, and cellular regulation.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Basic constituents of Life -Overview**	**6**
	1	Chemical Constituents of Life, Importance of water and physiological buffer system	
	2	Carbohydrates : Classification,mono,di,and polysaccharides with special emphasis on starch, glycogen, cellulose, and chitin	

	3	Glycoconjugates and its biological significance. glycosides, deoxy sugars, amino sugars, sugar alcohols and sugar acids (Lectins-CS)	
II		**Lipids**	8
	4	Classification of lipids	
	5	Fatty Acids,Triglycerides ,Phospholipids ,Sphingolipids - structure, properties and reactions	
	6	Function of Steroids–cholesterol (CS) and ergosterol, phosphatidyl choline and phosphatidyl ethanolamine, cerebrosides and gangliosides	
III		**Amino Acids and Proteins**	10
	7	Classification of amino acids, Physical properties, Chemical reactions of amino acids	
	8	Biological significance and classification- fibrous proteins, globular proteins, conjugated proteins(CS)	
	9	Elementary study of primary, secondary, tertiary and quaternary structure of proteins;(CS-motifs) oligopeptides-glutathione; Hemoglobin- structure and functions	
	10	Nucleic acids: Base compositions, structure of purines and pyrimidines, ribose and deoxyribose, nucleoside structure , nucleotides- nomenclature, structure of polynucleotide – DNA,RNA primary structure and inter nucleotide linkage Watson and Crick double helix model of DNA, different types of RNA.	
IV		**Metabolism of Biomolecules**	**12**
	11	Metabolism basic concepts- Energy rich compounds-ATP, Common types of reaction in metabolism-Oxidation, reduction, phosphorylation, hydrolysis, hydroxylation, carboxylation. High energy compounds with structures (ATP, ADP, Creatine phosphate, 1, 3 bisphosphoglycerate, PEP), role of high energy phosphate groups.	
	12	Metabolism of carbohydrates Glycolysis. Gluconeogenesis, Glycogen metabolism- glycogenesis, glycogenolysis. Regulation (Only pathway outlines, structures not required**).**	
	13	Metabolism of Lipids. Scheme of β- oxidation, ATP yield in β oxidation (stearate, palmitate as examples) and regulation. Basics of α- and ω- oxidation, ketone body formation, cytoplasmic system of fatty acid biosynthesis and regulation of the pathway, outline study of biosynthesis of cholesterol and bile acids (Only pathway outlines, structures not required**).**	
	14	Metabolism of amino acids. Reactions involved in the metabolism of amino acids- deamination, transamination and decarboxylation; coenzymes involved in these reactions. Urea cycle (structure not required). Metabolism of Nucleic Acids- De Novo & Salvage Pathway.	
V		**Enzymes**	**9**

	15	Enzymes - Classification Units of enzyme activity, progress curve, effect of enzyme concentration, substrate concentration- (Michaelis-Menten equation- derivation not expected), Michaelis-Menten constant, enzyme affinity, temperature and pH on reaction velocity of enzyme catalyzed reactions. Enzyme specificity- different types, enzyme activation.	

Practicals 30 hrs- Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Tests for amino acids: Solubility, ninhydrin reaction, xanthoproteic reaction, Millons test, Morners test, glyoxalic acid test, Ehrlich’s test, nitroprusside test, lead acetate, test for methionine, aldehyde test, Sakaguchi reaction and isatintes
2. Tests for proteins: Solubility, Ninhydrin reaction, Xanthoproteic reaction, Folin’s test, Lowry’s test, Biuret test, Heat denaturation, TCA precipitation, Alcohol precipitation.
3. Demonstration of Kinetics of Urease / Trypsin (Effect of pH, substrate Concentration, enzyme concentration• and temperature) .
4. Progress curve of Urease/Trypsin•
5. Digestion of carbohydrates –action of salivary amylase•

Suggested Readings:

1. Lehninger Principles of Biochemistry, 4th Edition by David L. Nelson David L. Nelson (Author)
2. Biochemistry (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc
3. TextBook of Biochemistry, 5th edition by DM Vasudevan and Sreekumar S, JAYPEE Publishers, New Delhi
4. Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi .
5. Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi,
6. Standard Methods of Biochemical Analysis, S. K. Thimmaiah (Ed), Kalyani Publishers, Ludhiana.
7. ES West, WR Todd, HS Mason and JT van Bruggen. A text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974.
8. E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
9. Principles and Techniques of Practical Biochemistry by Keith M. Wilson, John M. Walker Cambridge University Press

No.	**Upon completion of the course the graduate will be able to**	**Cognitive**	**PSO addressed**

		Level	
CO-1	Understanding how chemical constituents of life in a biotechnological perspective	U	PSO-1,2
CO-2	Explain biomolecule modifications and biological significance of various bioconjugates	R, U,Ap	PSO3,4
CO3	Understand complex metabolic pathways in living cells	R , U	PSO3
CO4	Evaluate various tests for presence of amino acids, carbohydrates on the basis of qualitative tests	U, Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Metabolism and energetic Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the basic constituents of Life	PSO-1,2	U	F, C	L	
CO-2	Explain how biomolecules function and its various structural and functional modifications	PSO3,4	R, U,Ap	P	L	
CO3	Understand the basics of metabolic networks	PSO3	R , U	F	L	
CO4	Evaluate the tests for important biomolecules	PSO3,4	U, Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	-	-	-	-						
CO 2	-	-	3	3	-	-						
CO 3	-	-	2	-	-	-						
CO 4	-	-	2	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions

- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

End Semester Examination

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4			✓	✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK3DSCBIT201				
Course Title	MICROBIOLOGY				
Type of Course	DSC				
Semester	III				
Academic Level	200 – 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge of Biology and Biochemistry				
Course Summary	The Microbiology course delves deeply into the microbial world, covering key aspects from past discoveries to practical applications in various fields. It equips students with a strong foundation in microbiology, necessary lab skills, and a thorough understanding of microbial functions, uses, and control methods vital in scientific and industrial contexts.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to the microbial world**	**6**
	1	Overview of key events and discoveries in microbial history. Discovery of the microbial world: Establishment of the theory of biogenesis, Contributions of Anton van Leeuwenhoek, Louis Pasteur and Robert Koch	
	2	Introduction to the prokaryotic world, eukaryotic microorganisms, acellular microorganisms (Viruses, Viroids, Prions)	

	3	Principles of microbial systematics: Taxonomy, phylogeny, and classification methods	
	4	Introduction to systems of classification: Binomial Nomenclature, Whittaker's Five Kingdom classification system, Carl Woese's Three Domain classification system, Comparative analysis and utility of different classification systems	
II		**Principles of microbial control**	**10**
	5	Introduction to microbial control principles: Control by killing, inhibition, and removal.	
	6	Importance and applications of microbial control in various industries and healthcare settings.	
	7	Physical Methods of Microbial Control Heat Treatment: Mechanisms and applications of heat in microbial control, including pasteurization and sterilization techniques. Low Temperature Control: Strategies for microbial control using refrigeration and freezing methods. High Pressure and Filtration: Utilizing pressure and filtration techniques for microbial control.	
	8	Chemical Methods of Microbial Control Modes of Action: Understanding how disinfectants act on microorganisms. Applications	
III		**Microbial physiology and structure**	**10**
	9	Ultra structure of bacteria: Cell wall and internal organisation, spores,	
	10	Bacterial cell shape and size Motility in bacteria – structure of flagella, types of flagella.	
	11	Nutritional requirements in bacteria and nutritional categories. Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media	
	12	Bacterial growth curve, factors affecting the growth of microbes.	
IV		**Bacterial Genetics and Metabolism**	
	13	Bacterial Chromosome, Plasmids, Transfer of genetic information in bacteria, Bacterial mutation and Repair	10
	14	Bacterial Recombination- Transformation, Transduction (Generalised and Specialised), Conjugation	
	15	Energy Production in Bacteria	
	16	Aerobic respiration in bacteria: Glycolysis and Krebs cycle, Electron Transport Chain and Oxidative phosphorylation in Bacteria Anaerobic respiration in bacteria: Alcohol, Acetic acid and Lactate fermentation	
V		**Applied Microbiology**	9
	17	Agricultural microbiology: Biological nitrogen fixation, Mycorrhizal associations,	

	18	microbes as biofertilizer – types and application	
	19	Microbes in extreme condition: role of Methanogenic bacteria, extremophiles – Thermophiles, Acidophiles, Halophiles and Alkalophiles Applications.	
	20	Case study and industrial visit	

<u>Practicals 30 hrs- </u>Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Handling Microscope
2. Preparation of smear on slide and focusing on microscope (low power and high power objective).
3. Sterilization and aseptic techniques-preparation and sterilization of glassware and solutions, Autoclaving, Hot air oven
4. Media Preparation- Preparation of Luria-Bertani medium, Nutrient agar and their sterilization (Broth and plates).
5. Serial dilution of bacterial cultures and spread plating (L rod) to find out population density of microbes in a given sample, incubation and observation of colonies
6. Examination of microbial flora of the available soil and water samples. a) Pour plate method, b) Streak plate method - Continuous, Quadrant & T streak.
7. .Staining of bacteria- Gram staining, Acid fast staining, Negative staining.
8. Microscopic tests for bacterial motility- Hanging Drop experiment

9.Identification of bacterial and fungal cultures microscopically.

10. Antibiotics sensitivity assays- Kirby Bauer Method

Suggested Readings:

1. A Textbook of Microbiology – P. Chakraborthy, New central Book agency Pvt. Ltd, calcutta
2. Modern concept of Microbiology – D D Kumar, S Kumar; Vikas Publishing House Pvt. Ltd. New Delhi
3. Introduction to Genetic Engineering & Biotechnology- A. J. Nair; Jones & Bartlett Publishers, Boston,USA.
4. Introduction to Microbiology- J Heritage, E G V Evans, R A Killington; Cambridge University Press.
5. Microbiology – L M Prescott, Brown Publishers, Australia
6. Advances in Microbiology – J P Tewari, T N Lakhanpal, I Singh, R Gupta and B P Chanola; A P H Publishing Corporation, New Delhi.
7. Microbiology: Principles and Explorations – Jacquelyn G. Black. Prentice Hall, New Jersey.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding the key events in microbial history.	U	PSO-1,2
CO-2	Explain scope of microbiology and different types of microorganisms.	R, U,A	POS1
CO-3	Understand Principles of Microbial classification, genetics and metabolism	U,A	PSO1
CO-4	Understand strategies for microbial control. Analyse disinfectants and their modes of action.	U,Ap,An	POS1,PSO3
CO-5	Differentiate between culture media types and understand factors affecting microbial growth.	U, An	POS1,PSO4
CO-6	Gain practical skills in sampling, isolation, staining, and morphology observation.	E, An	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: The world of microbes **credits: 2:1:2 (lecture:tutorial:practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand History of Microbiology	PSO-1,2	U	F, C	L	-
CO-2	Explains microbial classification	POS1	R, U,A	P	L	-
CO-3	Explains principle of microbial control	PSO1	U,A	F	L	-
CO-4	Analyse the factors affecting microbial Growth	POS1,PSO3	U,Ap,An	F	L	
CO-5	Understand the requirements to culture microbes in Lab condition	POS1,PSO4	U, An	P	L	P
CO-6	Gain practical skills in microbiology lab	PSO3	E, An	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	-	-	-	-	-						
CO 2	3	-	-	-	-	-						
CO 3	3	-	-	-	-	-						
CO 4	2	-	2	-	-	-						
CO 5	2	-	-	3	-	-						
CO 6	-	-	3	2	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz /Group Discussions/Assignment/Student Seminar
- Observation of practical skills/Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative-Internal test papers/Laboratory book/ report/Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK3DSCBIT202
Course Title	BASICS OF ENZYMOLOGY

<table>
<tr><td>Type of Course</td><td colspan="5">DSC</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299.</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>2 hours</td><td>1</td><td>2 hours</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic knowledge of Biology, Biochemistry & Cell bIology</td></tr>
<tr><td>Course Summary</td><td colspan="5">The Basics of Enzymology course provides a comprehensive introduction to the fundamental principles governing enzyme structure, function, kinetics, and regulation. Through a combination of lectures, laboratory sessions, and readings, students will gain a deep understanding of enzymatic mechanisms and their significance in biological processes. The course emphasizes both theoretical knowledge and practical skills necessary for studying enzymes in various biochemical contexts.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Nomenclature, Classification & Purification of Enzymes**	**10**
	1	Enzymes and catalysis: basis of Life, Enzyme nomenclature and classification:naming of cytochrome p-450. The Enzyme Commission’s system of classification and nomenclature	
	2	Extraction and Purification of Enzymes: Extraction of soluble and membrane bound enzymes; Purification of enzymes; Criteria of enzyme purity	
	3	Assay of enzymes, Zymography (MMP assay)	
II		**Structure and General properties of enzymes**	**10**
	4	Cofactors and enzymes. Active site; Specificity of enzyme-Types of specificity, lock and key hypothesis, induced fit hypothesis and strain or transition state stabilization hypothesis	
	5	Mechanism of enzyme catalysis: Acid Base catalysis, covalent catalysis and metal ion catalysis	
	6	Factors affecting enzyme activity	
	7	Isozymes; Coenzymes; Metalloenzymes (Nucleases); Membrane bound enzymes; Multienzyme complexes, Synthetic Enzyme, non-canonical enzymes	
III		**Kinetics of enzyme catalysed reactions**	**10**
	8	Kinetics of enzyme catalysed reactions: Michaelis-Menton, Lineweaver–Burk plot	
	9	Kinetics of bisubstrate enzyme catalyzed reactions – Ping-pong and random order mechanisms	

	10	Factors affecting enzyme kinetics,Enzyme inhibitors: types of inhibitors; Mechanism of enzyme inhibition –competitive, non–competitive, uncompetitive and mixed inhibition	
IV		**Regulatory mechanism in enzyme catalysis**	**6**
	11	Allosteric enzymes- Properties. Important metabolic pathways regulated by allosteric enzymes	
	12	Regulation of enzymes by covalent modification	
	13	zymogen activation	
V		**Enzyme technology**	**9**
	14	Introduction to enzyme technology, enzyme engineering, computational enzyme design	
	15	Applications of Enzymes; Applications in medicine: diagnostic enzymes, therapeutic enzymes	
	16	Industrial applications of enzymes, Applications in genetic engineering	
	17	Immobilization of enzymes and their applications	

Practicals 30 hrs- Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Perform an assay for the enzyme lactate dehydrogenase to measure the conversion of lactate to pyruvate by Spectrophotometric method. Use a spectrophotometer to measure the change in absorbance at a specific wavelength due to enzymatic activity

2. Enzyme kinetic Assay: Conduct experiments varying substrate concentrations while keeping enzyme concentration constant, and vice versa (use crude extract of enzymes if, possible eg: cellulose)

3. Investigate the effect of temperature and pH on enzyme activity by incubating the enzyme with its substrate at different temperatures and pH levels.

4. Substrate specificity: Test the ability of the enzyme to catalyze reactions with different substrates.

5. pH and temperature optima: Determine the pH and temperature at which the enzyme exhibits maximum activity.

6. Perform Immobilize the enzyme onto a solid support such as beads, membranes, or nanoparticles, and assess its stability and activity under different conditions.

7. Compare the properties of free and immobilized enzymes, including substrate specificity, stability, and reusability.

Suggested Readings:

1. Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox - This comprehensive book covers enzymology along with other fundamental concepts in biochemistry.
2. "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer - A thorough textbook covering the principles of enzyme structure, function, kinetics, and regulation, as well as applications in biotechnology and clinical chemistry.
3. "Principles of Enzymology for the Food Sciences" by John R. Whitaker, Alphons G.J. Voragen, and Dominic W.S. Wong - Focuses on the enzymology relevant to the food industry, covering topics such as enzyme kinetics, enzyme inhibition, and enzyme applications in food processing.
4. "Introduction to Enzyme and Coenzyme Chemistry" by T. D. H. Bugg - A concise introduction to the basic principles of enzyme and coenzyme chemistry, suitable for students with a background in chemistry or biochemistry.
5. "Enzyme Kinetics: Catalysis and Control" by Daniel L. Purich - Provides an in-depth understanding of enzyme kinetics, including detailed discussions on reaction mechanisms, rate equations, and enzyme inhibition.
6. "Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry" by Irwin H. Segel - Although not solely focused on enzymology, this book provides valuable guidance on mathematical aspects of enzyme kinetics and other biochemical calculations.
7. "Practical Enzymology" by Hans Bisswanger - Offers practical guidance on experimental techniques in enzymology, including enzyme purification, assay methods, and data analysis.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand Enzyme nomenclature, classification, extraction and purification of Enzymes	U, R	PSO-1,2
CO-2	Understand the Structure and General properties of enzymes and enzyme specificity	R, U	PSO1
CO-3	Explain Kinetics of enzyme catalysed reactions factors affecting enzyme catalysed reactions	U, An	PSO1,PSO3
CO-4	Understand Regulatory mechanism in enzyme catalysis and metabolic regulations	U	PSO1

CO-5	Perform enzyme assays, and determine the kinetics of enzymatic reaction.	Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Basics of enzymology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand Enzyme types and classification	PSO-1,2	U R	F, C	L	
CO-2	Understand nature of enzymes	PSO1	R, U	P	L	
CO-3	Explain how enzymes catalysed reactions functions	PSO1,PSO3	U, An	F	L	
CO-4	Understand the regulatory mechanisms of enzyme catalysed reactions	PSO1	U	F	L	
CO-5	Perform enzyme assays, and determine the kinetics of enzymatic reaction.	PSO3,4	Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	-	-	-	-						
CO 2	3	-	-	-	-	-						
CO 3	2	-	1	-	-	-						
CO 4	3	-	-	-	-	-						
CO 5	-	-	3	2	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5			✓	✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK3DSCBIT203				
Course Title	IICROBIAL METABOLISM				
Type of Course	DSC				
Semester	III				
Academic Level	200–299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in Microbiology and Biochemistry				
Course Summary	Microbial metabolism is a fundamental aspect of microbiology that explores the biochemical pathways and mechanisms by which microorganisms obtain energy, grow and interact with their environments. This graduate-level course delves into the intricate world of microbial metabolic processes, emphasizing the diversity of metabolic strategies employed by bacteria, archaea, fungi, and other microorganisms.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Nutritional classification & Nutrient transport in microbes**	**6**
	1	Nutritional classification of bacteria	
	2	Nutrient transport across the cell: Diffusion: Passive and facilitated; Primary active and secondary active transport	
	3	Group translocation (phosphotransferase system) electroneutral transport; transport of Iron.	
II		**Photosynthesis & Respiration in Bacteria**	**10**
	4	Photosynthetic pigments of bacteria- chlorophyll a and bacteriochlorophyll, carotenoids, phycobiliproteins, leghaemoglobin	
	5	Oxygenic and anoxygenic photosynthesis Mechanism of photosynthesis in bacteria (purple non sulphur bacteria, green sulphur bacteria) and cyanobacteria	

	6	Chemolithotrophy -– oxidation of sulphur, iron, hydrogen & nitrogen Methanogenesis, Bioluminescence	
	7	Respiration in bacteria- aerobic respiration Glycolysis and tricarboxylic acid cycle Electron transport and oxidative phosphorylation in Bacteria Anaerobic respiration- Fermentation- lactic acid and alcohol fermentation, mixed acid fermentation, Lactate fermentation (homofermentative and heterofermentative pathways).	
	8	Assimilation of nitrogen,sulphur, phosphorus	
III		**Synthesis of biopolymers**	**10**
	9	Biosynthesis of peptidoglycan, biopolymers, PHB	
	10	Biosynthesis of vitamins, amino acids and nucleotides	
	11	Regulation of metabolic pathways	
	12	Overview of Microbial metabolites-marine sources	
IV		**Biochemical characterization of bacteria**	**10**
	13	Importance of Biochemical characterisation Types: Carbohydrate fermentation test, Methyl red test, Citric acid utilization test. (D) Hydrogen sulfide production test.	
	14	Principle of Sugar utilization test, Sugar fermentation test, IMViC test	
	15	Enzyme detection – Catalase, Oxidase, Oxidative-fermentative test	
	16	Gelatinase assay	
V		**Industrial importance of Microbial metabolism**	**9**
	17	Microorganisms of industrial importance. Biology of industrial microorganisms: Isolation, Screening and Preservation.	
	18	Fermentation process, Types of fermentation and Downstream processing- recovery and purification of end products of metabolism-a basic account	
	19	Strain improvement of microbes for industrial purposes	
	20	Examples of commercial products of microbial origin- case study	

Practicals 30 hrs- Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Effect of temperature, pH, salt, Carbon source and Nitrogen source on the growth of bacteria
2. Study and plot growth curve of E.coli by turbidometric method
3. Demonstration of production of acid and gas during lactose fermentation
4. Urease test

5. Gelatin hydrolysis
6. Isolation and culture of photosynthetic bacteria.
7. Starch hydrolysis test by amylase producing microbes, and enzyme assay.

Suggested Readings:

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.

2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons

3. Nelson David L and Cox Michael M, Lehninger, Principles of Biochemistry, Macmillan Press, Worth Publishers, New Delhi.

4. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India

5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.

6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, MacMillan Press.

7. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understanding of bacterial nutritional requirements to classify bacteria & predict their growth conditions.	U, R	PSO-1,2
CO-2	Describe different mechanisms of nutrient transport across cell membranes & evaluate their significance in bacterial metabolism.	U, E	PSO1,3
CO-3	To know the process of photosynthesis in bacteria	U, R	PSO1
CO-4	Examine the environmental significance of chemolithotrophy	U, An	PSO3

CO-5	Compare the efficiency of aerobic & anaerobic respiration pathways in bacteria by comparing their energy yields.	U	PSO1
CO-6	Explain the regulatory mechanisms involved in biosynthetic pathways	U	PSO3,4
CO-7	Apply their practical skills to identify bacteria using different biochemical tests	Ap, An	PSO5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Microbial metabolism **Credits: 2:1:2 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand bacterial nutrition	PSO-1,2	U, R	F, C	L	-
CO-2	Describe the nutrient uptake in bacteria	PSO1,3	U, E	P	L	-
CO-3	Know the basics of photosynthetic bacteria	PSO1	U, R	F	L	-
CO-4	Examine the environmental significance of chemolithotrophy	PSO3,5	U, An	P	L	P
CO-5	Compare the respiratory process in different kind of bacteria	PSO1	U	F,P	L	-
CO-6	Explain the regulation of	PSO3,4	U,R	C	L	-

	metabolism in bacteria					
CO7	Identify bacteria based by biochemical tests	PSO5	Ap, An	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	2	2	-	-	-	-						
CO 2	2	-	3	-	-	-						
CO 3	2	-	-	-	-	-						
CO 4	-	-	2	-	2	-						
CO 5	2	-	-	-	-	-						
CO 6	-	-	3	3	-	-						
CO7					1							

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓			✓
CO7			✓	✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK3DSCBIT204				
Course Title	PLANT PHYSIOLOGY				
Type of Course	DSC				
Semester	III				
Academic Level	200 -299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
		2 hours	1	2	5
Pre-requisites	Basic knowledge on life science, specifically on physiological processes in plant body.Fundamentals of Biology, Biochemistry				
Course Summary	This course gives a fundamental knowledge on the biophysical and biochemical processes that function in a plant system. The students will learn the basic mechanisms governing the life processes of plants at a cellular, molecular, and whole-organism level.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to plant physiology**		8
	1	Physiological process, their significance and other application: Water relations and Mineral nutrition in plant body	
11	**Photosynthesis**		12
	2	Photosynthetic apparatus and pigment systems-chromatographic techniques for the separation of photosynthetic pigments, Raw materials of photosynthesis Light perception and signal transduction	
	3	a) Light reaction i) Radiant energy and its effects on chlorophyll pigments ii) Cyclic and non-cyclic photophosphorylation iii) Source of oxygen liberated iv) Hill reaction	
	4	b) Dark reaction i) Trace the path of carbon in photosynthesis ii) Calvin cycle iii) C3 and C4 plants. CAM plants. iv) Photorespiration v) Factors affecting photosynthesis. Law of limiting factors	
	5	Definition and general equation. Significance, Respiratory substrates, Mechanism - Glycolysis, Krebs cycle, terminal oxidation. Oxidative pentose phosphate pathway, Factors affecting respiration, Anaerobic respiration	
III	**Growth and Development**		10
	6	Seed germination and seedling establishment -Dormancy and germination of seeds. Flowering and reproductive development, Differentiation, morphogenesis Hormonal regulation of plant growth - Auxins, Gibberellins, Cytokinins, Abscissic acid, Ethylene and their practical applications	
	7	Senescence and programmed cell death	
	8	Signal Transduction and Plant Responses: how plants perceive and respond to internal and external signals. receptor proteins, intracellular signaling pathways, gene expression regulation, and the integration of multiple signaling inputs.	
IV	**Plant-biotic- abiotic Interactions**		6
	9	Interactions between plants and microorganisms, beneficial symbioses (e.g., mycorrhizae, nitrogen-fixing bacteria) and pathogenic infections.	

	10	Biotic stress responses (pathogens, herbivores)- Molecular communication, defense mechanisms, and the implications for plant health and agriculture	
	11	Abiotic stress responses (drought, salinity, temperature) Circadian rhythms and biological clocks	
V	**Biotechnological Applications**		9
	12	Crop improvement through biotechnology, Biofortification and nutritional enhancement	
	12	Phytoremediation and bioremediation	

<u>Practicals 30 hrs- </u>Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Evolution of oxygen during photosynthesis

2. Necessity of chlorophyll, CO2 and light in photosynthesis

3. Measurement of photosynthesis.

4. Simple respiroscope

5. Respirometer of R.Q.

6 . Anaerobic respiration

7. Geotropism and phototropism Klinostàt

8. Hydrotropism

9. Measurement of growth Arc or Lever Auxonometer

10.Plant tissue culture and transformation methods

11. Bioinformatics analysis of plant genomic data

Suggested Reading:

1. Devlin & Witham Plant Physiology, C B S publishers.

2. Devlin R.M. (1979) Plant Physiology.

3. Dieter Hess (1975): Plant physiology.

4. Jain V. K. (1996) Fundamentals of Plant Physiology.

5. Kochhar P. L. & Krishnamoorthy H. N. Plant Physiology. Atmaram & Sons Delhi, Lucknow.

6. Kumar & Purohit Plant Physiology - Fundamentals and Applications, Agrobotanical publishers.

7. Malik C. P. & Srivastava A. K. Text book of Plant Physiology Kalyani Publishers New Delhi.

8. Noggle G R & Fritz G J (1991) Introductory Plant physiology, Prentice Hall of India

9. Pandey S.N. & Sinha B. K. (1986) Plant physiology,Vikas publishing House- New Delhi.

10. Salisbury F.B and Ross C.W. (2006): Plant Physiology 4Edn, Wadsworth publishing company.

11. Sundara Rajan S. College Botany Vol. IV, Himalaya publishing House.

Course Outcomes

	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the physiological process of plant physiological process and molecular signalling involved	R, U	PSO1
CO-2	Aware the concept of photosynthesis	R, U	PSO3
CO-3	Analyse the significance of respiration	U,An	PSO1,3
CO-4	Understand the signal transduction pathways and hormonal regulation involved in growth and development	U,Ap	PSO3,4
CO-5	Understand the application of physiological process	U,An	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Plant physiology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the physiological process of plant physiological process and molecular signalling involved	PSO1	R, U	F, C	L	
CO-2	Aware the concept of photosynthesis	PSO3	R, U	P	L	
CO-3	Analyse the significance of respiration	PSO1,3	U,An	C	L	P
CO-4	Understand the signal transduction pathways and hormonal regulation involved in growth and development	PSO-3,4	U,Ap	C	L	
CO-5	Understand the application of physiological process	PSO3	U,An	P	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						
CO 2	-	-	3	-	-	-						
CO 3	2	-	3	-	-	-						
CO 4	-	-	2	2	-	-						
CO 5	-	-	3	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK3DSCBIT205
Course Title	ANIMAL PHYSIOLOGY

Type of Course	DSC				
Semester	III				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Fundamental Biology, Basic Cell biology				
Course Summary	This course provides an in-depth exploration of the fundamental principles governing the function of the human body, and will answer how our body functions. It examines the intricate mechanisms underlying various physiological processes, ranging from cellular functions to integration of organ systems. Through a combination of lectures, and discussions, students delve into the complex interplay of molecular, cellular, and systemic processes that maintain homeostasis and regulate bodily functions.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Nutrition and Respiration**	**6**
	1	Nutrition: Types of nutrition; Mechanical and chemical digestion of carbohydrates, proteins and fats; hormonal control of digestion; absorption mechanism; BMR Vitamin deficiency diseases.	
	2	Respiration: respiratory pigments and their role; gas transport – oxygen and CO_2 transport; Oxyhaemoglobin curve; Bohr effect; Carbon monoxide poisoning. Physiological effects of smoking	
II		**Circulatory system**	**8**
	3	Circulation: Body fluids – importance and types; closed and open types of circulatory system; blood– composition and functions; blood groups – ABO and Rh systems, MN, Lewis and Bombay groups; blood clotting – intrinsic and extrinsic mechanisms and their factors; anticoagulants.	
	4	Heart: Detailed structure and types of heart – tubular and chambered; neurogenic and myogenic; pacemakers and conducting system of human heart; cardiac rhythm; blood pressure; electrocardiogram. Common cardiovascular diseases (hypertension, arteriosclerosis, myocardial infarction), Adaptations for different metabolic demands	
III		**Physiology of excretion and muscle movement**	**12**
	5	Excretion: nitrogenous wastes; ammonotelic, ureotelic and uricotelic modes of excretion; structure of human nephron; urine formation in man – detailed account with countercurrent system; normal and abnormal constituents of urine; hormonal regulation of renal function; Dialysis and artificial kidney	
	6	Muscle Physiology: types of muscles; ultrastructure of striated muscle fibre; muscle contraction ,Skeletal adaptations for locomotion and support, Biomechanics of movement; chemistry of	

		contraction; neuromuscular junction; fatigue; muscle twitch; latent and refractory periods; rigor mortis	
IV		**Nerve Physiology**	**10**
	7	Nerve Physiology: Sense organs-eyes, (physiology of vision), ear (structure and functions- hearing and balancing), olfactory organs and taste receptors;	
	8	Structure of a typical neuron; types of neurons; myelinated and nonmyelinated nerve fibres; structure and types of synapse; initiation and conduction of nerve impulse;	
	9	EEG; Nervous disorders - epilepsy, Alzheimer's disease, Parkinson's disease.	
		Action potentials and neurotransmission- neurotransmitters; synaptic transmission; reflex action and reflex arc Hormonal regulation and signaling pathways, Integration of neural and endocrine control systems	
V		**Endocrinology**	**9**
	10	Endocrinology: hormones – definition and types of hormones; mechanism of hormone action-at the levels of cell membrane, organelles and genes; positive and negative feedback regulation	
	11	Structure and functions of endocrine glands – thyroid, parathyroid, thymus, islets of Langerhans, adrenal, pituitary, hypothalamus, pineal body, gonads and placenta; brief account of prostaglandins	
	12	Hormonal disorders	

Practicals 30 hrs- Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1.Paper partition chromatography of amino acids (3 amino acids and a mixture)
2.Blood smear preparation – identification of leukocytes
3.Determination of human blood group – A, B, AB and O, and Rh+ and Rh-
4.Osmotic properties of RBCs – effect of isotonic, hypotonic and hypertonic solutions.
5.Activity of human salivary amylase on starch
6. Detection of Abnormal constituents of urine (glucose and albumin).
7. Estimate the butterfat content of raw milk, collected fresh from different animal sources
8. Working in groups, chart out physiological adaptations in animals
9. Subject students groups to animal physiology simulations illustrating hierarchies in organisation
10. Separation of serum proteins by gel filtration.

Suggested Readings

1.Arora, Mohan P. Animal Physiology. Himalaya Publishing House
2.Mariakuttikan and Arumugam, N. Animal Physiology. Saras Publication
3.Nagabhushanam, R. et al. Textbook of Animal Physiology. Oxford & IBHS

4.Rastogi, S.C. Essentials of Animal Physiology. Wiley Eastern Ltd.
5.Sebastian, M.M. Animal Physiology. Madonna Books, Kottayam
6.Verma, P.S. Tyagi, B.S. and Agarwal, V.K. Animal Physiology. S.Chand & Co.
7.Berry, A.K. A Text book of Animal Physiology, Emkay Publications.
8.Best and Taylor's Physiological Basis of Medical Practice. West, J.B. (Ed.) B.I. Waverly.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand importance of nutrition and associated disorders	U	PSO-1,2
CO-2	Understand physiology of important vital organs and mechanism of function various parts	R, U	PSO1
CO3	Understand various physiological disorders associated with important organs and diagnosis	R, U	PSO3,4
CO4	Describe the effect of hormone action- at cellular level and structure and functions of endocrine glands	R, U	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module
Name of the Course: Animal physiology
Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand importance of nutrition physiological functions	PSO-1,2	U	F, C	L	
CO-2	Understand animal physiology	PSO1	R, U	P	L	

CO3	Understand various physiological disorders	PSO3,4	R, U	F	L	
CO4	Understand How hormones controls the physiological functions	PSO3	R, U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	1	3	-	-	-	-						
CO 2	3	-	-	-	-	-						
CO 3	-	-	2	2	-	-						
CO 4	-	-	2	-	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low

2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz Group Discussions/Assignment
- Student Seminar/Observation of practical skills/Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers/Laboratory book/ report/Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		✓

Discipline Specific Elective courses 200-299 DSE-1

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK3DSEBIT200				
Course Title	BIOPHYSICS AND INSTRUMENTATION				
Type of Course	DSE				
Semester	III				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	Basic Physiology, Basic Biochemistry, Fundamentals of Chemistry				
Course Summary	Biophysics and Instrumentation is an advanced graduate-level course that explores the interdisciplinary field where physics principles are applied to biological systems. The course integrates concepts from physics, biology, chemistry, and engineering to understand the physical properties of biological molecules and systems. Emphasis is placed on the development and application of various instrumentation techniques to study biological processes at molecular, cellular, and organismal levels.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Principles of thermodynamics**	12
	1	Thermodynamics and kinetics of biological processes, energy change in the biochemical reactions	
	2.	Electrical properties of biological compartments: membrane potential, Electricity as a potential signal in biological systems, measuring redox potentials in biological reactions. electrochemical gradients, ATP synthesis, and chemiosmotic hypothesis	
II		**Biophysics of physiological events**	12
	3.	Biophysics of Photosynthesis - Light reception in plants, microbes and animals. absorption spectra and action spectra of photosynthetic pigments, Fluorescence and phosphorescence	

	4.	Biophysics of Vision, Muscle movements and Hearing: Mechanism of vision, muscular movements and hearing, correction of vision faults, hearing aids.	
	5.	Intra and inter molecular interactions in the biological system - inter and intramolecular interactions with implications in biological systems. Overview of single-molecule techniques for studying biomolecular interactions and dynamics	
III		**Basic Instrumentation in Biology**	**12**
	6.	Electrophoresis: Principle of electrophoresis, types of electrophoresis, 2-D gel electrophoresis	
	7.	Microscopy: Principle of Microscopy, various types of Microscopy - Simple, Phase contrast, Fluorescence and electron microscopy (TEM and SEM). Overview of cryo-electron microscopy, Atomic force microscopy (AFM) Scanning probe microscopy and Confocal microscopy	
	8.	Basic principles and working of instruments: pHmeter, centrifugation, chromatography	
	9.	Overview: Electrophysiological techniques for studying membrane proteins and ion channels	
	10	Spectrophotometer(UV and Visible) and colorimeter - Beer-Lambert law, atomic absorption spectroscopy, IR, NMR and X-ray Crystallography and Mass Spectrometry.	
IV		**Isotopes and radioisotopes**	**12**
	11.	Application of isotopes and radioisotopes in biological research	
	12.	Overview: Introduction to computational modelling and simulation methods in biophysics.Molecular dynamics simulations for studying biomolecular structure and dynamics. Bioinformatics tools for sequence analysis, protein structure prediction, and systems biology	
V		**Applications of Biophysics and Instrumentation**	**12**
	13.	Drug discovery and development. Biomedical imaging and diagnostics. Biophysical approaches to understanding disease mechanisms. Emerging trends and future directions in biophysics research. Case study reports for radiotracer techniques	
	14.	Submit a report/flowchart for elucidation of the structure of plant metabolites	

Familiarize with the following techniques

1. pH Meter–Use of pH Meter, Familiarization of the instrument and Preparation Phosphate buffers and determination of pH.

2. Spectrophotometer–Familiarization of the working of the instrument, Quantitative estimation of Sugars by Dinitrosalysilic acid and Proteins by Lowry's Method
3. Development of absorption spectra of chlorophyll or any other biological sample
4. Electrophoresis–demonstration of PAGE and Agarose Gel Electrophoresis

Suggested Readings

1. Nelson, D. L., & Cox, M. M. (Year). *Lehninger's Biochemistry*. New York, NY: Worth Publishers.
2. Voet, D., & Voet, J. G. (Year). *Biochemistry*. Boston, MA: Jones & Bartlett
3. Roy, R. N. (Year). *A Textbook of Biophysics*. Calcutta, India: New Central Book Agency Pvt. Ltd.
4. Nair, A. J. (Year). *Introduction to Genetic Engineering & Biotechnology*. Boston, MA: Jones & Bartlett Publishers.
5. Volkenstein, M. V. (Year). *Biophysics*.
6. Cantor, C. R., & Schimmel, P. R. (Year). *Biophysical Chemistry*.
7. Phillips, R., Kondev, J., Theriot, J., & Garcia, H. (Year). *Physical Biology of the Cell*.
8. Lakowicz, J. R. (Year). *Principles of Fluorescence Spectroscopy*.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand how energy changes and conservation in the biochemical reactions is maintained	U	PSO 1, 2
CO-2	Understand the functioning of physiological events like vision, muscle movement and hearing and various types of biological interactions.	R, U	PSO 1
CO3	Understand basic instrumentation to analyse, elucidate and interpret a biomolecule	R U, An	PSO 3, 4
CO4	Analyse the use of isotopes and radioisotopes in understanding the biochemical and physiological events in biology.	R, U, An	PSO 3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Biophysics and instrumentation Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the concepts of energy conservation and changes in biological system	PSO-1,2	U	F, C	L	
CO-2	Understand the biophysics of basic physiological system	PSO1	R, U	P	L	
CO3	Understand Basic instrumentation to elucidate the structure of molecules	PSO3,PSO4	R U, An	F, P	L	P
CO4	Analyser the techniques follow up metabolic pathways	PSO3	R, U, An	P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	2	3	-	-	-	-						

CO2	3	-	-	-	-	-						
CO3	-	-	3	4	-	-						
CO4	-	-	2	-	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK3DSEBIT201				
Course Title	ENZYME ENGINEERING				
Type of Course	DSE				
Semester	III				
Academic Level	200-299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3	1	-	4
Pre-requisites	Biochemistry and metabolism				
Course Summary	Enzyme engineering is a multidisciplinary field that integrates principles from biology, chemistry, biochemistry, and engineering to modify enzymes for diverse applications. This course provides students with a comprehensive understanding of the basics of enzyme structure, function, and engineering methodologies. Students will explore the fundamental principles behind enzyme catalysis, techniques for enzyme characterization, and approaches for optimizing and modifying enzymes. Additionally, the course will showcase how engineered enzymes are applied in various industries including pharmaceuticals, food production, biofuels, and bioremediation.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to enzymes**	**12**
	1.	Enzymes, Extraction, purification, and characterization of enzymes from natural sources.	
	2.	Comparison of chemical and enzyme catalysts	
	3.	Mechanisms of enzyme action– concept of active site and energetics of enzyme-substrate complex formation, specificity of enzyme action	
II		**Preparation and properties of enzymes**	**12**
	4.	Media for enzyme production, Preparation of enzymes.	
	5.	Screening of for novel enzymes – Colorimetric, Fluorometric and biochemical assays Enzyme stabilization - stability of enzyme in various conditions, Strategies for stabilization. Enzyme specificity – level of specificity and factors affecting specificity	
	6.	Enzyme immobilization- Techniques, Benefits and applications	
III		**Enzyme engineering- objectives and Methods**	**12**
	7.	History and background of enzyme engineering, Fundamentals of protein chemistry, Objectives and Method of enzyme engineering.	
	8.	Methods- Rational design (overlap extension and whole plasmid single round PCR) and directed evolution, other methods include De novo enzyme engineering, site directed mutagenesis, random mutagenesis, DNA shuffling, phage display and mRNA display and computational methods.	
IV		**Enzyme engineering applications**	**12**
	9.	Industrial applications, such as enzyme catalysis in biocatalysis, food processing, and detergent manufacturing	
	10.	Application of enzymes in analysis -Biomedical applications, including enzyme-based therapeutics and diagnostics.	
	11.	Environmental applications, such as bioremediation and biofuel production.	

Familiarize with the following techniques

1. Immobilize a model enzyme using different techniques.
2. Test enzyme activity before and after immobilization.

3. Evaluate factors affecting immobilization efficiency.
4. Design mutations using computational tools to improve enzyme properties (e.g., activity, specificity, stability
5. Analyze industrial enzyme formulations and their applications.

Suggested readings

1. Palmer, T. (2008). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (2nd ed.). Affiliated East-West Press Pvt. Ltd.
2. Shukla, A. (2009). *Elements of Enzymology*. Discovery Publishing House Pvt. Ltd.
3. Bailey, J. E., & Ollis, D. F. (1988). *Biochemical Engineering Fundamentals* (2nd ed.). McGraw-Hill.
4. Shuler, M. L., & Kargi, F. *Bioprocess Engineering Basic Concepts* (3rd ed.).

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Demonstrate the comprehensive understanding of enzyme characterisation and purification including mechanism of enzyme action.	U	PSO-1,PSO3
CO-2	Analyse the preparation and screening of enzymes Evaluate enzyme immobilization	An, E	PSO3
CO3	Demonstrate historical background and objectives of enzyme engineering Investigate the methods through rational design and denovo enzyme engineering	R, An	PSO3,4
CO4	Explore the knowledge of enzyme engineering in Industry, biomedical and environmental fields	Ap	PSO4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Enzyme engineering **Credits: 3:1:0 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Evaluate the application of enzymes in various fields	PSO-1,PSO3	U	F, C	L	
CO-2	Understand the methods to improve the enzymes functions	PSO3	An, E	P	L	
CO3	Understand to preserve the structure and functions of the enzymes for long term	PSO3,4	R, An	P	L	P
CO4	Understand the application of engineered enzymes in various field	PSO4	Ap	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	-	2	-	-	-						
CO 2	-	-	3	-	-	-						
CO 3	-	-	2	2	-	-						
CO 4	-	-	-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations

CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK3DSEBIT202				
Course Title	INTRODUCTION TO MARINE BIOTECHNOLOGY				
Type of Course	DSE				
Semester	III				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week

	4	3	1	-	4
Pre-requisites	Basic Biotechnology, Microbiology				
Course Summary	Marine Biotechnology is an interdisciplinary field at the forefront of scientific research, harnessing the vast potential of marine organisms and ecosystems for various applications in biomedicine, aquaculture, environmental management, and beyond. This graduate-level course delves into the principles, methodologies, and applications of marine biotechnology, equipping students with the knowledge and skills necessary to navigate the complexities of this dynamic field.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Marine Microbial environment**	12
	1	Classification of the marine environment.	
	2	Marine microbial habitats , Diversity of Marine microorganism.	
	3	Characteristics of marine microorganisms. Specialized microorganisms: Extremophiles: barophiles, thermophiles, psychrophiles, , halophiles, actinomycetes, polyextremophiles, anaerobes	
II		**Techniques in Marine microbiology:**	12
	4	Techniques in Marine microbiology: Sampling: Water, Sediments.	
	5	Culture based methods for isolation and, identification of microbes. define, selective and differential culture media.	
III		**Bioactive molecules from marine sources**	12
	6	Microbial nutrition: i) autotrophic & heterotrophic modes	
	7	Antibacterial and anti biofilm molecules produced by marine bacteria, Chitin from poriferan	
	8	Chemotaxis, Phototaxis, Bioluminescence and indicator species and Biological Rhythms	
IV		**Marine bio resources**	12
	9	Marine bio resources. Brief introduction - Marine microbes (viruses, bacteria, archaea, protists, fungi) Marine algae and plants (seaweeds, sea grasses, mangrove, plants) Invertebrates: sponges, cnidarians, polychaetes, crustaceans, marine worms, molluscs, echinoderms, arthropods, Non-craniate (non-vertebrate) chordates,	
	10	Molecular Adaptations in Marine Organisms: Mechanisms of adaptation to extreme environments	
V		**Ecosystem functioning in marine environment**	12
	11	Food web dynamics and ecosystem functioning, Microbial loop - Role of microbes in marine food web dynamics, - Biogeochemical	

		processes: Nutrient cycling, carbon cycle, Nitrogen cycle, Sulphur cycle, Iron cycling, Phosphorus cycling and other cycles	

Familiarize with the following experiments

1.Demonstrate Marine Sampling Technique- sampling marine environments (e.g., plankton nets, sediment cores, water column sampling).

2.Collection of water samples from different marine habitats (coastal, pelagic, deep-sea).

3.Isolation and characterization of marine microorganisms using culture-dependent and culture-independent techniques (e.g., metagenomics).

4.Field trip to marine ecosystems such as coral reefs, mangroves, or hydrothermal vents.

5.Identification and collection of marine organisms with potential biotechnological application

Suggested Reading

1. Blue iotechnology: production and Use of Marine Biomolecules. Stephane La Barre, Stephen S Bates. 2018. Wiley
2. Munn, C.B. , (2004) Marine Microbiology: Ecology and Applications, BIOS Scientific Publisher.
3. Krichman, D.L.,(2000), Microbial Ecology of the Oceans. Wiley-Liss, New York.
4. Paul,J.,(2001) Methods in Microbiology : marine Microbiology, Academic Press.
5. Gram, L., (2009) Microbial Spolage of Fish and Seafood, Springer
6. Pelczar M.J. Jr., ChanE.C.S. and Kreig N.R. (2001) Microbiology, (5th Edition) CBS Publishers.
7. Josep M Gasol and David L Kirchman (2018) Marine ecology of the oceans, (3rd edition), John Wiley and Sons. Inc
8. Surajit Das Hirak Dash (2018) Microbial Diversity in the Genomic Era, Elsevier
9. Horikoshi K, Antranikian G, Bull A T, Robb F T and Stetter, K O (2011) Extremophiles Handbook, Springer
10. Madigan, Martinko, Bender, Buckley & Stahl and Thomas Brock (2017) Brock Biology of Microorganisms, Pearson

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss about Marine Microbial environment and its economic impact by biomaterial synthesis	U	PSO-1
CO-2	Identify the methods for biological and pharmaceutical investigation of crude extract, isolation , identification of active substances and synthesis of biomaterials	R, U,Ap	PSO3
CO3	Awareness of different bio-resources in marine environments and overview of different bioactive compounds	U,E	PSO1
CO4	Analyse different marine environments that affect overall productivity	R,U	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Introduction to marine biotechnology Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Discuss about Marine Microbial environment	PSO-1	U	F, C	L	
CO-2	Identify the methods investigation of active substances	PSO3	R, U, Ap	P	L	P
CO3	Awareness of different bio - resources in marine environment	PSO1	U, E	U	L	

CO4	Analyse different marine environment that affect overall productivity	PSO3,4	R, U	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						
CO 2	-	-	3	-	-	-						
CO 3	-	-	1	-	-	-						
CO 4	-	-	2	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK3DSEBIT203
Course Title	BIOMOLECULAR INTERACTIONS & CELL SIGNALLING

Type of Course	DSC				
Semester	III				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3	1	-	4
Pre-requisites	Cell biology & molecular biology				
Course Summary	This course covers a wide range of topics related to host-parasite interaction, cellular communication, and signalling regulation, providing students with a comprehensive understanding of these complex biological processes				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Biomolecular Interactions**	12
	1	Overview of biomolecules: proteins, nucleic acids, carbohydrates, and lipids Forces governing biomolecular interactions: electrostatic, hydrophobic, hydrogen bonding Techniques for studying biomolecular interactions: spectroscopy, chromatography, mass spectrometry	
	2	Cellular interactions: Extracellular matrix molecular interaction, matrix proteins, integrins, focal adhesions and hemidesmosomes; Cell-cell interactions and cellular junctions	
II		**General principles of cell communication**	12
	3	Basics of cell signaling: autocrine, paracrine, endocrine signaling Signal transduction pathways: receptor activation, intracellular signaling cascades- Hormones and their receptors, cell surface receptor, Ser/Thr protein kinases and phosphatises, Tyr phosphorylation signaling receptor and non-receptor TKs, Protein Kinase (PKC) Signaling, cytokine receptors and the JAK-STAT Pathway signaling through Gprotein coupled receptors,Toll like Receptors, Inflammasomes , Role of NO as an Intercellular Messenger , Regulation of cell signaling: feedback mechanisms, cross-talk between pathways	
	4	general principles of cell communication - cell adhesion and roles of different adhesion molecules, gap junctions, extracellular malrix, integrins, neurotransmission and its regulation	
	5	Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into host cel1s, alteration of host ce1l behaviour by pathogens ,bacterial signalling systems, bacterial chemotaxis and quorum sensing.	
III		**Protein-Protein Interactions**	12
	6	Structural basis of protein-protein interactions	
	7	Methods for studying protein-protein interactions: yeast two-hybrid, co-immunoprecipitation, surface plasmon resonance	
	8	Applications in drug discovery and protein engineering,	

		Post-translational modifications and their impact on protein function Membrane protein interactions and their significance in cellular processes	
IV		**Protein-DNA Interactions**	12
	9	Mechanisms of protein-DNA recognition and binding	
	10	DNA-binding domains and transcription factors	
	11	Genome-wide approaches for studying protein-DNA interactions: ChIP-seq, DNase-seq	
V		**Cell Signaling in Disease**	12
	12	Aberrant signaling in cancer, neurodegenerative diseases, and metabolic disorders Targeting signaling pathways for therapeutic interventions Case studies illustrating the role of biomolecular interactions in disease progression and treatment	

Familizarize with the following experiments

1. Stimulate cells with a signaling molecule (e.g., growth factor or hormone).
2. Monitor the activation of downstream signaling components using techniques like immunoblotting, immunofluorescence, or ELISA.
3. Examine the effect of signaling pathways on gene expression.
4. Treat cells with pathway activators or inhibitors.
5. Measure changes in mRNA expression using qRT-PCR, RNA-seq, or microarray analysis.

Suggested Reading

1.G. Karp, Cell and Molecular Biology, 5th Edn., Wiley, 2007
2. D. L. Wheeler, Y. Yarden, Receptor Tyrosine Kinases: Structure, Functions and Role in Human Disease, Springer, 2014
3. Q. A. Acton, Receptor Protein-Tyrosine Kinases: Advances in Research and Application, ScholarlyEditions, 2012
4. B. Alberts, A. Johnson, J. Lewis, and M. Raff, Molecular Biology of the Cell, 5th Edn., Garland Science, 2008.
5. H. Lodish, A.Berk, C.A. Kaiser, and M. Krieger, Molecular Cell Biology, 6th Edn., W. H. Freeman,2007.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Explore the role of biomolecular interactions in cellular processes and disease mechanisms.	U	PSO-1,2

CO-2	Explain the fundamental principles of cell communication, including signaling pathways, signal transduction, and cellular responses to extracellular stimuli.	R, U	PSO1
CO-3	Analyze various cell signaling pathways, including those mediated by hormones, growth factors, and cytokines, and their corresponding receptors.	U,AN	PSO1,PSO3,4
CO-4	Explore the role of biomolecular interactions in cellular processes and disease mechanisms..	U,AN	PSO4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Biomolecular interactions & cell signalling Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand basics of host –pathogen interaction	PSO-1,2	U	F, C	L	-
CO-2	Explain fundamentals of cell signalling	PSO1	R, U	P	L	-
CO-3	Discuss various receptors and signalling molecules	PSO1,PSO3,4	U,AN	F	L	-
CO-4	Analyse the cell signalling regulation	PSO4	U,AN	C	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	2	2	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	2	3	-	-						
CO 4	-	-	-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

Value Added Courses 200-299

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK3VACBIT200

Course Title	IPR,BIOETHICS AND BIOSAFETY				
Type of Course	VAC				
Semester	III				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1		3
Pre-requisites	Essentials of Biotechnology				
Course Summary	This course provides an in-depth exploration of the intersection of intellectual property rights, bioethics, and biosafety within the context of modern scientific research and biotechnology. It aims to equip students with a comprehensive understanding of the legal, ethical, and safety considerations inherent in the development, dissemination, and regulation of biotechnological innovations.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Basics of Intellectual Property Rights**	**9**
	1	**Basics of Intellectual Property Rights** Types of IPR-industrial-patent(types),design, trademark,trade secret, GI; non industrial-copyright(types, infringement, exclusions), Patentable and non-patentable, patenting life, Rights of traditional knowledge holders , Peoples biodiversity register	
	2	legal protection of biotechnological inventions, Pros & Cons of IP, World Intellectual Property Right Organization(WIPO), TRIPS agreement, UPOV convention Patent Infringement(Case Study), Plagiarism, plagiarism detection softwares and ways to avoid plagiarism	
II	**Biosafety**		**9**
	3	Biosafety-Different levels of Biosafety, Biosafety levels of specific Microorganisms;	
	4	Recommended Biosafety levels for Infectious agents and Infected animals, Biosafety Issues in Biotechnology, Biological Safety Cabinets; Containments- Types.	
	5	Examine the principles and practices of biosafety in laboratory and industrial settings. Evaluate risk assessment methodologies and strategies for mitigating biological hazards. Discuss regulatory frameworks and guidelines for biosafety compliance, including containment protocols and waste management.	
	6	Basic Laboratory and Maximum Containment Laboratory	
III		**Guidelines of Biosafety**	**9**
	7	Guidelines of Biosafety Biosafety guidelines and regulations (National and International) – Operation at National level; GMO's and LMO's – Definition,	

	8	Institutional Biosafety Committee, RCGM, GEAC, for GMO applications in Food and Agriculture,	
	9	Assessment and management of risks associated with GMO	
IV		**Bioethics**	**9**
	10	Bioethics -Introduction. key concepts and principles in bioethics, including autonomy, beneficence, nonmaleficence, and justice. Animal Ethics, Animal Rights, Biotechnology and Ethics	
	11	Ethical issues related to research in embryonic stem cell cloning	
	12	Ethical, Legal and Social Implications (ELSI) of Human Genome Project.	
V		**Essentials of scientific experiments**	**9**
	13	Values in science, Misconduct in science, Negligence and error, Conflict of interest, Techniques used and treatment of data	
	14	Analyze case studies and real-world examples to understand the practical application of IPR in biotechnology.	
	15	Debate contemporary bioethical issues such as gene editing, and access to healthcare.	

Suggested Reading

1. Intellectual Property Rights: A Practical Guide to Content, Protection, and Exploitation" by Stephen Johnson
2. "Intellectual Property: A Very Short Introduction" by Siva Vaidhyanathan
3. "Intellectual Property in the New Technological Age" by Robert P. Merges and Peter S. Menell
4. Bioethics: Principles, Issues, and Cases" by Lewis Vaughn
5. "Principles of Biomedical Ethics" by Tom L. Beauchamp and James F. Childress
6. "Bioethics: An Introduction" by Marianne Talbot
7. Biosafety in Microbiological and Biomedical Laboratories" by Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH)
8. "Biosafety in Industrial Biotechnology" by Preeti Jain and Rakesh Singh
9. "Handbook of Laboratory Health and Safety" by Robert H. Hill Jr. and David W. Smith

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand basics of Intellectual Property Rights and various treaties associated with it at international level	R ,U	PSO-2,5
CO-2	Awareness about legal protection of biotechnological inventions	U	PSO-2,5

CO3	Awareness about Biosafety levels at specific Microorganisms level and biosafety regulations	U	POS5
CO4	Understand Ethical issues related to research in different areas of Biotechnology	U	PSO5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: IPR,bioethics and biosafety Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understood IPR and treaty's	PSO-2,5	R ,U	F, C	L	P
CO-2	Awareness about legal protection to Biological inventions	PSO-2,5	U	P	L	
CO3	Awareness about Biosafety levels	PSO5	U	F	L	
CO4	Understand Ethical issues related to biological research	PSO5	U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	-	-	3	-						
CO 2	-	3	-	-	3	-						
CO 3	-	-	-	-	2	-						

CO 4	-	-	-	-	3	-					

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓

SEMETER IV

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK4DSCBIT206
Course Title	CELL BIOLOGY & GENETICS
Type of Course	DSC
Semester	IV

Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic understanding of cell structure and function, genetics and regulation				
Course Summary	At the graduate level, a course in Cell Biology and Genetics typically delves deep into the intricate mechanisms underlying cellular function, molecular genetics, and their profound implications in various biological processes				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Fundamentals of Cell Biology**	**4**
	1	History and scope of Cell Biology; discovery of cells. Cell theory and its modern version. General classification of cell types: prokaryotes and eukaryotes, PPLOs, bacteria, plant cell and animal cell	
	2	Structure of cell organelles: morphology, types, formation and functions. Nucleus–structure and function Vescicular transport	
	3	Mitosis, meosis - description of all stages with illustrations	
II		**Cell functions and regulations**	**12**
	4	Introduction to cell signaling pathways, Signal transduction mechanisms Receptor-mediated signaling and second messengers.	
	5	Cell stress responses, Apoptosis and programmed cell death Cell survival mechanisms	
	6	Cell cycle phases and checkpoints Regulation of cell cycle progression	
	7	Introduction to stem cell biology,Applications of stem cells in biotechnology Tissue engineering principles and techniques, Biopharmaceutical production,Cell-based therapies(CS)	
III		**Basic genetics**	**10**
	8	Mendelian genetics: Laws of inheritance , Allelic /non-allelic Genes Interaction: complete, incomplete dominance, co-dominance	
	9	Multiple alleles- ABO Blood group system, Rh group and its inheritance	
	10	Chromosomal theory of inheritance, Linked genes, factors affecting linkage ,Sex Linkage, , sex influenced genes, Crossing over and recombination	
	11	Genetic variation and its significance in biotechnology	

	12	Hardy-Weinberg equilibrium Genetic drift, gene flow, and population structure ,	
	13	Molecular evolution and phylogenetics Human population genetics and disease susceptibility	
IV		**Advanced Genetic Techniques**	**10**
	14	Gene cloning and expression	
	15	Genome editing techniques (CRISPR/Cas9, TALENs, Zinc finger nucleases)	
	16	Transgenic organisms and their applications	
	17	Genetic disorders, gene therapy	
	18	Industrial biotechnology: Microbial genetics, metabolic engineering	
V		**Human Genetics**	**9**
	19	Karyotyping, normal chromosome complement, pedigree analysis	
	20	Chromosomal anomalies in Human: Autosomal (eg. Down syndrome, Edwards syndrome), Allosomal (eg.Klinefelters syndrome, Turner's syndrome)	
	21	Biochemical genetics: Human biochemical genetics, biochemical pathway of phenylalanine - tyrosine metabolism in normal human body. Disorders - Phenylketonuria, Alkaptonuria, Tyrosinosis and Albinism	

Practicals 30 hrs- Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Measurement of size of microscopic objects using ocular and stage micrometers
2. Study of different types of cells (prokaryotes and eukaryotes) using slides/models/charts.
3. Study of cytoplasmic organelles and cell inclusions (through permanent slides, models and charts)
4. Study of interphase nucleus in human buccal smear and Barr bodies.
5. Study of mitochondria in insect flight muscles/ human buccal smear.
6. Study of stages of mitosis – squash preparation of onion root tip.
7. Calculation of mitotic index and metaphase index in onion root.

Genetics

1. Study of monohybrid ratio using coloured beads.
2. Study of normal chromosome complement and karyotype of man.
3. Preparation of karyoidiogram from microphotographs
4. Study of abnormal karyotypes and genetic syndromes of man (Down syndrome, Turner's syndrome and Klinefelter's syndrome)
5. Construction of pedigree chart – any two

6. Frequency of genetic traits in humans: blood groups, eye colour, widow's peak (any two traits).

Suggested Readings

Cell Biology

1. Powar,C.B.CellBiology.HimalayaPublishingHouse.
2. Verma,P.S.&Agarwal,V.K.Cytology,S.Chand&Co.
3. Alberts,B.etal.MolecularBiologyoftheCell.GarlandScience.
4. DeRobertis,E.D.P.andDeRobertis,E.M.F.CellandMolecularBiology,LippincottWilliamsand Wilkins
5. Karp,Gerald.CellandMolecularBiology.JohnWileyandSons
6. Lodish,Harveyetal.MolecularCellBiology.ScientificAmericanBooks
7. Sadava,D.E.Cell Biology.Jones and Bartlett Publishers.
8. Sharma,A.Chromosomes,Oxford&IBHWolfe,S.L.MolecularandCellularBiology.Wadsworth Pub.Co.

Genetics

1. Ahluwalia, K.B. Genetics. New Age International (P) Ltd. Publishers
2. Burns, G. W. &Bottino, P. J. The Science of Genetics. Maxwell McMillan
3. Curt Stein. Principles of Human Genetics. Euresia Publishing House
4. Gardner, E. J. et al. Principles of Genetics. John Wiley & Sons.
5. Goodenough, U. Genetics. Halt, Reinharts& Winston
6. Gupta, P.K. Cytogenetics. Rastogi & Co.
7. Sinnott, W.E., Dunn, L.C. and Dobzhansky, T. Principles of Genetics, TMH
8. Verma, P.S. and Agarwal V.K. Genetics. S.Chand and Co.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Explain the structure and function of different cell organelles and how they work	R, U	PSO-1,2
CO-2	Understand and explain Chromosome structure at molecular level	R, U	PSO1
CO-3	Understand and illustrate the cyclic events of cell division and types of cell division	R, U	PSO1

CO-4	Explain laws and concepts of Mendelian Genetics and illustrate and compare its deviations	R, U	PSO1,PSO3
CO-5	Understand and explain linkage and crossing over	R, U	PSO3,4
CO-6	Determining the chromosome structure using different genetic analysis methods	U, Ap	PSO4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Cell biology & Genetics **Credits: 2:1:2 (Lecture:Tutorial:Practical)**

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Explain how cell organelles works	PSO-1,2	R, U	F, C	L	
CO-2	Explain the architecture of chromosomes	PSO1	R, U	P	L	
CO-3	Explain how cell division happening	PSO1	R, U	C	L	
CO-4	Explains how inheritance is working	PSO1, PSO3	R, U		L	
CO-5	Explain how some genes works together and genetic linkage	PSO3,4	R, U	C	L	
CO-6	Analytical methods to determine	PSO4	U, Ap	P	-	P

	Chromosome structure and mapping					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	3	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	-	-	-	-						
CO 4	2	-	2	-	-	-						
CO 5	-	-	2	3	-	-						
CO 6	-	-	-	3	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz ,Group Discussions,Assignment,Student Seminar

- Observation of practical skills,Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative Internal test papers,Laboratory book/ report,Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓		✓	

University of Kerala

Discipline	BIOTECHNOLOGY

Course Code	UK4DSCBIT207				
Course Title	MOLECULAR BIOLOGY				
Type of Course	DSC				
Semester	IV				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Essentials of Biotechnology Basic understanding on Genetics and DNADNA structure				
Course Summary	This core-course imparts an essential foundation for understanding of mechanisms and regulations of gene expression at molecular level. Understanding the molecular basis of life is very important to apply manipulation strategies in the future for genetic engineering and genome editing.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Molecular basis of life**	**8**
	1	History and significant discoveries in molecular biology, Classicexperiments demonstrating DNA as the genetic material	
	2	Structure of DNA, Central dogma of molecular biology	
	3	Eukaryotic chromosomes- molecular organization, nucleosomes.	
	4	Replication of DNA(prokaryotic and eukaryotic), enzymes involved in DNA replication, Replication fork, action of telomerase.	
II		**Gene expression I**	**10**
	5	Transcription(Prokaryotic and Eukaryotic)- mechanism	
	6	RNA Polymerase, promoter, transcription factors	
	7	Types of RNA-mRNA, tRNA, rRNA and small nuclear RNA (snRNA), mi RNA.	
	8	Post-transcriptional modification of mRNA in eukaryotes-capping, tailing and splicing mechanisms.	
III		**Gene expression II**	**10**
	9	Organisation of prokaryotic and eukaryotic gene- split genes, introns and exons, reading frame, enhancers and silencers	
	10	Genetic code - properties of genetic code, Codons, codon assignment, redundancy and wobble theory(CS)	
	11	Translation- mechanism of translation in prokaryotic and eukaryotic mRNA	
	12	Post translational modification of proteins (CS), Extrachromosomal Inheritence	
IV		**Gene regulation**	**8**

	13	Prokaryotic gene regulation, operon, (lac and trp operon), catabolic repression, attenuation	
	14	Eukaryotic gene regulation; levels of control of gene expression, epigenetics (CS)	
	15	Regulation of RNA processing, mRNA degradation and protein degradation control, RNA interference, microRNAs, RNA interference,Translational regulation: riboswitches, RNA-binding proteins	
	16	Genome Editing Technologies Zinc finger nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs) CRISPR-Cas9 system: mechanism and applications	
	17	Non-coding RNAs: long non-coding RNAs (lncRNAs), circular RNAs (circRNAs) Synthetic biology: designing biological systems for specific purposes	
V		**Tools and Techniques in Molecular Biology**	**9**
	18	DNA isolation: Principle and Protocol, Purification and quantification methods- UV Spectrophotometry	
	19	Gel electrophoresis- Principle and applications in separating macromolecules.	
	20	PCR, Southern Blotting , Microarray- mRNA isolation, cDNA synthesis, expression profiling	
	21	Protein isolation, purification, western Blotting, enzyme assays	

Practicals 30 hrs- (Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Familiarisation of instruments and equipments used in molecular biology laboratory
2. Preparation of solutions and buffers for DNA isolation
3. Isolation of Genomic DNA from a suitable source- bacteria, plant or animal tissue
4. Examination of the purity of DNA by agarose gel electrophoresis.
5. Quantification of DNA by UV-spectrophotometer
6. Isolation and purification of plasmid DNA
7. Agarose gel analysis of plasmid DNA
8. Extraction of Protein and RNA from plant samples.
9. Visit a molecular biology laboratory within the entire course tenure

Suggested Reading:

1. Applied Molecular genetics – R L Miesfeld; Wiley.Liss, New Delhi.

3. Essential molecular Biology- A practical Approach, T A Brown; Oxford, New York

4. Gene VIII- Benjamin Lewin; Oxford University Press.

5. Molecular Biology, PS Verma and VK Agarwal, S.Chand & Company pvt Ltd, New Delhi

6. Introduction to Molecular biology- P. Paolella; McGraw Hill, New York

7. Molecular Biology of the gene – Watson, Baker, Bell Gann, Lewinw, Losick; Pearson Education Pvt.Ltd, New Delhi

8. Molecular cell biology, H S Bhamrah; Anmol Publications Pvt. Ltd., New Delhi.

9. PCR 3 - Practical Approach – C. Simon Hearington& John J O'Leary; Oxford, New York

10. Principles of Gene manipulation- R.W.Old& S.B. Primrose; Blackwell Scientific Publications

11. M. R. Green, J. Sambrook. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor, ed. 4, 2012).

12. M. M. Burell. Enzymes of Molecular Biology (Humana Press, 1993).

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concept of gene, its structure and expression	R, U	PSO-1,2
CO-2	Differentiate the mechanism of DNA replication in prokaryotes with eukaryotes	U, An	PSO1
C0-3	Understand the gene regulation mechanisms in a living cell	R, U	PSO1,PSO3
CO-4	Analyse the purity of a given DNA sample by UV spectrophotometry	U, An	PSO3,4
CO-5	Understand how the genome is compacted to chromosome level	R, U	PSO3,4
CO-6	Handle DNA samples for quantification, subjecting the sample to separation by gel electrophoresis	An, Ap	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Molecular Biology **Credits: 2:1:2 (Lecture:Tutorial:Practical)**

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understand the concept of gene	PSO-1,2	R, U	F, C	L	
CO-2	Differentiate prokaryotic and eukaryotic replication	PSO1	U, Ap	C, P	L	
CO-3	Understand the gene regulation	PSO1,PSO3	U, An	F,C	L	
C0-4	Analyse DNA sample purity	PSO3,4	An,Ap	P		P
CO-5	Understand genome compaction	PSO3,4	R,U	F,C	L	
CO-6	Handling DNA, for quantification and gel electrophoresis	PSO3	An,Ap	C, P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**

CO1	1	3	-	-	-	-						
CO2	2	-	-	-	-	-						
CO3	2	-	3	-	-	-						
CO4	-	-	2	3	-	-						
CO5	-	-	3	3	-	-						
CO6	-	-	3	-	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz

- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓		✓	✓
CO 5		✓		✓
CO 6			✓	

Discipline	BIOTECHNOLOGY				
Course Code	UK4DSCBIT208				
Course Title	DEVELOPMENTAL BIOLOGY				
Type of Course	DSC				
Semester	IV				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge on Cell Biology, Genetics and Biochemistry				
Course Summary	This course involves intricate processes that govern the growth, differentiation, and morphogenesis of organisms from a single cell to a complex multicellular organism. This course explores the molecular, cellular, genetic, and environmental factors that orchestrate these developmental processes with special emphasis on Human Physiology and Reproduction				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Developmental stages**	12
	1	Historical perspective- preformation, epigenesis, germplasm and biogenetic law; aim and scope of Developmental Biology Egg: structure of a typical egg; and classifications types of Cleavage: cell lineage.	
	2	Fertilization and early embryogenesis, Axis formation and pattern formation, Germ layer specification and gastrulation Organogenesis and limb development	
	3	Cell Differentiation: Cell fate determination and lineage commitment Signal transduction pathways in development Stem cells and their roles in tissue regeneration ,Parthenogenesis	
II		**Molecular Regulation of Development**	10
	4	Gene regulation during development Role of transcription factors and signaling molecules in fate determination , Epigenetic mechanisms in developmental programming	
	5	Experimental Embryology Morphogenesis and Tissue Engineering, Cell adhesion and migration Epithelial-mesenchymal transitions (EMT) Applications of developmental biology in tissue engineering and organ regeneration	

	6	Fate map construction: vital staining, carbon particle marking and radioactive tracers.Spemann's constriction experiments.Nuclear transplantation in amphibians. Embryonic induction: concept of induction and organizer; primary, secondary and tertiary induction and organizers. Cloning in animals	
III		**Human reproduction**	**7**
	7	Reproductive Biology Reproductive cycles: oestrous and menstrual cycles and their hormonal control. Gonads: Ovary, Graafian follicle, ovulation. Gametes: structure of ovum and spermatozoan. Gametogenesis: Spermatogenesis and oogenesis. Role of molecular signaling in embryo development, Causes of infertility in males and females	
	8	Development of man: fertilisation, blastocyst; implantation; brief account of pregnancy, gestation, parturition and lactation; teratology (definition).	
IV		**Diagnostics and treatment approaches of human reproduction**	**7**
	9	In vitro fertilization (IVF) and its applications Assisted reproductive technologies (ARTs) and ethical considerations Preimplantation genetic diagnosis (PGD) and screening	
	10	Disorders of the reproductive endocrine system,Role of hormones in fertility treatments Genetic basis of reproductive disorders Gene editing techniques and their potential applications in reproductive genetics Pharmacological interventions in reproductive endocrinology	
V		**New technological developments in Diagnostcis**	**9**
	11	new technological developments in Diagnostcis approaches in human reproduction	
	12	Case study report of lateral flow assays in diagnosis of body fluids	

Practicals 30 hrs- (Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1. Developmental Biology (charts/models/permanent slides)

2. Study of different types of eggs: frog, chick and man.

3. Frog development: Cleavage, Blastula, Gastrula

4. Chick embryology: Primitive streak stage and 24 hours embryo.

Suggested readings

1. Arora, Mohan P. Embryology. Himalaya Publishing House.
2. Arumugam, N. Developmental Zoology. SARAS Pub.
3. Gayatri Prakash. Reproductive Biology. Narosa Pub. House
4. Majumdar, N.N. Textbook of Vertebrate Embryology. TMH
5. Rao, K. Vasudeva. Developmental Biology: A Modern Synthesis. Oxford IBH
6. Verma, P.S. and Agarwal V.K. Chordate Embryology. S.Chand and Co.
7. Bejley, D.J. et al. Human Reproduction & Developmental Biology. McMillan
8. Berril, N.J. & Karp, G. *Development*. TMH.
9. Patten, B.M. *Early Embryology of the Chick*. TMH.
10. Patten, B.M. *Foundations of Embryology*. McGraw Hill.
11. Rugh, R. *Frog Reproduction and Development*.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Describe the embryonic development and differentiation of mammalian egg	U	PSO-1,2
CO-2	identify various areas of mammalian egg and describe the fate map of embryonic layers	R, U	PSO1
CO3	Understand the development ,structure and functions of human reproductive system	R, U	PSO1
CO4	Understand various Diagnostics approaches of human reproductive function	U, Ap	PSO1,3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Developmental Biology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Describe the concepts of	PSO-1,2	U	F, C	L	-

	embryonic development					
CO-2	Describe the embryonic layer and its molecular regulation	PSO1	R, U	P	L	-
CO3	Understand how human reproductive system works	PSO1	R, U	F	L	-
CO4	Understand the diagnostics approaches in Human reproductive functions	PSO1,3	U, Ap	F,P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	2	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	-	-	-	-						
CO 4	2	-	2	-	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics: Continuous Comprehensive Assessment:

Formative : · Interactive Quiz /· Group Discussions/· Assignment/· Student Seminar

· Observation of practical skills/· Journal Club presentations/· Punctuality in lab, and time management in completing assigned laboratory tasks

Summative-· Internal test papers/· Laboratory book/ report/ Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY

Course Code	UK4DSCBIT209				
Course Title	METABOLISM AND ENERGETICS				
Type of Course	DSC				
Semester	IV				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge on Biochemistry and Cell biology				
Course Summary	Metabolism and energetics are fundamental processes governing life at the molecular level. This graduate-level course delves into the intricate biochemical pathways that regulate metabolism and the principles of energy conversion within living organisms. Students will explore the structure and function of key metabolic pathways, the regulation of metabolic processes, and the integration of metabolism with cellular function and organismal physiology.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Metabolism: Basic concepts**	**6**
	1	Metabolism basic concepts- Energy rich compounds-ATP	
	2	Common types of reaction in metabolism-Oxidation, reduction, phosphorylation, hydrolysis, hydroxylation, carboxylation.	
II		**Metabolism of Biomolecules-I**	**10**
	3	Metabolism of carbohydrates Glycolysis. Gluconeogenesis, Glycogen metabolism-glycogenesis, glycogenolysis. Regulation (Outline study; Only pathway outlines, structures not required).	
	4	Metabolism of Lipids (outline study). Scheme of β- oxidation, ATP yield in β oxidation (stearate & palmitate as examples) and regulation. Basics of α- and ω- oxidation, ketone body formation, cytoplasmic system of fatty acid biosynthesis and regulation of the pathway, outline study of biosynthesis of cholesterol and bile acids (structure not required).	
III		**Metabolism of Biomolecules-II**	**10**
	5	Metabolism of amino acids. Reactions involved in the metabolism of amino acids-deamination, transamination and decarboxylation; coenzymes involved in these reactions. Urea cycle (structure not required)	
	6	Metabolism of Nucleic Acids-Salvage & Denova Pathway.	
IV		**Bioenergetics and Redox reactions**	**10**

	7	Bioenergetics Redox reactions, redox potential and free energy, mitochondrial electron transport chain, coenzymes and prosthetic groups of respiratory chain enzymes.	
	8	Sites of ATP production, P/O ratio, inhibitors of electron transport chain, oxidative phosphorylation- chemiosmotic hypothesis (outlines only), uncouplers of oxidative phosphorylation. Formation of ATP- oxidative and substrate level phosphorylation	
	9	High energy compounds with structures (ATP, ADP, Creatine phosphate, 1, 3 bisphosphoglycerate, PEP), role of high energy phosphate groups.	
V		**Overview of Microbial metabolism**	**9**
	10	Microbial products as primary and secondary metabolites	
	11	Pathways for the synthesis of primary and secondary metabolites of commercial importance. intermediates from primary metabolism and their secondary metabolite derivatives	

<u>Practicals 30 hrs- (</u>Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

1.Quantitative Analysis of Amino acids and Proteins

Estimation of Tyrosine by Folin-Lowry method.

Estimation of Protein by Biuret method.

Estimation of Protein by Folin-Lowry method.

2.Quantitative Analysis of Nucleic Acids

Estimation of DNA by diphenylamine method.

Estimation of RNA by Orcinol method

3. Qualitative analysis of Lipids Test for fatty acids (stearic acid/ oleic acid): Solubility, translucent spot tests, test for unsaturation

Test for glycerol: solubility, acrolein test, borax-fusion test.

Test for cholesterol: Solubility, Salkowski reaction, Liebermann-Burchard reaction

Quantitative Analysis of Lipids

Estimation of cholesterol by Carr-Drecktor method.

Estimation of cholesterol by Zak's method.

Determination of acid value.

Determination of saponification value.

Determination of iodine number of oil

Suggested Readings:

1. Principles of Biochemistry" by Albert L. Lehninger, David L. Nelson, and Michael M. Cox
2. Biochemistry" by Jeremy M. Berg, John L. Tymoczko, and Gregory J. Gatto Jr.
3. Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter:
4. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry" by Irwin H. Segel:
5. Advanced Nutrition and Human Metabolism" by Sareen S. Gropper, Jack L. Smith, and Timothy P. Carr
6. Metabolic Engineering: Principles and Methodologies" edited by Greg Stephanopoulos, Aristos A. Aristidou, and Jens NielsenCourse Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the basic concept of metabolism	U	PSO-1,2
CO-2	Functioning of various biomolecule.	R, U	PSO1
CO-3	Explain various methods involved in the generation of energy molecules	U, R	PSO3
CO-4	Analysis of various biomolecules	An, Ap	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Metabolism and Energetics Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understand the basic concept of metabolism	PSO-1,2	U	F, C	L	-

CO-2	Functioning of various biomolecules.	PSO1	R, U	P	L	-
CO-3	Explain various methods involved in the generation energy molecules	PSO3	U, R	C	L	-
CO-4	Analysis of various biomolecules	PSO3	An, Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	1	1	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	-	-	1	-	-	-						
CO 4	-	-	2	-	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low

2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4			✓	✓

Discipline Specific Elective courses 200-299, DSE2

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">BIOTECHNOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK4DSEBIT204</td></tr>
<tr><td>Course Title</td><td colspan="5">BIOINFORMATICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">DSE</td></tr>
<tr><td>Semester</td><td colspan="5">IV</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299.</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>4</td><td>2 hours</td><td>1</td><td>2</td><td>5</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Essentials of biotechnology, Molecular Biology</td></tr>
<tr><td>Course Summary</td><td colspan="5">Bioinformatics is a multidisciplinary subject that is a combination of studies related to Life Science, Computer Languages, Data Science, Systems Biology and Basic Engineering. This course is intended to introduce the subject of bioinformatics to the students of biotechnology, to empower them with the skills of computational biology, to analyse and process data using bioinformatics tools.This course will familiarise students to the importance of role of omics in the better learning of Systems Biology in a holistic way. The basic learning of this Bioinformatics course will help them to pursue a career in Bio Analytics, Data Analytics, Proteomics, Pharmacology and AI.</td></tr>
</table>

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**introduction to bioinformatics**	6

	1	History and evolution of bioinformatics, Scope and impact of bioinformatics in Life Science research.	
	2	Introduction to Systems Biology, Generation of large scale molecular biology data	
	3	Databases and DBMS, Biological Databases- Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary, Composite, and Secondary).Specialized Genome databases: (SGD, TIGR, and ACeDB). Structure databases (CATH, SCOP, and PDBsum). Data mining	
	4	Fundamentals of programming languages and statistical methods in Bioinformatics	
II	**sequence alignment**		10
	5	Sequence homology Vs Similarity	
	6	Sequence alignment- Global and Local alignment- Dynamic programming	
	7	Pairwise alignment (BLAST and FASTA Algorithm)	
	8	Multiple sequence alignment (Clustal W and PRAS algorithm).	
III	**structural bioinformatics**		10
	9	Levels of protein structure, structure prediction methods for proteins' secondary (Chou Fasman) and tertiary structures (Homology Modeling)	
	10	Introduction to Molecular Docking and docking softwares.	
	11	Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization.	
	12	Applications of Structural Bioinformatics	
IV	**Applications I: omics**		10
	13	Genomics: Genome architecture, types of genome & its components, genome annotation, Parsing Structural Genomics, Functional genomics, Comparative Genomics, Metagenomics	
	14	Metabolomics: Concept of Metabolome and Metabolic pathways(KEGG)	
	15	Proteomics – technology of protein expression analysis, 2D PAGE, MS, Protein identification through database search, PDB	
	16	Applications of genomics and proteomics	
V	**Applications II**		9
	17	Bioinformatics tools for Phylogenetic analysis- tree construction- distance based methods and character based methods, PHYLIP	
	18	Drug Discovery and design : Target identification , Target Validation , Lead Identification , lead optimization,	

		Chemoinformatics tools for drug discovery; ChemBank, PUBCHEM	
	19	AI driven tools of Bioinformatics; DRAGEN, Rosetta, DeepVariant	
	20	Future potential of Bioinformatics	

Practicals 30 hours-Essential practical -15 0hrs, group or individual work 15 hours

Essential Experiments

1. Sequence Analysis: Sequence Alignment: Use tools like BLAST, ClustalW, or MUSCLE for pairwise or multiple sequence alignments. Analyze the results to identify conserved regions, mutations, or evolutionary relationships.

2. Sequence Searching: Perform database searches using tools like NCBI BLAST or HMMER to identify similar sequences in large databases such as GenBank or UniProt.

3. De Novo Genome Assembly: Assemble short reads generated from high-throughput sequencing platforms (e.g., Illumina) into longer contiguous sequences (contigs) using assemblers like Velvet, SPAdes, or SOAPdenovo.

4. Phylogenetic Tree Construction: Construct phylogenetic trees using molecular sequence data (DNA or protein) with programs like PHYLIP, RAxML, or MrBayes.

Suggested reading

1. Statistical Methods in Bioinformatics: An introduction, Ewens, W. J. and Grant, G. R. Springer, 2001
2. Programming Languages-Concepts and Constructs, Sethi R, 2nd Edition, Pearson
3. Introduction to Bioinformatics –5th Edition, Lesk A. M, Oxford
4. From Genes to Genomes, Concepts and Applications of DNA Technology, third edition, Jeremy W. Dale, Malcolm von Schantz , Nicholas Plant, Wiley Blackwell, 2011
5. Introduction to Proteomics: Tools for the New Biology, Liebler D., Springer Science + Business media, LLC
6. “Introduction to Data mining with case studies”, G.K. Gupta, PHI Private limited, New Delhi, 2008.
7. An Introduction to Bioinformatics Algorithms Neil C. Jones and Pavel A. Pevzner
8. Bioinformatics and Computational Biology Solutions Using R and Bioconductor, Robert Gentleman, Vincent Carey, Wolfgang Huber, Rafael Irizarry, Sandrine Dudoit, Oxford University Press
9. "*Bioinformatics*: *Sequence and Genome Analysis*" by David W. Mount, 2nd edition, 2004
10. Bioinformatics - A Practical Guide to the analysis of Genes and Proteins-Andreas Baxevanis&B.F.Francis Ouellette. ISBN: 978-0-471-46101-2, Wiley

11. Developing Bioinformatics Computer Skills, first edition, 2001,Jambeck P, Gibas .C. ISBN: 1-56592-664-1, O'Reilly
12. Primrose S.B, TwymanR.m., and Old R.w., Principles of gene manipulations, 6th ed, 2002, Blackwell publishers, Oxford.
13. S C Rastogi, N Mendiratta and P Rastogi, " Bioinformatics: Methods and Applications" , ISBN : 978-81-203-4785-4, PHI Learning Private Limited, 2015.
14. Attwood, T.K., Parry, D.J., Smith, Introduction to Bioinformatics, Pearson Education, 2005.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the scope and impact of Bioinformatics in Data analysis in life science research	U, An	PSO1
CO-2	Demonstrate different categories of databases and their utility	R, U, An	PSO4
CO-3	Understand the various applications of omics approaches	U, Ap	PSO4
C0-4	Use Molecular Visualisation tools to study molecular structures proteins	U, Ap	PSO1,4
CO-5	Compare and analyze biological sequences to interpret the results of their analyses.	U, An, E	PSO3,4
CO-6	Search and retrieve information from genomic and proteomic databases by data mining tools	U, Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Bioinformatics Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)

CO-1	Understand the scope and impact of Bioinformatics	PSO1	U, An	F, C	L	
CO-2	Demonstrate different categories of databases	PSO4	R, U, An	F, C, P	L	
CO-3	Understand the various applications of omics approaches	PSO4	U, Ap	F,C, P	L	
C0-4	Use Molecular Visualisation tools to study molecular structures proteins	PSO1,4	U, Ap	F,C, P	L	P
CO-5	Compare and analyze biological sequences	PSO3,4	U, An, E	F,C, P	L	
CO-6	Search and retrieve biological informations	PSO3,4	U, Ap	C, P	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7

CO 1	3	-	-	-	-	-	1						
CO 2	-	-	-	3	-	-	2						
CO 3	-	-	-	2	-	-	2						
CO 4	2	-	-	3	-	-	3	1					
CO 5	-	-	3	3	-	-	3						
CO 6	-	-	3	3	-	-	2						1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Quiz / Assignment/ Quiz/ Discussion / Seminar/Midterm Exam

Programming Assignments/Final Exam /Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4				✓
CO 5				✓

CO 6	✓			✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK4DSEBIT205				
Course Title	IICROBIAL METABOLISM				
Type of Course	DSE				
Semester	III				
Academic Level	200–299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in Microbiology and Biochemistry				
Course Summary	Microbial metabolism is a fundamental aspect of microbiology that explores the biochemical pathways and mechanisms by which microorganisms obtain energy, grow and interact with their environments. This graduate-level course delves into the intricate world of microbial metabolic processes, emphasizing the diversity of metabolic strategies employed by bacteria, archaea, fungi, and other microorganisms.				

Detailed Syllabus:

Module	Unit	Content	Hrs

I	**Introduction to Microbial Metabolism**		**6**
	1	Overview of microbial metabolism	
	2	Metabolic diversity in microorganisms	
	3	Energy metabolism: ATP generation, redox reactions	
II	**Photosynthesis & Respiration in Bacteria**		**10**
	4	Carbohydrate Metabolism Glycolysis and fermentation,Mixed acid fermentations, Anaplerotic pathways in TCA cycle Pentose phosphate pathway Tricarboxylic acid (TCA) cycle	
	5	Mechanism of photosynthesis in bacteria (purple non sulphur bacteria, green sulphur bacteria) and cyanobacteria	
	6	Chemolithotrophy -— oxidation of sulphur, iron, hydrogen & nitrogen Methanogenesis**,** Bioluminescence	
	7	Amino Acid Metabolism Biosynthesis and degradation of amino acids, Nitrogen assimilation Ammonia detoxification	
	8	Lipid Metabolism Lipid biosynthesis and degradation,Fatty acid metabolism, Lipid signaling pathways	
III	**Synthesis of biopolymers**		**6**
	9	Biosynthesis of peptidoglycan, biopolymers, PHB	
	10	Genetic basis of biopolymer synthesis	
	11	Fermentation techniques for biopolymer production	
	12	Overview of Microbial metabolites-marine sources	
IV	**Metabolic Regulation**		**14**
	13	Metabolic Regulation, Signaling Pathways and Metabolic Regulation Crosstalk between metabolic and signaling networks Enzyme regulation, Metabolic control mechanisms, Feedback inhibition and allosteric regulation	
	14	Metabolic engineering principles Synthetic biology approaches Case studies in metabolic pathway optimization	
	15	Importance of Biochemical characterisation Types: Carbohydrate fermentation test, Methyl red test, Citric acid utilization test. (D) Hydrogen sulfide production test	

		.Principle of Sugar utilization test, Sugar fermentation test, IMViC test	
	16	Enzyme detection – Catalase, Oxidase, Oxidative-fermentative test Gelatinase assay	
V		**Industrial importance of Microbial metabolism**	**9**
	17	Microorganisms of industrial importance. Biology of industrial microorganisms: Isolation, Screening and Preservation.	
	18	Fermentation process, Types of fermentation and Downstream processing- recovery and purification of end products of metabolism-a basic account	
	19	Strain improvement of microbes for industrial purposes	
	20	Examples of commercial products of microbial origin- case study	

<u>Practicals 30 hrs- </u>Essential Experiments (15 hrs) , Group Work (15 hrs)

Essential Experiments

8. Effect of temperature, pH, salt, Carbon source and Nitrogen source on the growth of bacteria
9. Study and plot growth curve of E.coli by turbidometric method
10. Demonstration of production of acid and gas during lactose fermentation
11. Urease test
12. Gelatin hydrolysis
13. Isolation and culture of photosynthetic bacteria.
14. Starch hydrolysis test by amylase producing microbes, and enzyme assay.

Suggested Readings:

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.

2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons

3. Nelson David L and Cox Michael M, Lehninger, Principles of Biochemistry, Macmillan Press, Worth Publishers, New Delhi.

4. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India

5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.

6. Textbook: "Microbial Metabolism in Biotechnology" by [Author Name].

7. Journal Articles: Selected readings from relevant journals such as "Microbial Cell Factories" and "Applied Microbiology and Biotechnology".

8. Online Resources: Access to databases and bioinformatics tools for metabolic pathway analysis.7. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education

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Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding of bacterial nutritional requirements to classify bacteria & predict their growth conditions.	U, R	PSO-1,2
CO-2	Describe different mechanisms of nutrient transport across cell membranes & evaluate their significance in bacterial metabolism.	U, E	PSO1,3
CO-3	To know the process of photosynthesis in bacteria	U, R	PSO1
CO-4	Examine the environmental significance of chemolithotrophy	U, An	PSO3
CO-5	Compare the efficiency of aerobic & anaerobic respiration pathways in bacteria by comparing their energy yields.	U	PSO1
CO-6	Explain the regulatory mechanisms involved in biosynthetic pathways	U	PSO3,4
CO-7	Apply their practical skills to identify bacteria using different biochemical tests	Ap, An	PSO5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Microbial metabolism **Credits: 2:1:2 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)

CO-1	Understand bacterial nutrition	PSO-1,2	U, R	F, C	L	-
CO-2	Describe the nutrient uptake in bacteria	PSO1,3	U, E	P	L	-
CO-3	Know the basics of photosynthetic bacteria	PSO1	U, R	F	L	-
CO-4	Examine the environmental significance of chemolithotrophy	PSO3,5	U, An	P	L	P
CO-5	Compare the respiratory process in different kind of bacteria	PSO1	U	F,P	L	-
CO-6	Explain the regulation of metabolism in bacteria	PSO3,4	U,R	C	L	-
CO7	Identify bacteria based by biochemical tests	PSO5	Ap, An	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	2	-	-	-	-						

CO 2	2	-	3	-	-	-						
CO 3	2	-	-	-	-	-						
CO 4	-	-	2	-	2	-						
CO 5	2	-	-	-	-	-						
CO 6	-	-	3	3	-	-						
CO7					1							

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative

- Internal test papers
- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓			✓
CO7			✓	✓

Value added Courses 200-299

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK4VACBIT201				
Course Title	GOOD LABORATORY PRACTICES AND QUALITY CONTROL IN BIOTECHNOLOGY				
Type of Course	**VAC**				
Semester	IV				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1		3
Pre-requisites	Essentials of Biotechnology, Microbiology				
Course Summary	This course provides students with a comprehensive understanding of good laboratory practices (GLP) and quality control (QC) in the field of biotechnology where students will learn the importance of adhering to GLP guidelines and implementing QC measures to ensure the reliability, reproducibility, and accuracy of experimental results in biotechnological research and industry.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Good Laboratory Practices (GLP)**	**9**
	1	Historical perspective, Definition, purpose, Principles	
	2	Lab rules for best lab practices, aseptic lab procedures, Facility design, equipment calibration and maintenance, personnel training, and responsibilities.	
	3	Documentation and Record Keeping -maintenance of records and log books, Equipment Calibration and Maintenance.	
	4	Handling, sampling, storage and SOP.	
II		**Biosafety, hazards, risks and management**	**9**
	5	Types of hazards – Biological hazards, physical hazards, chemical hazards, Symbols in biohazards.	
	6	Risk assessment and management- containment facility, biosafety level and its classification. Assessment of biological hazards, Risk assessment process examples and tools, Biosafety measures and Guidelines.	
	7	Types of laboratory wastes and methods of disposal of laboratory wastes- Chemical, Physical and Biological.	
	8	Classification of chemicals and hazard levels.	
III		**Regulations in QC and validation**	**9**
	9	Overview of GLP and QC regulations, guidelines, and standards applicable in biotechnology. Government regulations and amendments and national and international standards – FDA, ISI, Codex , ISO,OECD.Role of FDA in India.	
	10	Hazard analysis and quality control analysis – HACCP- Significance, Seven Principles– Significance GLP.	
	11	Activities – Design qualification (DQ), Installation qualification (IQ), Operational qualification (OQ), Performance qualification (PQ)	
IV		**Quality control in biotechnology industry**	**9**
	12	Implementation of QA/QC systems to monitor and ensure the quality of processes, products, and data. Quality management and quality assurance in BI	
	13	Identification, assessment, and mitigation of potential risks to quality and compliance. GMP as an element in QC- Importance of QC in BI	
	14	Principles and procedures for validating and verifying analytical methods used in biotechnology. Sampling, inspection, testing, of raw and packaging materials,product, release and rejection of batches.	
V		**Assesment**	**9**
	15	Write an overview of quality management in a Pharmaceutical/Food industry/Beverage industry after visiting one of your choice. Case Studies and Best Practices: Examination of real-world case studies and best practices in GLP and QC implementation within the biotechnology industry.	

Suggested Reading

1. "Good Laboratory Practice Regulations" by CRC Press
2. "Quality Control in the Pharmaceutical Industry" by CRC Press
3. "Laboratory Quality Management System: Handbook" by WHO
4. "Statistical Methods for Quality Control" by John Wiley & Sons
5. "Good Clinical, Laboratory and Manufacturing Practices: Techniques for the QA Professional" by CRC Press
6. International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH) guidelines
7. United States Pharmacopeia (USP) standards
8. Food and Drug Administration (FDA) regulations
9. World Health Organization (WHO) guidelines on GLP and QC in biotechnology
10. "Good Clinical, Laboratory and Manufacturing Practices: Techniques for the QA Professional" by CRC Press

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain the significance of adhering to good laboratory practices (GLP) in biotechnological research and industry and understand the principles and methods of GLP	U	PSO1
CO-2	Classify the different types of hazards, biosafety levels, wastes, assess the risks and evaluate the various biosafety levels in handling the same.	An, A	PSO3
CO3	Understand the various regulation at national and international levels in QC and validation and identify the principles of HACCP	R, U	PSO3
CO4	Describe the significance and methods of QC in biotechnology industry	U	PSO5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Good laboratory practices and quality control in biotechnology **Credits: 2:1:0 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)

CO-1	Understood principles of good Lab Practices	PSO1	U	F	L	
CO-2	Understood about Biohazards and different Biosafety levels	PSO3	An, A	F	L	P
CO3	Understand the various regulation at national and international levels in QC	PSO3	R, U	F	L	
CO4	Describe the significance in Biological research	PSO5	U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO 1	2													
CO 2			3											
CO 3			3											
CO 4					3									X

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low

2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓			✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK4VACBIT202
Course Title	ENVIRONMENTAL MONITORING AND ASSESSMENT
Type of Course	VAC
Semester	IV
Academic Level	200 - 299.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3

Pre-requisites	Environmental studies,Basics of IT
Course Summary	Environmental Monitoring and Assessment is a graduate-level course designed to provide students with an in-depth understanding of the principles, methods, and applications of environmental monitoring and assessment. The course emphasizes the importance of monitoring environmental parameters to assess the status, trends, and impacts of human activities on the environment. Students will learn about various monitoring techniques, data collection methods, and analytical tools used in environmental assessment.

Module	Unit	Content	Hrs
I	**Introduction to Environmental Monitoring and Assessment**		**9**
	1	Overview of environmental monitoring, potential risks factors for pollution. Importance of monitoring in environmental management and policy-making.	

		Historical development and key concepts in environmental monitoring and assessment.	
	2	**Environmental Parameters and Indicators** key environmental parameters and indicators relevant to air, water, soil Selection criteria for monitoring parameters, Use of indicators to assess environmental quality, ecological health, and human health risks.	
II	**Sampling Design and Techniques and anlaysis**		**9**
	5	Principles of sampling design, Sampling methods and techniques for collecting representative samples from air, water, soil, and biological matrices.	
	6	Instrumentation and Analytical Methods: Analytical techniques for the quantification of environmental parameters and pollutants.	
III	**Data Analysis and Interpretation**		**9**
	9	Spatial and temporal analysis of monitoring data using Geographic Information Systems (GIS) and time-series analysis techniques. Interpretation of monitoring results and identification of trends, patterns, and anomalies.	
	10	Environmental Monitoring Programs: environmental monitoring programs for pollution control, habitat conservation, human health protection	
	11	Ecological Monitoring and Biodiversity Assessment: Principles of ecological monitoring and biodiversity assessment. Methods for quantifying biodiversity, species abundance, and ecosystem structure and function. Field Measurements (Water, Air, Soil),	
IV	**Human Health and Environmental Impact Risk Assessment**		**9**
	18	Human Health Risk Assessment Principles of human health risk assessment for environmental contaminants. Exposure assessment, risk characterization. Regulatory frameworks and guidelines for assessing human health risks	
	19	Environmental Impact Assessment (EIA): Overview of Environmental Impact Assessment (EIA) process and requirements. Case studies and examples of EIA in different sectors (e.g., infrastructure, energy, mining	
	20	Remote Sensing and Monitoring Technologies:	

		Introduction to remote sensing principles and satellite imagery analysis for environmental monitoring.	
V		**Emerging Technologies and Future Trends**	**9**
	23	Emerging technologies and innovations in environmental monitoring (e.g., sensor networks, unmanned aerial vehicles, citizen science).	
	24	Case Studies and Practical Applications: Case studies illustrating the application of environmental monitoring and assessment techniques in real-world settings. Group projects or fieldwork assignments involving the design, implementation, and analysis of environmental monitoring studies.	

Suggested Reading

1. Environmental Monitoring Handbook" by Frank R. Spellman and Joanne Drinan:
2. Environmental Monitoring with Arduino: Building Simple Devices to Collect DataAbout the World Around Us" by Emily Gertz and Patrick Di Justo
3. "Principles of Environmental Monitoring and Assessment" by M. Nageeb Rashed:.

   Course Outcomes

4. U.S. Environmental Protection Agency (EPA) website:
5. United Nations Environment Programme (UNEP)

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	provides comprehensive understanding of environmental monitoring and assessment principles, methods, and applications,	U	PSO-2,5
CO-2	equipping with the knowledge and skills needed to address complex environmental challenges and contribute to evidence-based decision-making in environmental management and policy	R, U	PSO-2,5
CO3	Awareness about Risk Assessment on Human and Environmental Health	U	PSO-2,5

CO4	Awareness about emerging technologies and management policies in environmental monitoring	U	PSO-3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Environmental Monitoring and Assessment credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand principles of environmental monitoring	PSO-2,5	U	F, C	L	P
CO-2	Equipping with environmental monitoring skills	PSO-2,5	R, U	P	L	-
CO3	Awareness about risk assessment on Human and environmental health	PSO-2,5	U	F	L	-
CO4	Awareness about managing environmental monitoring with new technologies and policies	PSO-3,5	U	C	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

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

CO 4	-	3	-	-	3	-								

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓

Skill enhancement Courses 200-299

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK4SECBIT200				
Course Title	BIOASSESSMENT AND BIOMONITORING				
Type of Course	SEC				
Semester	IV				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1		3
Pre-requisites	Basic microbiology, Environmental studies				
Course Summary	Bioassessment and biomonitoring are critical tools in environmental science, providing insights into the health and integrity of ecosystems. This graduate-level course delves into the principles, methods, and applications of bioassessment and biomonitoring, focusing on their role in assessing environmental quality, identifying stressors, and guiding conservation and management efforts.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**General principle of Biomonitoring and Bioassessment**	**9**
	1	Definition and scope of bioassessment and biomonitoring, Historical perspective and evolution of biomonitoring techniques, Importance of biological indicators in environmental pollution.	
	2	Biological Indicators: Types of biological indicators (e.g., macroinvertebrates, fish, algae, bacteria) Sampling methodologies in biomonitoring – types – air, water, soil and marine.	
II		**Bioindicators**	**9**

	3	Water Quality Indicators – Physico-chemical, Biological Bioindicators of water quality (e.g., benthic macroinvertebrates, diatoms, fishes) Water quality indices and their applications (dissolved oxygen, chemical identification Case studies on water quality assessment using biological indicators	
	4	Biological indicators of soil and sediment quality: Methods for assessing soil health (e.g., earthworms, microbial communities), Sediment bioassays, soil nutrient assay (NPK) and toxicity testing	
	5	Air Quality Monitoring: Bioindicators of air pollution (e.g., lichens, mosses) Biomonitoring techniques for airborne contaminants, plant species abundance- identifying parameters, air filters, bioscrubbers Applications of biomonitoring in urban and industrial environments	
III		**Ecological Risk Assessment**	**9**
	6	Ecological Risk Assessment: Principles of ecological risk assessment, Integrating bioassessment data into risk assessment frameworks.	
	7	Applications of Bioassessment in Aquatic Ecosystems Applications of Biomonitoring in Terrestrial and Marine Ecosystems	
IV		**Emerging Technologies in Biomonitoring**	**9**
	8	Sampling methods and study design, Examine the methodologies for sampling, collecting, and analyzing biological data in the field and laboratory. Data analysis and interpretation techniques	
	9	Advances in molecular biomonitoring (e.g., DNA barcoding, metagenomics), Remote sensing applications in bioassessment, Future trends and challenges in biomonitoring technology.	
V		**Integrating Biological and Environmental Data**	**9**
	10	Integrating Biological and Environmental Data	
	11	Case Studies and Real-world Applications	
	12	Critically evaluate case studies and research articles to understand the strengths and limitations of bioassessment and biomonitoring approaches.	

Suggested Reading :

1. Biomonitoring of Environmental Status and Trends (Edited by Eric Mellegers)
2. Bioassessment and Management of North American Freshwater Wetlands (Edited by James G. Gosselink and Louis R. DeLaune)
3. Environmental Biomonitoring: Exposure Assessment and Specimen Banking (Edited by Frederic Kirschbaum)
4. Methods in Stream Ecology (Edited by Richard Hauer and Gary Lamberti)

5. Principles and Methods of Toxicology (Edited by A. Wallace Hayes and Claire L. Kruger)

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Evaluate the impact of pollution on environmental as well as human health	U	PSO-2,5
CO-2	Awareness on indicators of environment quality	R, U	PSO3
CO3	Understand the Principles of ecological risk assessment	U	PSO5
CO4	Awareness on emerging technologies in Biomonitoring	R,U	PSO3,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Bioassessment and Biomonitoring **Credits: 2:1:0 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Evaluate the impact of pollution on environmental as well as human health	PSO-2,5	U	F, C	L	-
CO-2	Awareness on indicators of environment quality	PSO2	R, U	P	L	P
CO3	Understand the Principles of ecological risk assessment	PSO5	U	F	L	P

CO4	Awareness on emerging technologies in Biomonitoring	PSO3,5	R,U	P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	2	-	-	2	-						
CO 2	2	-	-	-	-	-						
CO 3	-	-	-	-	2	-						
CO 4	-	-	2	-	3	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4		✓		✓

Discipline	BIOTECHNOLOGY				
Course Code	UK4SECBIT201				
Course Title	BASICS OF PHYTOCHEMISTRY AND MEDICINAL PLANT-BASED INDUSTRY				
Type of Course	SEC				
Semester	IV				
Academic Level	200 - 299.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3
Pre-requisites	Biochemisty,Bioinstrumentation				
Course Summary	The course gives a basic idea on phytochemistry and various techniques involved in harnessing active constituents from plants and looking for their potential applications in pharmaceutics.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to phytochemistry and medicinal plant-based industry**		**9**
	1	Natural products from plants, History	
	2	Phytochemical evaluation of plant drugs, morphological, organoleptic, microscopic, and biological study of aromatic plants	
	3	Applications of Phytochemistry and Phytochemicals	
	4	medicinal and aromatic plant-based industries – phytopharmaceutical products, use in indigenous medicine, bioprospecting and introduction to access and benefit sharing	
	5	Pharmacology and pharmacognosy	
II	**Extraction and characterisation techniques**		**9**
	5	Types and principles of extraction – cold, hot - Soxhlet, steam distillation, solid-liquid extraction, Clevenger apparatus.	
	6	Separation and characterisation techniques- Chromatography types- TLC, HPLC, GC-MS, HPTLC, UV-visible spectroscopy, IR spectroscopy, NMR.	
III	**Active principles from plants**		**9**
	7	Primary and secondary metabolic pathways (shikimic – chorismic, mevalonate pathways) and metabolites	
	8	Types and features of active constituents, quality purity and pharmaceutical use.	
	9	Classification of phytochemicals, Sources, Biosynthesis, extraction, isolation, identification and therapeutic applications-Alkaloids, Flavonoids, Phenolics, Terpenes, Volatile oils.	
	10	Adulteration and alternation- Detection methods.	

	11	Metabolic Engineering	
IV	**Type study of a few important medicinal plants**		**9**
	12	Utilization of Medicinal Plants in Pharmaceuticals, Drug discovery from natural sources,Development of plant-based medicines,Formulation and dosage forms	
	13	Study of medicinal plants, methods of extraction, therapeutic uses- *Ocimum sanctum, Aegle marmalos, Cymbopogancitratus, Curcuma longa, Santalum album, Aloe barbadensis*	
V	**Herbal Products and Nutraceuticals**		**9**
	14	,Dietary supplements,Functional foods,Herbal cosmetics	
	15	Regulatory Aspects and Quality Control,Good Manufacturing Practices (GMP),Quality control parameters (purity, potency, identity),Safety and toxicological assessment,Ethical considerations in wild harvesting	
	16	Case study report of Taxol, artemisinin, Antioxidants from seaweeds	

Suggested reading

1. Phytochemical Methods A Guide to Modern Techniques of Plant Analysis by JB Harborne. Springer, 1998**.**
2. Krishnaswamy, N. R., 2003. Chemistry of Natural Products. Universities press, Hyderabad
3. Daniel, M., 1991. Methods in Plant chemistry and Economic Botany. Kalyani publishers, New Delhi
4. Phytochemistry- Vol 1- Fundamentals, Modern techniques, and applications, ChukwuebukaEgbuna, Ifemeje, J. C (Editors). CRC Taylor & Francis, 2019.
5. Biren, Shah and Seth, A. K. Textbook of Pharmacognosy and Phytochemistry. New Delhi: Elsevier, 2010.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Summarise the various natural products and apply the methods of phytochemical evaluation. Identify the various process in bioprospecting and importance of access and benefit sharing.	R, U, A	PSO1
CO-2	Distinguish among the various extraction and characterisation techniques of phytochemicals	An	PSO1

CO3	Understand the various metabolic pathways and classify among the various phytochemicals involved and list the pathway manipulation techniques	R, U, A	PSO3
CO4	Identify a few important medicinal plants and compare the various methods of extraction of phytochemicals and their uses.	R, U	PSO1
CO5	Demonstrate the various techniques for extraction and analysis of any one phytochemical of choice	A	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Basics of Phytochemistry and Medicinal plant-based Industry Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO1	Understand phytochemicals and its various application	PSO1	R, U, A	F	L	
CO-2	Understand the extraction principles of various phytochemicals	PSO1	An	F	L	
CO3	Awareness about metabolic pathway and its manipulation for improved production and extraction	PSO3	R, U, A	C	L	
CO4	Evaluate the traditional medicinal plants and bioactives	PSO1	R, U	F	L	P
CO5	Skilled in phytochemical extraction methods	PSO3	A	P	-	P

	PS O1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2													
CO 2	3													
CO 3			3											
CO 4	2													
CO 5			3											

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓

CO 4	✓			✓
CO 5	✓			✓

UK4INTBIT200 SUMMER INETRNSHIP

Credit-2

All the students shall undergo internship/apprentiship in a firm/industry or training in labs with faculty and researchers in their institution or other HEIs/research institutions during the summer term. The internship has two credits and shall be completed in the first three years of FYUGP. The department council of the HEI shall approve the firm/Institution from where the student shall undergo an internship after verifying the quality and geniness of the firm /Institution

SEMESTER V

University of Kerala

Discipline	BIOTECHNOLOGY

Course Code	UK5DSCBIT300				
Course Title	RECOMBINANT DNA TECHNOLOGY				
Type of Course	DSC				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic Knowledge in Cell biology, genetics & molecular biology				
Course Summary	This core-course aims to acquaint students with the tools and techniques employed in genetic engineering and recombinant DNA technology. This knowledge enables students to innovatively apply this technique in basic and applied fields of biological research involving gene manipulation.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to gene cloning**:	**6**
	1	History and milestones in the development of recombinant DNA technology	
	2	Restriction endonucleases, classification and general characteristics of RE	
	3	Other DNA modifying Enzymes- DNA polymerase, DNA ligase, alkaline phosphatase, Polynucleotide kinase, Terminal transferase, Reverse Transcriptase	
	4	Adaptors, Linkers, Homopolymer tailing	
II		**Vectors: the vehicle for cloning**	**8**
	5	Ideal features of a vector	
	6	Various types of cloning vectors: Plasmid cloning vectors- pBR322, pUC18, and pUC19; Expression vectors- pET vector Bacteriophage cloning vectors – λ phage cloning vectors, M13 phage-based vector Combination vectors- Phagmid and Cosmid vectors	
	7	Artificial Chromosomes: Bacterial artificial chromosome vectors (BACs), Yeast artificial chromosome vectors (YACs) Applications of BAC and YAC	

	8	Shuttle vectors for animals (Adenoviral, Retroviral vectors) and plants (Caulimo viral, TMV vectors), Mammalian vectors for gene therapy	
III		**rDNA- Construction and Screening**	**12**
	9	Construction of recombinant DNA; host cells, competent cells, bacterial transformation - methods	
	10	Screening methods of transformed cells & recombinants Insertional inactivation, Blue-white screening, antibiotic screening, colony hybridization, colony PCR, Immunological methods	
	11	DNA libraries: genomic DNA libraries and cDNA libraries- construction & applications	
	12	Various methods of genetic transformation in eukaryotic cells- Direct gene transfer and vector mediated gene transfer	
IV		**Techniques for genome analysis and applications**	**10**
	13	Molecular hybridization techniques: RFLP, AFLP, RAPD, Southern hybridization	
	14	PCR: Principle, types(Real time, RT) and applications	
	15	DNA sequencing: Principle and applications, Genome sequencing methods- Maxam-Gilbert method, Sangers sequencing, NGS. Human genome project	
	16	Gene expression analysis – Northern hybridization, Micro array	
V		**Biosafety and ethics in Genetic engineering**	**9**
	17	Impact of transgenic organisms in agriculture, medicine, and environment	
	18	Bioethics: issues with genome modification-case study examples: terminator seeds, environmental impact	
	19	HGP-ELSI	
	20	BSL categories for ensuring appropriate containment for rDNA laboratories	

Practicals- (30 Hours)-[Essential Experiments (15 Hours), Group/Individual Experiments (15 Hours)]

Essential Experiments

1. Preparation of the reagents for rDNA experiments
2. Purification of Plasmid from bacterial Cultures
3. Estimation of plasmid DNA by UV-VIS spectrophotometer
4. Restriction Digestion of pUC 18 and band analysis by agarose gel electrophoresis
5. Ligation of DNA using ligase
6. *E. coli* Competent cell preparation & Transformation with pUC 18 and selection of ampicillin resistant clones
7. Extraction and purification of Genomic DNA from various sources
8. Quantification of DNA using diphenyl amine method
9. Problem solving assignments
10. Virtual lab on recombinant DNA experiments
11. Research lab visit

Suggested Reading

1. Molecular Biotechnology, 1st Edition (2016) - Dehlinger CA, Jones & Bartlett Learning
2. Principles of gene Manipulation, 7th Edition (2013) - Primrose SB, Twyman RM, Wiley Blackwell sciences
3. Molecular Biotechnology, Principles and Applications of recombinant DNA, 4th Edition (2010)- Glick BR, Pasternak J J and Pattern CL, ASM Press, Washington D
4. Gene Cloning & DNA Analysis an Introduction, 7th Edition (2016) – Brown TA, Wiley Blackwell publishers
5. Introduction to Genetic Engineering & Biotechnology, 1st Edition (2010) - Nair, A. J., Jones & Bartlett Publishers, Inc
6. Modern concept of Biotechnology, 1st Edition (1998) - H D Kumar; Vikas Publishing House, Pvt. Ltd., New Delhi.
7. Biotechnology, B. Sc. Edition (2016) – Singh BB, Kalyani Publishers, New Delhi

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the basic tools required to conduct genetic engineering.	R, U	PSO-1,2

CO-2	Familiarise to the modern tools and techniques for manipulation and analysis of genomic sequences.	U, Ap	PSO1,PSO3
CO-3	Understand the Biosafety and ethics concerns connected with genetic engineering.	U, An	PSO5
CO-4	Design a genetic engineering experiment, selecting appropriate tools	Ap, C	PSO3
CO-5	Apply rDNA technology in Biotechnological research	Ap	PSO3,PSO4
CO-6	Handle vectors, enzymes and host cells to conduct rDNA experiments	Ap	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create
Note: 1 or 2 COs/module

Name of the Course: Recombinant DNA Technology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the basic tools required to conduct genetic engineering	PSO1, PSO 2 PO-1, PO-2	R, U	F, C	L	
CO-2	Familiarise to the modern tools and techniques for manipulation and analysis of genomic sequences	PSO -1, PSO-3 PO-1, PO-6	U, Ap	C, P	L	P
CO-3	Understand the Biosafety and ethics concerns	PSO5 PO -8	U, An	F,C	L	

	connected with genetic engineering					
CO-4	Design a genetic engineering experiment, selecting appropriate tools	PSO3 PO-3	Ap, Cr	P, M	-	P
CO-5	Apply rDNA technology in Biotechnological research	PSO3,PSO-4 PO-3, PO-6	Ap	P, M	-	P
CO-6	Handle vectors, enzymes and host cells to conduct rDNA experiments	PSO3 PO-6	Ap	P, M	-	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	-	-	-	-	3	2						
CO 2	3	-	2	-	-	-	2					3		

CO3	-	-	-	-	3	-								3
CO4	-	-	2	-	-	-			3					
CO5	-	-	3	2	-	-			2			3		
CO6	-	-	3	-	-	-						3		

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓		✓
CO 4		✓	✓	✓

CO 5		✓	✓	✓
CO 6			✓	✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSCBIT301				
Course Title	FOOD AND INDUSTRIAL BIOTECHNOLOGY				
Type of Course	DSC				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	Basic of Microbiology				
Course Summary	This course encompasses an interdisciplinary field that integrates principles of biology, chemistry, engineering, and technology to develop innovative solutions for the food technology and industrial process. This course deals with various aspects of biotechnological applications in industrial production of microbial products, food production, preservation, and quality enhancement				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Industrial Biotechnology**		8
	1	History and scope of Industrial Biotechnology	
	2	Biotechnology industries in India	
	3	Industrial Microorganisms: Screening, Selection, characterization, and strain improvement for industrial applications	
II	**Bioreactors, Upstream and Downstream processing**		15
	4	Bioreactor Design and Operation: Principles of bioreactor design, types of bioreactors, and parameters influencing bioprocesses	

		Fermentation Technology: Optimization of fermentation processes and scale-up strategies	
	5	Upstream Processing: Media for fermentation, characteristics of ideal production media, media sterilization, aeration, pH, temperature Bioprocess Monitoring and Control: Techniques for monitoring cell growth, product formation, and controlling bioreactor conditions Batch fermentation, Continuous fermentation, Chemostatic cultures	
	6	Downstream processing: Downstream processing and product recovery, Different physical and chemical methods for the separation of fermentation products	
III	**Industrial production of biomolecules**		13
	7	Production of therapeutic proteins, antibodies, and vaccines – General strategy Microbial production of antibiotics-Penicillin, vitamins- B12, amino acids- Glutamic acid; Organic acid-Citric acid; Beverages-beer; solvents- butanol	
	8	Agricultural waste and food industry wastes as the substrate for fermentation, solid state fermentation; production of single cell proteins, microbial production of enzymes- protease and amylase; Immobilization of cells and enzymes-applications	
IV	**Food Biotechnology**		12
	9	Microbial contamination and foodborne pathogens, food borne infections and ,intoxications Biotechnological approaches for enhancing food quality and safety-detection of pathogens, toxins, and allergens	
	10	Microbial cultures and starter cultures in food fermentation	
	11	Food preservation- principles of preservation of foods, Role of biopreservation -Role of lactic acid bacteria, bacteriocins, and probiotics in preservation Biocontrol mechanisms and applications- Hurdle Technology-competitive microflora, bacteriocins, and enzymatic inhibitors Genetic approaches to enhance microbial preservation	
	12	Microbs in food industry- Dairy Biotechnology- dairy products, Industrial process of cheese making, spoilage, milk borne diseases Definition and classification of functional foods	
V	**Case Studies and Industry Perspectives**		12
	13	Concepts and examples of Functional foods, and Nutraceuticals	
	14	Case studies on Production of bioactive components , highlighting successful applications of industrial biotechnology	
	15	Visit to different industries	

Suggested Reading

1. Food Microbiology, 2nd Edition (2002) - Adamas MR and Moss MO; Panima Publishing Corporation, New Delhi.
2. Fermentation technology, 3rd Edition (2016) - Stanbury P F, Whitaker A, Hall S J, Butterworth-Heinemann
3. Food Microbiology, 5th Edition (2017) - Frazier WC, Dennis C. Westhoff and N.M. Vanitha, McGraw Hill Education
4. Microbiology, 8th Edition (2011) - Prescott L. M., Harley, J. P., and Klein D. A. Mc Graw Hill, New York
5. Industrial Microbiology, 2nd Edition (2022) – Patel A H, Laxmi Publications
6. Food Processing: Biotechnological Applications, Reprint Edition 2015 - Marwaha SS and Arora JK, Asiatech Publishers Inc., New Delhi
7. Modern concept of Biotechnology, 1st Edition (1998) - H D Kumar; Vikas Publishing House, Pvt. Ltd., New Delhi.
8. Industrial microbiology, 2nd Edition (2019) - Casida L E, New Age International Private Limited

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Describe the selection of industrially important microbes for production of biomolecules for human welfare	U	PSO-1,2
CO-2	Design a controlled environment for microbes for optimum growth and production	R, U, C	PSO-3
CO3	Evaluate various methods for recovery and purification of bioproduct after fermentation	U, E	PSO-3, PSO-5
CO4	Aware about application of industrial biotechnology in various field of biotechnology such as fermented food production	U	PSO-1
CO5	Identify biotechnology industries in India and its opportunities	An	PSO-5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Food and Industrial Biotechnology Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Describe the selection of industrially important microbes for production of biomolecules for human welfare	PSO-1, PSO-2 PO-1, PO-2	U	F, C	L	-
CO-2	Design a controlled environment for microbes for optimum growth and production	PSO-3 PO-3	R, U, C		L	
CO3	Evaluate various methods for recovery and purification of bioproduct after fermentation	PSO-3, PSO-5 PO-2	U, E		L	
CO4	Aware about application of industrial biotechnology in various field of biotechnology such as fermented food production	PSO-1 PO-1	U	F	L	-
CO5	Identify biotechnology industries in India and its opportunities	PSO-5 PO-6	An	M	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	-	-	-	-	3	2				
CO 2	-	-	3	-	-	-			2			

CO 3	-	-	3	-	2	-		2				
CO 4	3	-	-	-	-	-	3					
CO5					2							1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO5	✓	✓		

Uuniversity of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSCBIT302				
Course Title	IMMUNOLOGY				
Type of Course	DSC				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3	1	-	4
Pre-requisites	Basic knowledge in Cell Biology and Molecular Biology				
Course Summary	This course deals with the complex mechanisms of the immune system, exploring both fundamental principles and application level topics in immunology. Through a combination of lectures, discussions, and activities, students will gain a comprehensive understanding of the cellular and molecular components of the immune system, their roles in host defense, and their dysregulation in disease states.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Immunology**	12
	1	Historical perspective and development of basic concepts in immunology	
	2	Immune system and immunity Organs and cells of the human immune system - Structure and role in immunity	
	3	Types of immunity: Innate and specific or acquired immunity; Humoral immunity and cell mediated immunity	
	4	Major Histocompatibility complex- types and functions	
	5	Innate immune receptors: Toll-like receptors, cytokines, chemokines ,inflammasome research (case study)	
	6	Complement- Properties and activation pathways, Classical, Lectin & Alternative pathway	
II		**Antigen and Antibody**	12

	7	Antigens, immunogens, haptens, Adjuvants	
	8	Immunoglobulins- structure and types of Immunoglobulins Isotypes, allotypes and idiotypes	
	9	Genetic basis of antibody diversity, Clonal proliferation theory	
	10	Antibody-antigen interaction: Affinity, Avidity Antigen-antibody reactions - Agglutination, Precipitation, ABO blood grouping, RH incompatibility	
III		**Immuno-techniques, Applications and therapeutics**	12
	11	Immuno-diffusion, immuno-electrophoresis, ELISA, RIA	
	12	Production of polyclonal and monoclonal antibodies - Hybridoma technology	
	13	Antibodies in targeting therapeutic agents- therapeutic antibodies	
	14	Immunity to infections of diseases, Vaccination, Vaccines - Types of vaccines, CAR-T cell therapy	
IV		**Autoimmune diseases and Hypersensitivity Reactions**	12
	15	Autoimmunity and Autoimmune diseases – Organ specific and Systemic; Mechanisms involved in the development of autoimmune disorders - Hashimoto's thyroiditis; Myasthenia gravis; Rheumatoid Arthritis, Pernicious anemia,	
	16	Hypersensitivity reactions: Types, Asthma	
V		**Experimental Immunology and Transplantation immunology**	12
	17	Experimental immunology: Knock out mice, inbred strains	
	18	Transplantation, Different types of transplants, Stem cell transplantation Transplant rejection: Mechanism and stages of rejection Transplant rejection therapies - Immunosuppressive drugs, Recent advances	
	19	Host-pathogen interactions,Immune evasion strategies of pathogens	

Suggested Readings

1. Kuby Immunology, 8th Edition (2018) - Jenni Punt, Sharon Stranford, Patricia Jones, and Judith A Owen, WH Freeman
2. Roitt's Essential Immunology, 13th Edition (2017) – Martin SJ, Burton DR, Roitt IM, and Delves PJ, Wiley-Blackwell
3. Cellular and Molecular Immunology, 10th Edition (2021) – Abbas AK, Lichtman AH, and Pillai S, Elsevier
4. Clinical Immunology, 2022- Rezaei N, Academic Press, Elsevier
5. An Introduction to Immunology, 3rd Edition (2016) – C V Rao, Narosa Publishing House, New Delhi
6. Basics of Biotechnology, 1st Edition (2004) - A J Nair; Laxmi Publications, New Delhi
7. Immunology, 5th Edition (2007) – Joshi, Osama; Agrobios India, New Delhi

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand how immune system functions and various cells and organs involved in generating immune functions in the body	R,U	PSO-1
CO-2	Explain how antibody specificity and diversity generated and its significance in immune functions	R, U	PSO1
CO3	Identify antibody as a tool in immune system and understand antibody mediated immunological detection methods and therapeutic achievements	U,An,Ev	PSO3
CO4	Discuss how autoimmunity develops in the body and risk factors associated with immunological disorders	Ev	PSO3, PSO-1
CO5	Critically analyse and make reports on immunological experiments	Ev	PSO-4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: I mmunology, Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO1	Understand how immune system functions and various cells and organs involved in generating immune functions in the body	PSO-1 PO-1	R,U	F, C	L	-
CO2	Explain how antibody specificity and diversity generated and its	PSO-1 PO-1	R, U		L	-

	significance in immune functions					
CO3	Identify antibody as a tool in immune system and understand antibody mediated immunological detection methods and therapeutic achievements	PSO-3 PO-2	U, An	C	L	
CO4	Discuss how autoimmunity develops in the body and risk factors associated with immunological disorders	PSO-1 PO-1	Ev	F, C	L	-
CO5	Critically analyse and make reports on immunological experiments	PSO-4 PO-1	Ev	F,C,M	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	-	2					
CO 2	2		-	-	-	-	2					
CO 3	-	-	3	-	-	-		2	-			
CO 4	3	-	-	-	-	-	3					
CO5				2			3					

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	-	✓
CO 2	✓	✓	-	✓
CO 3	✓	✓	-	✓
CO 4	✓	✓	-	✓
CO 5		✓		

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSCBIT303				
Course Title	ETHNOBOTANY AND MEDICINAL BOTANY				
Type of Course	DSC				
Semester	V				
Academic Level	300-399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2	5
Pre-requisites	Essentials of Botany and Biotechnology				
Course Summary	At the graduate level, a course in Ethnobotany and Medicinal Botany delves into the intricate relationship between plants and human societies, exploring how various cultures utilize plants for medicinal, cultural, and economic purposes. The course typically covers a broad range of topics, including:				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Ethnobotany and Medicinal Botany**	6
	1	Definition and scope of ethnobotany and medicinal botany Methods in ethnobotanical research Traditional Knowledge of Medicinal Plants- Traditional healing systems (e.g., Ayurveda, Traditional Chinese Medicine, Indigenous medicine) Case studies of medicinal plants in different cultures Chemical constituents of medicinal plants (alkaloids, terpenoids, phenolics, etc.)	
11		**Biosynthesis of bioactive compounds**	10
	2	Biosynthetic pathways of major classes of bioactive compounds Regulation of biosynthetic pathways Genetic engineering approaches for modifying biosynthetic pathways	
	3	Pharmacological activities of plant-derived compounds (antioxidant, antimicrobial, anti-inflammatory, anticancer, etc.) Mechanisms of action of bioactive compounds Clinical trials and therapeutic applications in human health	
	4	A general account of the medicinal value of the following plants Rhizome - Curcuma and Zingiber; Bulb - Allium cepa and A. sativa; Root - Asparagus, Hemidesmis, Acorus calamus; Adhatoda vasica, Catharanthus roseus, Phyllanthus amarus, Andrographis paniculata; Leaves - Aloe vera, Centella asiatica, Asoka (Saraca indica) and Brahmi (Bacopa monnieri), Sarpagandha (Rauvolfia serpentina).	
	5	Production of herbal drugs. Extraction procedure (maceration, percolation, Hot continuous (soxhlet), aqueous alcoholic extraction by fermentation, counter current extraction, Sonication, superficial fluid extraction, phytotonic process.) - Adulteration of drugs	
III		**Biotechnological Approaches in Medicinal Botany**	10
	6	Plant tissue culture techniques for mass propagation Metabolic engineering for enhanced secondary metabolite production Genomic and proteomic approaches in drug discovery	
	7	Drug Discovery and Development-Screening methods for bioactivity assessment, Drug metabolism and pharmacokinetics Preclinical and clinical trials for plant-derived drugs	

IV	**Phytochemistry and Pharmacognosy**		10
	8	Definition and scope of Pharmacognosy .Sources of crude drugs roots,rhizome, bulb, corm, leaves, stems, flowers, fruits and seeds Techniques for phytochemical analysis,Pharmacological screening methods	
	9	Formulation development and delivery systems for plant-derived drugs Nutraceutical applications of medicinal plant compounds Cosmeceutical uses in skincare and personal care products	
V	**Conservation of medicinal plants**		9
	10	Importance and the need for medicinal conservation- Sacred groves. Role of CSIR-CIMAP, NMPB, BSI, JNTBGRI in conservation and cultivation of medicinal plants.	

Practicals-30 hours- essential experiments 15 hours, group/ individual work-15 hours

Essential experiments

1 Visit a tribal area and collect information on their traditional method of treatment using crude drugs.

2. Familiarize with at least 5folk medicines.

3 Observe the plants of ethno botanical importance in your area.

4Students are expected to identify the plants mentioned in the Ethnobotany syllabus.

5Visit to Ayurveda college or other Ayurvedic institutions is recommended.

Suggested Reading

1. Ethnobotany: Principles and Applications" by C. M. Cotton
2. "Medicinal Plants: Chemistry, Biology and Omics" edited by A. K. Gupta and D. K. Sharma
3. "Pharmacognosy: Fundamentals, Applications, and Strategies" by S. Sarker and L. Nahar Kapoor LD, 2001 Hand Book of Ayurvedic Medicinal Plants, CRC Press New York,
4. Davis, P. and Haywood, V.H, 1963. Principles of Angiosperm Taxonomy, Oliver and Boyd, London.
5. K. Jain. Glimpses of Ethnobotany. Oxford and IBH Publishing Company, New Delhi.
6. S.K. Jain, 1987. A Manual of Ethno botany. Scientific Publishers, Jodhpur
7. T.E Walles. Text book of Pharmacognosy,
8. Rajiv K Sinha. Ethnobotany

	Upon completion of the course the graduate will be able to	**Cognitive Level**	**PSO addressed**
CO-1	To comprehend the diversity of chemical constituentspresent in medicinal plants. .	R, U	PSO1
CO-2	To understand the biosynthetic pathways of bioactivecompounds in plants	R, U	PSO1
CO-3	To explore the extraction techniques for isolating bioactive compounds from medicinal plants.	U,An	PSO3
CO-4	To analyze the pharmacological properties and therapeutic potential of plant-derived compounds	U	PSO4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Ethnobotany and Medicinal botany Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	To comprehend the diversity of chemical constituentspresent in medicinal plants. .	PSO1	R, U	F, C	L	
CO-2	To understand the biosynthetic pathways of bioactivecompounds in plants	PSO1	R, U	P	L	
CO-3	To explore the extraction techniques for isolating bioactive compounds from medicinal plants.	PSO3	U,An	F	L	
CO-4	To analyze the pharmacological properties and therapeutic potential of plant-derived compounds	PSO4	U	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	-	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	-	-	2	-	-	-						
CO 4	-	-	-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

Discipline Specific Elective courses 300-399, DSE3(P), DSE4

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT300				
Course Title	GENOMICS AND PROTEOMICS				
Type of Course	DSE				
Semester	V				
Academic Level	300 – 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1		4
Pre-requisites	Genetics, molecular biology, biochemistry, and/or cell biology.				
Course Summary	Genomics and Proteomics is an advanced graduate-level course that explores the fundamental principles, methodologies, and applications of genomics and proteomics in modern biological research. The course integrates concepts from genetics, molecular biology, bioinformatics, and biotechnology to provide students with a comprehensive understanding of how genomes and proteomes function and contribute to various biological processes.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Genomics**:	12
	1	Organisation and structure of genome-Prokaryotes and eukaryotes and Viruses ,DNA polymorphism, Genes, Early Sequencing efforts, genome sequences and data bases, Discovery of new genes and their functions	
	2	DNA sequencing methods-manual and automated: Maxum and Gilbert's method and Sanger's method	

		Overview –Pyrosequencing.Genomes sequencing: shotgun and hierarchical (clone contig)methods. Computer tools for sequencing projects: genome sequence assembly software.	
	3	Integrated genomic circuits, Selected model organisms-Drosophilla and Arabidopsis, Genetic and physical maps, microarray in functional genomics, DNA amplification markers, STS mapping of genome, transcriptome analysis, genome annotations.	
II	**Proteomics**		12
	4	Introduction to proteomics-Introduction to proteins, building blocks, large scale preparation of proteins, protein structure, properties of proteins.	
	5	Protein detection methods-PAGE, 2D gel electrophoresis, X-ray crystallography, NMR spectroscopy, Analysis of proteome, protein cleavage, Edman protein microsequencing.	
	6	Merrifield synthesis of peptides, use of peptide as probes, Proteins as drugs: yeast 2 hybrid system. Mass spectrometry-based analysis of protein expression. iCAT labelling, protein chip-Automation in proteomics-Metabolomics analysis at different levels.	
III	**Database in proteomics and genomics**		12
	7	Types of databases-primary and secondary	
	8	Databases for genomics-EMBL, VISTA, UCSC Genome browser, NCBI genome, DDBJ, COGS.	
	9	Data bases for protein analysis- PDB, PIR, SWISSPORT, MMDB, CATH, SCOPE	
IV	**Application of proteomics and genomics**		12
	10	Application of proteome analysis of drug development and toxicology.	
	11	Application in functional genomics, medicine and gene knockdown, Genome editing techniques: CRISPR-Cas9, TALENs, and ZFNs Analysis of gene function using high-throughput methods, protein modelling, molecular docking and drug designing.	
V	**Integration of Genomics and Proteomics**		12
		Systems biology approaches integrating genomic and proteomic data	
		Multi-omics data integration and analysis	
		Case studies in personalized medicine and functional genomics	

Suggested reading

1. Brown, T.A. (2002). “Genomes.” John Wiley & Sons.
2. Brown, S.M. (2016). “Next-Generation DNA Sequencing Informatics.” Cold Spring Harbor Laboratory Press.
3. Korpelainen, E. (2015). “RNA-seq Data Analysis: A Practical Approach.” CRC Press.
4. Voytas, D.F. (2017). “Genome Editing: The Next Step in Gene Therapy.” National Academies Press.
5. Twyman, R. (2004). “Principles and Practice of Proteomics.” BIOS Scientific Publishers.
6. Whitford, D. (2005). “Protein Structure and Function.” Wiley-Blackwell.
7. Egan, J.M. (2010). “Bioinformatics for Proteomics.” CRC Press.
8. Choi, S. (2015). “Systems Biology: Principles, Methods, and Applications.” Academic Press.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	The students will have a basic understanding in proteomics and genomics.	R, U	PSO-1,3,4
CO-2	The students should describe the tools used in genomics and proteomics.	U, Ap	PSO-3,4
CO3	Students can identify proteins in samples by PAGE analysis	U, Ap, E	PSO-3
CO4	The students will have a basic understanding of how to localize protein by using softwares.	U,An	PSO-3,4
CO5	Students will be able to explain basics in peptide synthesis	U, Ap	PSO-3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 Cos/module

Name of the Course: Genomics and Proteomics Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	The students will have a basic understanding in proteomics and genomics.	PSO-1,3,4	R, U	F, C	L	
CO-2	The students should describe the tools used in genomics and proteomics.	PSO-3,4	U, Ap	P	L	
CO3	Students can identify proteins in samples by PAGE analysis	PSO-3	U, Ap, E	P	L	P
CO4	The students will have a basic understanding how to localize protein by using softwares.	PSO-3,4	U,An	C	L	
CO5	Students will be able to explain basics in peptide synthesis	PSO-3,4	U, Ap	P	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of Cos with PSOs and Pos :

	PSO1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	-	2	3	-	-	2						

CO 2	-	-	2	3	-	-	1						
CO 3	-	-	3	-	-	-	1						
CO 4	-	-	2	3	-	-	1						2
CO 5	-	-	3	3	-	-	1						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of Cos to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT301				
Course Title	MOLECULAR DIAGNOSTICS				
Type of Course	DSE				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2	5
Pre-requisites	Undergraduate coursework in biology, genetics, biochemistry, or related fields is recommended.				
Course Summary	Molecular diagnostics is a rapidly evolving field that integrates principles of molecular biology, genetics, and clinical medicine to diagnose diseases, monitor treatment response, and predict patient outcomes. This graduate-level course provides a comprehensive understanding of the theoretical foundations, laboratory techniques, and clinical applications of molecular diagnostics. Through lectures, laboratory sessions, and case studies, students will develop the knowledge and skills necessary to effectively utilize molecular diagnostic methods in research and clinical settings.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Molecular Diagnostics**	6
	1	Overview of molecular diagnostics,Historical perspective and milestones, Ethical considerations and regulatory issues	
	2	Structure and function of nucleic acids, DNA replication, transcription, and translation,Genetic variation and mutation	
	3	Introduction to various diagnostic techniques	
II		**Nucleic acid based diagnosis**	10
	4	PCR and its variants, PCR-ELISA Next Generation sequencing Methods (NGS) Overview of Microarrays, CRISPR,“CHIP” based technology Nuclear hybridization methods-Southern, Northern blotting; Karyotyping for detection of genetic diseases,Pharmacogenomics and personalized medicine	

	5	Infectious disease diagnostics (viral, bacterial, and fungal- identification based on 16S rRNA sequences- Amplified Ribosomal DNA Restriction analysis (ARDRA), Molecular diagnosis of fungal pathogens based on 18S rRNA sequences	
III		**Protein based diagnosis:**	10
	6	In-situ (including FISH), – types and applications; Western blotting, Proteomics- Clinical Proteomics- laser capture microdissection (LCM) technique, Biomarker detection using Mass spectrometry (MS), MALDI - TOF, Protein stability testing; amino acid sequence analysis	
IV		**Advanced diagnostic technique**	10
	7	Flow cytometry for cancer detection, Forensic application, STR typing (short tandem repeat), - Molecular barcoding RFLP, AFLP, SSR, VNTR, SNP, Pyrosequencing	
	8	Immunodiagnosis,Liquid biopsy and circulating tumor DNA,Genetic testing and counseling	
	9	Engineered microbes and nano sensor based diagnosis	
V		**Ethical issues in molecular diagnostics:**	9
	10	privacy, consent, and genetic discrimination	
	11	Regulatory frameworks governing molecular diagnostic tests Intellectual property rights and patents in molecular diagnostics	

Practicals-Essential experiments -15 hours, group/Individaul work -15 hours

Essentail Experiments

1. Design primers for a specific target gene or sequence.
2. Optimize PCR conditions (annealing temperature, MgCl2 concentration, primer concentration) to enhance specificity and yield.
3. Perform PCR using genomic DNA or plasmid DNA as a template.
4. Analyze PCR products by agarose gel electrophoresis to confirm amplification.
5. Prepare a standard curve using serial dilutions of known DNA concentrations.
6. Measure the size of DNA fragments using a DNA ladder.
7. Isolate DNA from a sample (e.g., bacterial culture,
8. Analyze sequencing data using bioinformatics tools to identify mutations or sequence variations.
9. Transform the recombinant plasmid into a suitable host (e.g., E. coli).
10. Screen transformed colonies for the presence of the insert by colony PCR or restriction enzyme digestion.

11. Isolate and purify the recombinant plasmid DNA for downstream applications.
12. Analyze microarray data to identify differentially expressed genes between samples.

Suggested Reading

Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker 2. Bioinstrumentation, Webster

3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic

1."Molecular Diagnostics: Fundamentals, Methods and Clinical Applications" by Lela Bu

2.PCR (The Basics)" edited by H. A. Erlichckingham and Maribeth Flaws

3.Molecular Diagnostics: Techniques and Applications for the Clinical Laboratory" by Wayne W. Grody, Robert M. Nakamura, and Frederick L. Kiechle

4.Molecular Biology Techniques: A Classroom Laboratory Manual" by Susan Carson and Heather B. Miller

5.Ethical, Legal, and Social Issues in Medical Genetics" by Anita E. Beck

6.Molecular Diagnostics: Advances and Applications" edited by P. Michael Conn

7.Biological Research Protocol: A Hands-On Guide" by Deanna M. D'Alessandro

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the principles of molecular biology and genetics underlying molecular diagnostics.	U	PSO-1
CO-2	Gain proficiency in laboratory techniques commonly used in molecular diagnostics, including nucleic acid isolation, amplification, sequencing, and analysis.	R, U	PSO-3,4
CO3	Explore the applications of molecular diagnostics in various disease areas, including infectious diseases, cancer, genetic disorders, and pharmacogenomics.	E	PSO-1,3

CO4	Analyze case studies to understand the role of molecular diagnostics in clinical decision-making and patient care.	An	PSO-4
CO5	Evaluate the current challenges and emerging technologies in molecular diagnostics, such as point-of-care testing and liquid biopsy.	E	PSO-3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Molecular Diagnostics
Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the principles of molecular biology and its applications	PSO-1	U	F, C	L	
CO-2	Gain proficiency in laboratory techniques commonly used in molecular diagnostics,	PSO-3,4	R, U	P	L	P
CO3	Explore the applications of molecular diagnostics in various disease areas	PSO-1,3	E	C	L	
CO4	Analyze case studies to understand the role of molecular diagnostics in clinical decision-making and patient care.	PSO-4	An	F	L	
CO5	Evaluate the current challenges and emerging	PSO-3	E	C	L	

	technologies in molecular diagnostics					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	-	-	-	-	-	1							
CO 2	-	-	2	2	-	-	1							
CO 3	2	-	3	-	-	-	1						1	
CO 4	-	-	-	1	-	-	2							
CO 5	-	-	1	-	-	-	3	1						1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT302				
Course Title	NANOBIOTECHNOLOGY				
Type of Course	DSE				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2	5
Pre-requisites	essentials of biotechnology chemistry for life sciences, biomolecules				
Course Summary	This elective course provides basic overview of nanomaterials and their applications. This course begins with an overview of development of nanobiotechnology as a scientific stream. Subsequently the course covers synthesis methodologies, physical and chemical characterization of nanomaterials. Application of nanomaterials in diverse fields are elaborated further in this course which will provide the student a strong foundation in this rapidly progressing field, whose active areas are all highlighted.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to nanoworld**	**9**
	1	History and Development: Lycurgus cup (dichroic glass.), Islamic world Luster, Renaissance pottery, Faraday’s Ruby Gold, STM, Feynman’s concept, Progress of nanotechnology in various streams of science.	
	2	Classification of Nanomaterials– Based on spatial confinement: 0D, 1D, 2D & 3D Based on structural composition : Organic, Inorganic, Carbon-based &Composite	
	3	Properties of nanoparticles: a. Physical, structural and chemical properties b. Mechanical, optical, electromagnetic and biological properties	
	4	Effect of size and shape of nanoparticles : high surface area to volume ratio Surface functionalization	

II		**synthesis and characterization of nanoparticles**	**10**
	5	Synthesis of Nanomaterials:- Top Down & Bottom Upapproaches	
	6	Methods of synthesis - Physical, Chemical &Biological (Plant and Microbes)	
	7	Characterization of Nanomaterials: UV-VIS SPEC, XRD, FTIR, EM (TEM, SEM)	
	8	Toxicity evaluation of Nanomaterials – Cytotoxicity and Genotoxicity assays	
III		**Applications** I	**10**
	9	Agriculture: Nanopesticides and Nanofertilizers, Nano-biostimulants and soil enhancers, Nano-enabled technologies for abiotic stress management	
	10	Environmental– Air, Soil &Water Purification, Contamination detection and Remediation. Nanosensors – applications of nanobiosensors: molecular recognition elements, transducing elements	
	11	Food processing and preservation– Detection of food pathogens, Chemicals, Pesticides, Toxins, Adulterants and Residual veterinary antibiotics. Quality Monitoring of vitamin components in food.	
	12	Food packaging- Biodegradable food packaging- Polysaccharides, Proteins, Synthetic polymers, Antimicrobial active packaging, smart and intelligent packaging (labels).	
IV		**Applications - II**	**7**
	13	Medical nanotechnology : Nano systems in medical diagnosis, sensing and imaging	
	14	Nanoparticles in drug targeting and drug delivery	
	15	Nanotechnology in therapy (Hyperthermia, Nano vectors in gene therapy, Cancer therapy and Photodynamic therapy)	
	16	Nanomaterials for biomedical implants, Nano-scaffold in tissue engineering, Nanomaterials as antimicrobials, Recent advances – Nanobots, Nanoflares, Nanoinformatics	
V		**Challenges, ethics and future**	**9**
	17	Toxicity of nanomaterials and possible environmental hazards	
	18	Regulatory acts and ethical issues (SEI) in the use of nanomaterials	
	19	Nanobiotechnology as an emerging interdisciplinary research avenue	
	20	Scope and future potential of Nanobiotechnology	

Practicals-30 hours –Essential experiments-15 hours, Group/Individual work-15 hour

Essential experiments

1. Synthesize nanoparticles using various methods such as chemical reduction, sol-gel, or biological synthesis.

2. Characterize the synthesized nanoparticles using techniques like UV-Vis spectroscopy, Dynamic Light Scattering (DLS), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), and Fourier Transform Infrared Spectroscopy (FTIR).

3. Functionalize nanoparticles with biomolecules such as proteins, DNA, or antibodies for specific applications.

4. Characterize the functionalized nanoparticles to confirm successful attachment of biomolecules using techniques like FTIR, UV-Vis spectroscopy, and zeta potential measurements.

5. Assess the toxicity of nanoparticles using in vitro methods

6. Investigate the use of nanomaterials for environmental remediation purposes, such as water purification or pollutant degradation.

Suggested Reading

1. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley VCH, Second Edition 2013.
2. Nanostructures and Nanomaterials – Synthesis, Properties and Applications, G. Cao, Imperial College Press 2006.
3. Nanostructured materials: Processing, Properties and Potential Applications, Edited by Carl. C. Koch, Noyes Publications, 2002.
4. Bionanotechnology, Lesson from Nature– David S Goodsell, Wiley - Liss, 2004
5. Nanobiotechnology: Concepts,Applications and Perspectives – C M Niemeyer and C A Mirkin, 2004
6. Introduction to Bionanotechnology - Young-Chul Lee , Ju-Young Moon, Springer Link, 2020
7. Nanobiotechnology - II more concepts and applications. (2007) - Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**

CO-1	Understand the nanoscale functionalities of materials	R, U	PSO-1,2
CO-2	Understand the classification and characterisation of nanomaterials	R, U	PSO1
C0-3	Understand the various applications of nanomaterials	U, An	PSO3
C0-4	Understand the different ways to use nanotechnology in medicine	U, An	PSO1
CO-5	Critically analyse the ethics principles based on case studiebsespecially nanobugs gray goo theorem	U, An, E	PSO1
CO-6	Prepare a case study report on the applications of nanotechnology in agriculture	An, Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Nanobiotechnology, Credits: 2:1:2(Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
1	Understand the nanoscale functionalities of materials	PSO-1,2	R, U	F, C	L	
2	Understand the classification and characterisation of nanomaterials	PSO1	R, U	C, P	L	
3	Understand the various applications of nanomaterials	PSO3	U, An	F,C	L	
4	Understand the different ways to use nanotechnology in medicine	PSO1	U	F,C	L	

5	Critically analyse the ethics principles based on case studies especially nanobugsgray goo theorem	PSO1	U, An	F,C	L	
6	Prepare a case study report on the applications of nanotechnology in agriculture	PSO3,4	An, Ap	C, P	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	1	-	-	-	-	-	1							
CO 2	2	3	-	-	-	-	2							
CO 3	-	-	1	-	-	-	1							
CO 4	-	-	2	3	-	-	1							
CO 5	-	1	-	-	-	-	1							
CO 6	-	-	-	3	-	-	3							2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4				✓
CO 5				✓
CO 6	✓			✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK5DSEBIT303
Course Title	CANCER BIOLOGY
Type of Course	DSE
Semester	V
Academic Level	300 - 399.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5

Pre-requisites	Cell Biology, Genetics, Molecular Biology
Course Summary	This course will familiarize the student with the conceptual understanding of the disease cancer, its types, heterogeneity, molecular mechanisms and the role of stem cells in cancer aggression. Also equip the students with knowledge and skill to identify the symptoms and tackle challenges in diagnosis and therapeutic strategies.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction**	6
	1	Hallmarks of cancer	
	2	Tumor development and progression	
	3	Types of cancer and heterogeneity,	
	4	Metastasis and invasion, Epithelial Mesenchymal Transition (EMT)	
	5	Cell death mechanisms- Apoptosis, Necrosis and Autophagy.	
II		**Cancer Cell Signalling**	10
	6	G-protein coupled receptor cascade	
	7	Tyrosine kinase receptor cascade (P13K/Akt, Jak/STAT, Wnt/B catenin, Ras/MAPK)	
	8	Tumor suppressor gene- Rb, cyclins and CDKs, NF-1, p53	
	9	Proto oncogenes, Ras Myc, BRAF	
III		**Cancer Stem Cells**	10
	10	Origin of cancer stem cells, Epithelial mesenchymal transition in development of cancer stem cells	

	11	Cancer stem cells in solid tumors, Leukemia stem cells	
	12	Genetic diversity and clonal expansion and evolution	
	13	Cancer stem cell targeted therapy.	
IV	**Diagnosis and Treatment**		10
	14	Symptoms of cancer, Cancer screening and diagnosis, Problems in cancer screening.	
	15	Techniques for cancer diagnosis-Radiological examination, Biopsy and its type	
	16	Treatments,-Surgery, radiotherapy and chemotherapy, Hormone therapy, Transplantation, Targeted therapies, Gene therapy.	
V		**Cancer Genetics and Genomics**	9
	17	Epigenetics and Cancer, Cancer Genetics and Genomics, Resistance Mechanisms and Treatment Strategies	
	18	Preclinical Models and Clinical Trials in Cancer Research	

Practicals (30 Hours)-(Essential Experiments-15 hours,Group /Individual work -15 hours)

Essential Experiments

1. Laboratory safety and good laboratory practices
2. Principles and application of Laboratory instruments-microscope, CO2incubator, autoclave, LAF, filtration unit.
3. Culturewares used in cancer cell culture- 96 well plate, 12 well plate, 6 well plate, 4 well plate, petriplates, T-25, T-75 flasks.
4. Cleaning and Sterilization of cell cultureware
5. Preparation of media- DMEN, MEM, RPMI
6. Culture morphology of cancer cell lines.
7. Demonstration of Cryopreservation
8. Immunohistochemistry protocol, Image analysis

Suggested Readings

1. The Biology of Cancer., Robert A. Weinberg · 2023.,Publisher:W.W. Norton.

2. Introduction to Cancer Biology., Robin Hesketh., 2013., Publisher: Cambridge University Press

3. Cancer Biology., Raymond W. Ruddon., 2007., Publisher: Oxford University Press, USA

4. The American Cancer Society's Principles of Oncology Prevention to Survivorship., 2018., The American Cancer Society., Publisher: Wiley.

5. Role of Cancer Stem Cells in Cancer Biology and Therapy., Kurt S. Zänker, Thomas Dittmar., 2016., Publisher: CRC Press.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	arize the student with the concepts that serve as the foundation for cancer as a genetic disease	R, U	PSO-1
CO-2	Build the foundation to provide a comprehensive summary of the major signalling pathways that affect tumour development.	R, U	PSO-1
CO3	Understand the cellular and molecular mechanisms involved in the transformation of normal cell into malignant cells, the invasiveness of cancer cells into host tissues, and the metastatic spread of cancer cells in the host organism.	R, U	PSO-1
CO4	Learn about the most common types of cancer and symptoms that are responsible for diagnosing and treating patients with cancer.	U, Ap, An	PSO-2, 4, 5
CO5	Practice basic laboratory skill essential for the cancer research	R, U, Ap	PSO-3, 4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Cancer Biology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Familiarize the student with cancer as a genetic disease.	PSO-1	R, U,	F, C	L/T	
CO-2	Build the foundation major signalling pathways	PSO-1	R, U,	F, C	L/T	

	in tumour development.					
CO3	Understand the molecular mechanisms in cancer	PSO 1	R, U,	F, C	L/T	
CO4	Learn about the most common types of cancer	PO-1, 2 PSO-2, 4, 5	U, Ap, An	C, M	L/T	
CO5	Practice basic laboratory skill essential for the cancer research	PO-6 PSO-3, 4	R, U, Ap	P		p

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	-	-	-	-	-	1							
CO 2	2	-	-	-	-	-	1							
CO 3	2	-	-	-	-	-	2							
CO 4	-	-	3	3	-	-	2	1						

CO5	-	-	3	3	-	-	2	1				1		
CO6	-	-	-	-	-	-								

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5	✓			✓
CO 6				

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT304				
Course Title	IICROBIAL METABOLISM				
Type of Course	DSE				
Semester	V				
Academic Level	300–399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in Microbiology and Biochemistry				
Course Summary	Microbial metabolism is a fundamental aspect of microbiology that explores the biochemical pathways and mechanisms by which microorganisms obtain energy, grow and interact with their environments. This graduate-level course delves into the intricate world of microbial metabolic processes, emphasizing the diversity of metabolic strategies employed by bacteria, archaea, fungi, and other microorganisms.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Nutritional classification & Nutrient transport in microbes**	**6**
	1	Nutritional classification of bacteria	
	2	Nutrient transport across the cell: Diffusion: Passive and facilitated; Primary active and secondary active transport	
	3	Group translocation (phosphotransferase system) electroneutral transport; transport of Iron.	

II	**Photosynthesis & Respiration in Bacteria**		**10**
	4	Photosynthetic pigments of bacteria- chlorophyll a and bacteriochlorophyll, carotenoids, phycobiliproteins, leghaemoglobin	
	5	Oxygenic and anoxygenic photosynthesis Mechanism of photosynthesis in bacteria (purple non sulphur bacteria, green sulphur bacteria) and cyanobacteria	
	6	Chemolithotrophy -— oxidation of sulphur, iron, hydrogen & nitrogen Methanogenesis**,** Bioluminescence	
	7	Respiration in bacteria- aerobic respiration Glycolysis and tricarboxylic acid cycle Electron transport and oxidative phosphorylation in Bacteria Anaerobic respiration- Fermentation- lactic acid and alcohol fermentation, mixed acid fermentation, Lactate fermentation (homofermentative and heterofermentative pathways).	
	8	Assimilation of nitrogen,sulphur, phosphorus	
III	**Synthesis of biopolymers**		**10**
	9	Biosynthesis of peptidoglycan, biopolymers, PHB	
	10	Biosynthesis of vitamins, amino acids and nucleotides	
	11	Regulation of metabolic pathways	
	12	Overview of Microbial metabolites-marine sources	
IV	**Biochemical characterization of bacteria**		**10**
	13	Importance of Biochemical characterisation Types: Carbohydrate fermentation test, Methyl red test, Citric acid utilization test. (D) Hydrogen sulfide production test.	
	14	Principle of Sugar utilization test, Sugar fermentation test, IMViC test	
	15	Enzyme detection – Catalase, Oxidase, Oxidative-fermentative test	
	16	Gelatinase assay	
V	**Industrial importance of Microbial metabolism**		**9**
	17	Microorganisms of industrial importance. Biology of industrial microorganisms: Isolation, Screening and Preservation.	
	18	Fermentation process, Types of fermentation and Downstream processing- recovery and purification of end products of metabolism-a basic account	
	19	Strain improvement of microbes for industrial purposes	
	20	Examples of commercial products of microbial origin- case study	

Practicals 30 hrs

Essential Experiments (15 hrs) , Group Work (15 hrs)

1. Effect of temperature, pH, salt, Carbon source and Nitrogen source on the growth of bacteria
2. Study and plot growth curve of E.coli by turbidometric method
3. Demonstration of production of acid and gas during lactose fermentation
4. Urease test
5. Gelatin hydrolysis
6. Isolation and culture of photosynthetic bacteria.
7. Starch hydrolysis test by amylase producing microbes, and enzyme assay.

Suggested Readings:

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.

2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons

3. Nelson David L and Cox Michael M, Lehninger, Principles of Biochemistry, Macmillan Press, Worth Publishers, New Delhi.

4. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India

5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.

6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, MacMillan Press.

7. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understanding of bacterial nutritional requirements to classify bacteria & predict their growth conditions.	U, R	PSO-1,2
CO-2	Describe different mechanisms of nutrient transport across cell membranes & evaluate their significance in bacterial metabolism.	U, E	PSO1,3

CO-3	To know the process of photosynthesis in bacteria	U, R	PSO1
CO-4	Examine the environmental significance of chemolithotrophy	U, An	PSO3
CO-5	Compare the efficiency of aerobic & anaerobic respiration pathways in bacteria by comparing their energy yields.	U	PSO1
CO-6	Explain the regulatory mechanisms involved in biosynthetic pathways	U	PSO3,4
CO-7	Apply their practical skills to identify bacteria using different biochemical tests	Ap, An	PSO5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: microbial metabolism Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand bacterial nutrition	PSO-1,2	U, R	F, C	L	-
CO-2	Describe the nutrient uptake in bacteria	PSO1,3	U, E	P	L	-
CO-3	Know the basics of photosynthetic bacteria	PSO1	U, R	F	L	-
CO-4	Examine the environmental significance of chemolithotrophy	PSO3,5	U, An	P	L	P
CO-5	Compare the respiratory process	PSO1	U	F,P	L	-

	in different kind of bacteria					
CO-6	Explain the regulation of metabolism in bacteria	PSO3,4	U,R	C	L	-
CO7	Identify bacteria based by biochemical tests	PSO5	Ap, An	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	**PSO2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	2	2	-	-	-	-						
CO 2	2	-	3	-	-	-						
CO 3	2	-	-	-	-	-						
CO 4	-	-	2	-	2	-						
CO 5	2	-	-	-	-	-						
CO 6	-	-	3	3	-	-						
CO 7					1							

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

Continuous Comprehensive Assessment:

Formative :

- Interactive Quiz
- Group Discussions
- Assignment
- Student Seminar
- Observation of practical skills
- Journal Club presentations
- Punctuality in lab, and time management in completing assigned laboratory tasks

Summative -Internal test papers

- Laboratory book/ report
- Periodical lab tests

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Observation of Practical skills	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓

CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6	✓			✓
CO7			✓	✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT305				
Course Title	GENERAL VIROLOGY				
Type of Course	DSE				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Cell Biology, Microbiology				
Course Summary	This course in General Virology provides an in-depth understanding of viruses, their structure, replication, pathogenesis, and interaction with host organisms. Gives an overview of viruses, their classification, structure, and composition and introduction to key virological concepts and techniques.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**History, inception and development of viruses,**	**6**
	1	History: History, inception and development of viruses, Characteristics of viruses.	
	2	Nomenclature and classification of viruses: Guidelines for naming and classification, ICTV	

		classification of viruses of bacteria, plants, animals and humans.	
	3	Morphology and properties of viruses: morphology and structure, chemical composition. dsDNA virus- Adenovirus, Herpes ssDNA virus- PARVO, Gemini dsRNA virus – Retro virus, ssRNA Virus- Corona, Hepatitis.	
	4	Virus culture methods: using whole organism, embryo & cell culture	
II		**Bacteriophages**	**10**
	5	Diversity and classification of Bacteriophages, one step multiplication curve, lytic and lysogenic cycle of phage, early and late proteins in bacteriophage's replication cycle, Transcription regulation in lambda phage.	
III		**Viral Transmission, andHost Interactions**	**10**
	6	Modes of viral transmission: Persistent, non-persistent, vertical and horizontal	
	7	Viral multiplication: Interaction of viruses with cellular receptors (CS) and entry of viruses.	
	8	Replication strategies of viruses: Assembly, maturation and release of virions.	
IV		**Viral diseases of humans& management**	10
	9	Viral diseases of humans- pneumotropic viral diseases-influenza, adenoviral infection, rhino viral infection, Dermo trophic viral diseases-herpes simplex, chickenpox, measles,rubella Viscerotropic viral diseases- yellow fever,dengue fever, Neurotropic viral diseases-rabies, polio, NIPAH Introduction to oncogenic viruses: Types of oncogenic DNA and RNA viruses, oncogenes and proto-oncogenes Prevention & management of viral diseases: Antiviral compounds, Interferons and their mode of action. General principles of viral vaccination	
V		**Bio-safety principles:**	**9**
	10	Containment facilities, maintenance and handling of laboratory animals and criteria of virological laboratory	
	11	Applications of Virology Viral vectors and it's uses in cloning and expression, Phage therapy, Phage display and gene therapy	

Practicals-(30 hours)-(Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Introduction to biosafety protocols and laboratory safety.
2. Demonstration and practice of aseptic techniques.
3. Introduction to microscopy techniques for viral visualization.
4. Practice in handling viral cultures under biosafety cabinets.
5. Introduction to cell culture techniques.
6. Preparation of cell culture media.
7. Virtual/Visit a nearby virology Lab and observe:

Suggested Reading

1. Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus, eds.), 3rd Edition. Lippincott-Raven, Philadelphia, PA.

2. Laboratory Animal Medicine: Principles and Procedures. Margi Sirois. Latest edition / Pub. Date: November 2004. Publisher: Elsevier Health Sciences.

3. Guides for the Care and Use of Laboratory Animals. National Research Council. Latest edition / Pub. Date: January 1996. Publisher: National Academy Press.

4. Laboratory Biosafety Manual, WHO,

http://www.who.int/csr/resources/publications/biosafety/who_cds_csr_l yo_20034/en/

5. Virology: 1994. 3rd ed. Frankel Conrat et al, Prentice Hall.

6. Introduction to Modern Virology. 2007. 6th ed. Dimmock et al., Blackwell Scientific Publ.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Discuss strategies to Identify various types of viruses and giving nomenclature based on special features	U ,R	PSO-1,2

CO-2	Discuss bacteriophages and its life cycle	R, U	POS1
CO3	Discuss modes of Transmission and special features of viral genome, host entry andReplication	U, An	PSO1,3
CO4	Identify virus as a causative agent for various diseases and preventive measures	U , Ap	PSO1
CO5	Discuss the measures for handling viruses in laboratory environment and application of virology in research and therapeutics	U, An, Ap	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: General Virology
Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Discuss on Virus nomenclature and types	PSO-1,2	U ,R	F, C	L	-
CO-2	Special emphasis on how bacteriophages works	POS1	R, U	P	L	-
CO3	Discuss how Virus invading its host	PSO1,3	U, An	F	L	-
CO4	Discuss about various viral Diseases	PSO1	U , Ap	F	L	-
CO5	Discuss the fundamentals of Virological laboratories	PSO3	U, An, Ap	P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	2	-	-	-						
CO 4	3	-	-	-	-	-						
CO 5	-	-	-	-	2	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓		-	✓
CO 2	✓		-	✓
CO 3	✓		-	✓
CO 4		✓	-	✓

CO 5		✓	-	✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT306				
Course Title	FOOD MICROBIOLOGY				
Type of Course	DSE				
Semester	V				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Microbiology,Nutrition and Health,Industrial Biotechnology				
Course Summary	Food Microbiology is a multidisciplinary field that encompasses microbiology, food science, and public health. This course provides an in-depth exploration of the role of microorganisms in food, focusing on their growth, survival, and interactions within food systems. Students will examine the impact of microbial activity on food quality, safety, and shelf-life, as well as the principles and practices of food preservation and microbiological analysis.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Food Microbiology**		**6**
	1	Overview of microorganisms in food Microbial growth and factors affecting growth Food microbiota: beneficial and spoilage microorganisms Microbial ecology in food systems,Soil,Air,water borne bacteria and fungi. spores and their significance	
	2	Indicator microorganism	
II		**Microbial Spoilage of Food**	**10**
	3	Types of food spoilage, Factors influencing microbial spoilage Detection and identification of spoilage microorganisms	
	4	Foodborne Pathogens,Common foodborne pathogens and their characteristics,Routes of contamination and transmission Pathogenicity and virulence factors,Regulatory standards and guidelines for food safety	
	5	Stress response in food borne bacteria	
	6	Spoilage of milk and milk products, poultry, fruits, vegetables and grains	
		Epidemology of pathogenic bacteria, nonbacterial pathogens and toxins	
III		**Food Preservation Techniques**	**10**
	7	Heat processing (pasteurization, sterilization),Low-temperature storage and refrigeration,Control of water activity Emerging preservation methods (e.g., high-pressure processing, irradiation, novel physical methods, Overview of Nanotechnology in food packaging and preservation	
	8	Chemical preservatives and natural food antimicrobials	
	9	Microbiological Analysis of Foods,Sampling techniques and sample preparation,Microbial enumeration methods (e.g., plate count, membrane filtration),Detection and identification of specific microorganisms (e.g., pathogens, indicator organisms), Rapid testing methods in food microbiology	
	10	Molecular techniques for microbial identification and characterization. Genetically modified organisms (GMOs) in food production and safety assessment. Biosensors and rapid detection methods for foodborne pathogens.	
IV	**Food Safety Management Systems**		**10**
	11	Hazard Analysis and Critical Control Points (HACCP),Good Manufacturing Practices (GMPs),Food safety regulations and compliance	

	12	Emerging Issues in Food Microbiology,Genetically modified organisms (GMOs) in food production,Antimicrobial resistance Novel food ingredients and their microbiological implications, Probiotics and prebiotics: applications in functional foods. Bioremediation of food contaminants: mycotoxins, pesticides, and heavy metals.	
V		**Assessments**	**9**
	13	Assignments: Critical analysis of research articles, case studies, and problem-solving exercises Laboratory Reports: Documentation and analysis of laboratory experiments and microbial assays	

Practicals (30 hours)- (Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Preparation of serial dilutions of food samples.
2. Inoculation of dilutions onto appropriate agar plates.
3. Incubation of plates at suitable temperatures for microbial growth.
4. Identification of Microorganisms
5. Observation of colony morphology on agar plates.
6. Gram staining of isolated colonies for bacterial identification.
7. Discussion on biochemical tests for microbial identification (e.g., catalase test, oxidase test).
8. Interpretation of results and identification of common foodborne pathogens
9. Calculation of microbial counts based on colony-forming units (CFU) per ml of sample.
10. Discussion on interpreting microbial counts in terms of food safety and quality.

Suggested Reading

1. Food Microbiology: Fundamentals and Frontiers" by MichaelDoyle, Robert Buchanan, and Arnold Katz
2. Food Microbiology, MR Adams,MO Moss, New Age International
3. Scientific articles and research papers
4. Laboratory manuals and protocols
5. Online resources and multimedia materials

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the diversity and characteristics of microorganisms relevant to food microbiology.	U	PSO1

CO-2	Explore the role of microorganisms in food spoilage and foodborne illness.	R, U	PSO1,5
CO-3	Learn the principles and methods of food preservation and control of foodborne pathogens. 5.	U,E	PSO1,5
CO-4	Gain practical skills in microbiological analysis techniques used in food testing and quality assurance.	U,Ap	PSO3
CO-5	Analyze the impact of processing, packaging, and storage conditions on microbial safety and quality of food products.	E	PSO2
CO6	Develop critical thinking skills in evaluating and implementing food safety and sanitation practices.	U	PSO2,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Food Microbiology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the diversity and characteristics of microorganisms	PSO1	U	F, C	L	
CO-2	Explore the role of microorganisms in food spoilage.	PSO1,5	R, U	P	L	P
CO-3	Learn the principles and methods of food preservation.	PSO1,5	U,E	F	L	

CO-4	Gain practical skills in microbiological analysis	PSO3	U,Ap	C	L	
CO-5	Analyze the impact of processing, packaging, and storage conditions on microbial safety	PSO2	E	C	L	
CO6	Develop critical thinking skills in evaluating and implementing food safety and sanitation practices.	PSO2,5	U	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	-	-	-	-	-						
CO 2	2	-	-	-	2	-						
CO 3	2	-	-	-	3	-						
CO 4	-	-	3	-	-	-						
CO 5	-	1	-	-	-	-						
CO 6	-	2	-	-	2	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK5DSEBIT307
Course Title	MARINE BIOTECHNOLOGY
Type of Course	DSE
Semester	V
Academic Level	300 –399.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5

Pre-requisites	Basics of Microbiology, Biochemistry
Course Summary	Marine Biotechnology at the graduate level delves into the interdisciplinary field that merges marine science with biotechnology, exploring the vast potential of marine organisms for various applications in industries ranging from pharmaceuticals to environmental conservation. This course provides students with advanced knowledge and skills in marine biology, genetics, molecular biology, biochemistry, and bioprocessing techniques tailored specifically to marine microorganisms

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Marine Microbial environment**	6

	1	Overview of marine biodiversity ,Marine microbial habitats ,Diversity of Marine microorganism.	
	2	Importance of marine biotechnology in industry and research	
	3	Characteristics of marine microorganisms. Specialized microorganisms: Extremophiles	
	4	Marine microalgae- bioactive Marine molecules	
	5	Indian cone snails, marine dinoflagellates-emerging therapeutic targets	
II		**Techniques in Marine microbiology:**	10
	6	Techniques in Marine microbiology: Sampling: Water, Sediments.	
	7	Culture based methods for isolation and, identification of microbes. define, selective and differential culture media.	
	8	Biological and pharmaceutical investigation of crude extract,isolation , identification of active substances and synthesis of biomaterials	
	9	Culture of microalgae and invertebrates Chemotaxonomy, Genetic engineering of marine organisms	
III		**Bioactive molecules from marine sources**	10
	10	Bioprospecting and discovery of novel marine biomolecules Enzymes from marine organisms and their industrial applications	
	11	Marine natural products and drug discovery , Antibacterial and anti biofilm molecules produced by marine bacteria, Chitin from poriferan	
	12	marine scaffolds,guanidinium toxin,carrageenans,maine pigments-marennine like pigments,peptide antibiotic from marine microbes, marine polysaccharides, cyanobacterial UV protective compounds, ovothiol	
	13	Applications of Marine Bioactive Molecules enzymes, biofuels, and biomaterials, Nutraceuticals and cosmeceuticals	
IV		**Marine bio resources**	10
	14	Marine bio resources. Brief introduction - Marine microbes (viruses, bacteria, archaea, protists, fungi) Marine algae and plants (seaweeds, sea grasses, mangrove, plants) Invertebrates: sponges, cnidarians, polychaetes, crustaceans, marine worms, molluscs, echinoderms, arthropods, Non-craniate (non-vertebrate) chordates, Adaptations of organisms to different habitats	
	15	Bio-communication in oceans, Microbe-microbe interaction, Quorum sensing, Microbe-metazoan interaction	
	16	Chemotaxis, Phototaxis, Bioluminescence and indicator species and Biological Rhythms	
V		**Ecosystem functioning in marine environment**	9
	17	Food web dynamics and ecosystem functioning, Microbial loop - Role of microbes in marine food web dynamics, - Biogeochemical processes: Nutrient cycling, carbon cycle, Nitrogen cycle, Sulphur cycle, Iron cycling, Phosphorus cycling and other cycles	

Practicals -30 hours -Essential Experiments-15 hours, group/individual work-15 hours

Essential Experiments

1. Collect samples from marine environments and isolate microbial species
2. Use various techniques such as streak plating, serial dilution, and selective media to isolate different strains.
3. Use molecular techniques like PCR and 16s rRNA Sequencing for identification.
4. Isolate and characterize bioactive compounds from marine organisms like sponges, algae, or bacteria.
5. Set up microcosms or mesocosms with contaminated marine samples and monitor the degradation of pollutants over time.
6. Analyze microbial diversity and activity using molecular techniques and biochemical assays

Suggested Reading

1.Blue iotechnology: production and Use of Marine Biomolecules. Stephane La Barre, Stephen S Bates. 2018. Wiley

2.Munn, C.B. , (2004) Marine Microbiology: Ecology and Applications, BIOS Scientific Publisher.

3.Krichman, D.L.,(2000), Microbial Ecology of the Oceans. Wiley-Liss, New York. 3.Paul,J.,(2001) Methods in Microbiology : marine Microbiology, Academic Press.

4.Gram, L., (2009) Microbial Spolage of Fish and Seafood, Springer

5.Pelczar M.J. Jr., ChanE.C.S. and Kreig N.R. (2001) Microbiology, (5th Edition) CBS Publishers.

6.Josep M Gasol and David L Kirchman (2018) Marine ecology of the oceans, (3rd edition), John Wiley and Sons. Inc

7.Surajit Das Hirak Dash (2018) Microbial Diversity in the Genomic Era, Elsevier

8.Horikoshi K, Antranikian G, Bull A T, Robb F T and Stetter, K O (2011) Extremophiles Handbook, Springer

9.Madigan, Martinko, Bender, Buckley &Stahl and Thomas Brock (2017) Brock Biology of Microorganisms, Pearson

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Discuss about Marine Microbial environment and its economic impact by biomaterial synthesis	U	PSO-1,2
CO-2	Identify the methods for biological and pharmaceutical investigation of crude extract, isolation , identification of active substances and synthesis of biomaterials	R, U,Ap	PSO3,PSO4

CO3	Awareness of different bio -resources in marine environment and overview of different bioactive compounds	U,E	PSO4
CO4	Analyse different marine environment that affect overall productivity	R,U	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Marine Biotechnology credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Discuss the scope of Marine biotechnology	PSO-1,2	U	F, C	L	
CO-2	Identify the potential of Biactive compounds and its isolation	PSO3,PSO4	R, U,Ap	P	L	P
CO3	Identify the scope of different marine microenvironment	PSO4	U,E	F	L	P
CO4	Analyse the microbial productivity of marine environment	PSO3	R,U	C	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	-						
CO 2	-	-	3	3	-	-						
CO 3	-	-	-	2	-	-						

CO 4	-	-	2	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓		✓	✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT308				
Course Title	AGRICULTURE BIOTECHNOLOGY				
Type of Course	DSE				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic knowledge in Plant physiology Genetic Engineering				
Course Summary	Agriculture Biotechnology is an interdisciplinary field that combines biological sciences with agricultural practices to enhance crop productivity, food quality, and sustainability. This course provides students with advanced knowledge and skills for applying Biotechnology aspects and tools in Agriculture and agriproduct development.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction**	**6**
	1	Soil science - Types of soils, soil profile, Components of soil, Nature and properties of soil, soil and plant microbiome	
	2	Crop Physiology - Types of nutrients and their role in crop production, Nutrient mobility	
	3	Nutrient deficiency and their identification symptoms in plants,	
	4	Biotic and abiotic factors affecting crop production	
	5	Major crops in India and agricultural research institutes in India	
II		**Biotechnology in Agriculture**	**12**
	6	Traditional plant breeding, Molecular marker assisted plant breeding, Genomic selection and breeding, Gene stacking and trait pyramiding, Artificial seeds	
	7	Stress Tolerance in Crops- Biotic and abiotic stresses in agriculture Strategies for enhancing stress tolerance in crops using biotechnology Engineering resistance to pests, diseases, and environmental stresses Insect resistant plants (Bt brinjal, Bt cotton-CS)	
	8	Advantages of genetically modified foods, Ecological impact of transgenic plants , Shelf life and nutritional value improvement by genetic modification	
	9	Biofertilizers - types of biofertilizers, Role of microorganisms in nitrogen fixation	
	10	Biocontrol agents - biopesticides, bioinsecticides, bio-herbicides,bio-fungicides, biochemical pesticides	
III		**Post Harvest Management**	**10**
	11	Ripening and senescence in cereals, pulses, fruits and vegetables Maturity indices and harvesting of vegetables	
	12	Post harvest loss, phases of loss and measures to reduce the losses	
	13	Application of Biotechnology for improvement of post harvest life of fruits and vegetables - delaying of senescence	
	14	Grain storage - types of storage and structure	
	15	Post Harvest Pest management -preventive and curative methods Post harvest pest management - Biological Control	
IV		**Molecular Farming**	**8**
	16	Production of pharmaceuticals and industrial products in plants Biopharming and its applications	
	17	Overview of Precision Agriculture and Smart Farming	
V		**IPR and Ethics**	**9**
	18	IPR in agriculture	
	19	Patented plant varieties and agri-products from India	

	20	Case studies: Patent story of Neem, Turmeric and Basmati rice Terminator seed technology	
	21	Food security and Genetically modified plants, Bioethics of genetically modified food	
	22	Field visit	

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Practicum (30 Hrs)- [Essential Experiments (15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Field visit and collection of samples

   i) Isolation of soil bacteria- observation of colony morphology.
   ii) Analysis of physical parameters of soil- soil texture, moisture, pH, salinity,
   iii) Isolation and culture of root nodule bacteria
   iv) Isolation of plant DNA from and quantification by spectrophotometric method

2. Surface sterilization of explants, inoculation and micropropagation of crop plants
3. Synthesis of artificial seeds
4. Production of transgenic crops - virtual lab
5. Management of agricultural waste products - composting/recycling
6. Value added products from agricultural waste materials

Suggested Reading

1. Introduction to Plant Biotechnology, 3rd Edition (2020) - Chawla HS, Oxford & IBH Publishing
2. Introduction to Agricultural Biotechnology, (2022) - Donald Shaffer, Murphy & Moore Publishing
3. Horticultural Practices And Post- Harvest Technology (2022) - Mandal A D S , Nag S, Books & Allied (p) Ltd
4. Agriculture Waste Management and Bioresource: The Circular Economy Perspective, (2022) - Suruchi Singh, Pardeep Singh, Anu Sharma, Moharana Choudhury, Wiley Publishers
5. An Introduction to Plant Tissue Culture (2016), M K Razdan, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi
6. Plant Tissue culture (2008) - Kalyan Kumar De, New Central Book Agency
7. Soil Microbiology, (2020) - Rao S, Oxford & Ibh
8. Environmental Biotechnology: Basic Concepts and Applications, 2nd Edition (2013) - Thakur I S, I K International Publishing House Pvt. Ltd

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand basic of agriculture and crop physiology	U	PSO-1
CO-2	Describing various measures that can take to improve plant protection, pest control and its impact on agricultural field	R, U,A	PSO1,PSO2,PSO5
CO3	Identify various methods for preventing the harvest lost, improved storage and protection of food commodities and applications of biotechnology in this field	U, E	PSO4, 5
CO4	Discuss and plan Management strategies of Agriculture waste and production of high value products from agricultural waste	U, Ap, E	PSO-2, PSO-5
CO-5	Express their views on IPR and ethics related issues in agriculture biotechnology	An, E	PSO-5
CO-6	Micropropagation of improved varieties of crops	P	PSO-3, PSO-5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course:Agriculture biotechnology
Credits:2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand basic of agriculture and crop physiology	PSO-1 PO-1	U	F, C	L	
CO-2	Describing various measures that can take to	PSO1,PSO2,PSO5	R, U, An	F, C, M	L	

	improve plant protection, pest control and its impact on agricultural field	PO-1, PO-2				
CO3	Identify various methods for preventing the harvest lost, improved storage and protection of food commodities and applications of biotechnology in this field	PSO4, 5 PO-2, PO-3	U, Ap	M	L	
CO4	Discuss and plan Management strategies of Agriculture waste and production of high value products from agricultural waste	PSO-2, PSO-5 PO-2, PO-3	U, Ap, E	P	L	P
CO5	Express their views on IPR and ethics related issues in agriculture biotechnology	PSO-5 PO-8	An, E	M	L	
CO 6	Micropropagation of improved varieties of crops	PSO-3, PSO-5 PO-6	Ap	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO 1	3		-	-	-	2							

CO 2	2	2	-	-	2	1	2						
CO 3	-	-		1	3		2	3					
CO 4	-	3	-	-	3		3	3					
CO 5					3								3
CO 6			3		3						2		

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓	✓	✓

CO 5	✓	✓		
CO 6	✓		✓	

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT309				
Course Title	MICROBIAL DIVERSITY AND PHYTOPATHOLOGY				
Type of Course	DSE				
Semester	V				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic Microbiology, Essentials of Botany				
Course Summary	This graduate-level course explores the intricate relationship between microbial diversity and plant pathology. It delves into the vast array of microorganisms that interact with plants, both beneficial and detrimental, and				

	examines the mechanisms by which these interactions influence plant health and disease. Through a combination of lectures, discussions, laboratory work, and research projects, students will gain a comprehensive understanding of microbial diversity, plant-microbe interactions, and strategies for managing plant diseases.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Microbial world and diversity**	**9**
	1	Overview of microbial diversity: bacteria, fungi, viruses, and their significance in agriculture	
	2	Introduction to phytopathology: plant diseases, symptoms, and classifications.	
	3	Taxonomy and classification of phytopathogens.Morphological, physiological, and genetic diversity of plant pathogens.	
	4	Case studies of significant phytopathogens affecting global agriculture.	
II		**Molecular Mechanisms of Plant-Microbe Interactions**	**10**
	5	Recognition and signaling mechanisms in plant immunity. Effector biology and virulence strategies of phytopathogens.	
	6	Defense mechanisms in plants against microbial pathogens. Discovery; Physiochemical and biological characteristics; Classification (including Baltimore's);	
	7	Dynamics of host-specificity and pathogen adaptation. Mutualistic, commensal, and parasitic interactions between plants and microbes.	
	8	Impact of environmental factors on host-microbe interactions.	
III		**Biotechnological Approaches in Phytopathology**	**10**
	9	Use of Genomics and transcriptomics in studying plant-pathogen interactions.	
	10	Plant disease diagnostics and surveillance using molecular tools.	
	11	Biotechnological interventions for disease management: genetic resistance, biocontrol, and microbial consortia.	
	12	Biotechnological innovations for sustainable agriculture and crop protection. Synthetic biology approaches in engineering plant immunity. Challenges and opportunities in harnessing microbial diversity for agricultural sustainability.	
IV		**Microbes involvd in plant pathology**	**10**
	13	Disease caused by Bacteria ,Fungi,and virus in plants General characteristics and distribution of algae	
		Molecular Approaches: Introduce molecular tools and techniques used in the study of microbial diversity and phytopathology, including genomics, transcriptomics, and proteomics.	
	14	Strategies for managing plant diseases, including biological control, host resistance breeding, cultural practices, and the use of pesticides.	
V		**Microbes and plant health**	**9**

	15	Use of microbial consortia for disease suppression Integrated disease management approaches	
	16	Biocontrol agents for plant disease management	
	17	Biosensors for rapid detection of plant pathogens	

Practicum (30 Hrs)- [Essential Experiments (15 Hrs), Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. By virtual lab/hands on
2. Morphological and physiological characterization of plant pathogens.
    a. Perform gram staining procedure of gram positive and gram negative bacteria
3. Make micropreperations of various algae,fungi involved in plant pathology
4. Identify the disease mentioned with respect to causative organism and symptoms- Tapioca mosaic virus and bunchy top of banana

Suggested Reading

1. Alain Durieux 2009, Applied Microbiology, Springer International Edition

2.Alexopoulos C.J & MIMS C.V 1988. Introductory Mycology, John Wiley & Sons.

3. Chapman V.J & Chapman D.J, The Algae, Macmillan.

4. Dr. G. Gunasekharan – Labortary Manual of Microbiology – New Age Pub:

5. Fritsch F. B 1945, Structure and Reproduction of Algae Vol.I & II. Cambridge University Press.

6. Heritage. L. 2007, Introductory Microbiology, Cambridge University Press India Pvt Ltd

7. Jim Deacon 2007, Fungal Biology, 4th edition, Blackwell Publishing, Ane Books Pvt. Ltd.

8. Kanika Sharma 2009, Manual of Microbiology, Ane Books Pvt. Ltd.

9. Mamatha Rao 2009, Microbes and Non flowering plants, Impact and applications; Ane Books Pvt. Ltd.

10. R .C .Dubey & D .K .Maheswari – A text Book of Microbiology – Chand & Co: 11. Schlegel ,2008 General Microbiology , Cambridge University Press India Pvt Ltd

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	To understand various microbes and their diversity	U	PSO1
CO-2	Understanding the structure, classification of virus	U,Ap	PSO3,4
CO-3	Analyze various disease caused by virus	U,Ap	PSO3,4
CO-4	Understand the structure and staining techniques in bacteria	Ap, An	PSO 1,3
CO-5	Analysis of various anatomical structure in algae and fungi	Ap, An	PSO1

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Microbial diversity and phytopathology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	To understand various microbes and their diversity	PSO1	U	F, C	L	
CO-2	Understanding the structure,classification of virus	PSO3,4	U,Ap	P	L	
CO-3	Analyze various disease caused by virus	PSO3,4	U,Ap	C	L	
CO-4	Understand the structure and staining techniques in bacteria	PSO 1,3	Ap, An	F	L	
CO-5	Analysis of various anatomical structure in algae and fungi	PSO1	Ap, An	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						
CO 2	-	-	2	2	-	-						
CO 3	=	-	3	2	-	-						
CO 4	2	-	2	-	-	-						
CO 5	2	-	-	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

Discipline	BIOTECHNOLOGY				
Course Code	UK5DSEBIT310				
Course Title	PHARMACEUTICAL BIOTECHNOLOGY				
Type of Course	DSE				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	rDNA technology, Molecular Biology, Animal Cell Biotechnology				
Course Summary	Biotechnology has applications in the field of medicine in diagnosis, prevention and cure of diseases, generation of new and cheaper pharmaceutical drugs. This course is aimed at acquainting the student towards applications of Biotechnology in generating novel drugs and therapeutics, emphasising the potential of the subject to revolutionise the fields of Biological sciences and influence human healthcare.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Production of drugs by means of Biotechnology**	**12**
	1	Pharmaceuticals Vs Biopharmaceuticals Production of therapeutic proteins through biotechnological methods: Genetic engineering, Protein engineering and fermentation technology	
	2	Fermentation technique : submerged, solid state, General requirements : media formulation, sterilization methods, sparging, stirring.	
	3	Scale up of biopharmaceutical: Large scale production: fermenter design and its various controls, purification of product. Examples : interferons, insulin and growth hormones,vitamins, amino acids, monoclonal antibodies, vaccines	
	4	Immobilization of enzymes: Industrial applications of immobilized enzymes -amylase,protease,catalase,lipase	
II		**Drugs -ADMETOX**	**12**
	5	Drugs- administration - routes, Drug receptors	
	6	Drug Absorption- Mechanisms of drug absorption	

	7	Distribution- Tissue permeability of drugs, binding of drugs.	
	8	Drug metabolism and excretion - Factors affecting renal excretion of drugs	
III		**Targeted drug delivery**	**12**
	9	Introduction: concept, basis, need, physicochemical and physiological basis	
	10	Drug targeting: microspheres, liposomes, nanoparticles	
	11	Drug targeting in cancer and infectious diseases	
	12	Use monoclonal antibodies in immunodiagnostics: as ligands for targeted drug delivery, diagnostics, imaging and therapy	
IV		**Evaluation of drug safety**	**12**
	13	Drug toxicity testing- identification of adverse effects of drugs: *in vitro* (cytotoxicity assays), *in vivo* and *in silico* methods, Pharmacokinetics	
	14	Genotoxicity assays: Ames test	
	15	Clinical trials: types: screening trials, diagnostic trials, treatment trials. Phases of clinical trials: Phase I to IV	
	16	Regulatory requirement for conducting clinical trials in India - Central Drugs Standard Control Organization (CDSCO) guidelines	
V		**Bioethics**	**12**
	17	Clinical trials and Patient safety, informed consent, stringent guidelines from healthcare authorities	
	18	Conflict of interest- transparency and trust, bias, industry influence	
	19	Concerns with exploitation of vulnerable populations for drug testing, ensuring affordability in drug pricing, cost/effectiveness ratio, clinical safety assessment.	
	20	Animal welfare: Reducing the use of NHPs (non-human primates) for preclinical trials of biopharmaceuticals	

Familiarize with the following experiments

1. Spectrophotometry: Determination of DNA, RNA, and pr Gel electrophoresis: Visualization of DNA fragments.
2. Aseptic techniques: Handling of cell culture materials.
3. Cell counting and viability assays.
4. Cell lysis and protein extraction.
5. Chromatography techniques
6. SDS-PAGE analysis of purified proteins.
7. Protein quantification assays.

8. Plasmid DNA isolation and restriction enzyme digestion.

Virtual Lab

1. ELISA: Quantitative analysis of proteins or small molecules.
2. Western blotting: Detection of specific proteins.
3. Fermentation techniques: Batch
4. Monitoring parameters: pH, temperature, and agitation.
5. Downstream processing: Harvesting, clarification, and purification of bioproducts.
6. Nanoparticle synthesis: Preparation of drug-loaded nanoparticles.
7. Liposome preparation and characterization.

Suggested Reading

1. Biopharmaceutics and Clinical Pharmacokinetics by, Milo Gibaldi.
2. Biopharmaceutics and Pharmacokinetics; By Robert F Notari
3. Ethics and the Pharmaceutical industry, Michael A Santoro, Thomas m Gorie
4. ADMET for Medicinal Chemists: A Practical Guide, Katya Tsaioun and Steven A. Kates
5. Drug Safety Evaluation- Pharmaceutical development series- 4th edition- Shayne Cox Gad, Dexter W. Sullivan Jr.
6. Pharmaceutical Biotechnology- Fundamentals and Applications- K. SambamoorthyAshutoshKar: New Age International Publishers
7. Pharmaceutical Biotechnology: Concepts and Applications- Gary Walsh

<u>Course Outcomes</u>

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the concept of metabolism of drugs	R, U	PSO-1,2
CO-2	Evaluate different kinds of biopharmaceutical production assisted with a company visit	U, E	POS3,4
C0-3	Understand the regulatory rules in biopharmaindusty	U, An	PSO3,4
C0-4	Understand the different ways to check safety of drug	U, An	PSO1,3
CO-5	Critically analyse the bioethics principles based on case studies	U, An, E	PSO5

CO-6	Create a chart on clinical trials happening in the state, with emphasis on informed consent, and following guidelines	An, Ap	PSO2,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: Pharmaceutical biotechnology Credits: 3:1:0(Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
1	Understand the concept of drug metabolism	PSO-1,2	R, U	F, C	L	
2	Evaluate biopharmaceutical production	POS3,4	U, Ap	C, P	L	
3	Understand the regulatory rules	PSO3,4	U, An	F,C	L	
4	Understand the methods to analyse drug purity	PSO1,3	U	F,C	L	
5	Analyse bio issues	PSO5	U, An	F,C	L	
6	Creating clinical trial chart	PSO2,5	An,Ap	C, P	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	2	-	-	-	-						
CO 2	-	-	2	2	-	-						

CO 3	-	-	1	2	-	-						
CO 4	2	-	2	-	-	-						
CO 5	-	-	-	-	3	-						
CO 6	-	2	-	-	3	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics: Quiz / Assignment/ Quiz/ Discussion / Seminar/Midterm Exam /rogramming Assignments /Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓			✓
CO 4				✓
CO 5				✓
CO 6	✓			✓

Skill enhancement Courses 300-399

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK5SECBIT300				
Course Title	PLANT TISSUE CULTURE ENTREPRENEURSHIP				
Type of Course	SEC				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3
Pre-requisites	Biochemistry,plant Biotechnology				
Course Summary	This graduate-level course provides students with a comprehensive understanding of plant tissue culture techniques and their applications in entrepreneurship within the agricultural and biotechnological sectors. Through a blend of theoretical lectures, case studies, and entrepreneurial projects, students will develop the knowledge, skills, and mindset necessary to establish and manage successful ventures in plant tissue culture.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Plant Tissue Culture**	**9**
	1	History and significance of plant tissue culture. Principles and fundamentals of plant tissue culture. Basic laboratory setup and equipment	
	2	Plant Tissue Culture Techniques. Explant selection and preparation, Media preparation and sterilization techniques. Types of plant tissue cultures: organogenesis, embryogenesis, and somatic embryogenesis. Callus induction, shoot proliferation, and rooting techniques. Micropropagation protocols for various plant species.	
	3	Introduction to genetic engineering techniques in plant tissue culture. Transgenic plant production and applications.	
II		**Entrepreneurship & Business Planning Fundamentals**	**0**
	4	Entrepreneurship Fundamentals Definition and characteristics of entrepreneurship Identifying opportunities in plant tissue culture,Assessing risk and feasibility	

	5	Business Planning : Developing a business model canvas for a plant tissue culture enterprise. Writing a business plan: components and structure Financial projections and budgeting.	
III		**Market Analysis & Regulatory and Ethical Considerations**	**9**
	6	Market Analysis : Understanding market trends and dynamics in plant tissue culture. Identifying target markets and customer segments, Competitive analysis and positioning	
	7	Regulatory and Ethical Considerations: Regulatory requirements for plant tissue culture businesses Intellectual property rights and patents, Ethical considerations in biotechnology entrepreneurship	
IV		**Scaling and Growth Strategies**	**9**
	8	Scaling and Growth Strategies :Scaling up production in plant tissue culture. International expansion and export opportunities. Strategic partnerships and collaborations	
	9	Innovation and Problem-Solving Innovations in plant tissue culture techniques and applications. Identifying and solving common challenges in plant tissue culture entrepreneurship. Case studies of successful plant tissue culture startups	
V		**Analysis of industry trend**	**9**
	10	Success stories and challenges faced by existing tissue culture companies.	
	11	Real-world examples of innovative applications in agriculture, horticulture, and pharmaceuticals.	
	12	Analysis of industry trends and emerging technologies. Students will work in teams to develop a business plan for a hypothetical or real plant tissue culture venture. Incorporation of scientific knowledge, market analysis, and financial projections. Presentation of business plans to peers and industry professionals.	

Suggested Readings

1. Plant Tissue Culture: Theory and Practice" by S.S. Bhojwani and M.K. Razdan
2. Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants" by Ralph R. Weis and Roger R. Ruan
3. Plant Biotechnology and Agriculture: Prospects for the 21st Century" edited by Arie Altman –

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Awareness on plant tissue culture techniques	U	PSO-1,5
CO-2	Assess the possibility of Entrepreneurship & Business Planning in plant tissue culture	R, U	PSO2,5
CO3	Understanding market trends and dynamics in plant tissue culture	U	PSO5
CO4	Awareness on scaling up production in plant tissue culture and export opportunities	E,Ap	PSO5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Plant tissue culture entrepreneurship Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Awareness on plant tissue culture	PSO-1,5	U	F, C	L	P
CO-2	Assess the possibility of Entrepreneurship	PSO2,5	R, U	P	L	
CO3	Understanding market trends	PSO5	U	F	L	
CO4	Awareness on scaling up	PSO5	E,Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	1	-	-	-	3	-						
CO 2	1	3	-	-	3	-						
CO 3	-	-	-	-	3	-						
CO 4	-	-	-	-	3	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics: Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam /Programming Assignments /Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK5SECBIT301

Course Title	ENTREPRENEURSHIP IN BIOTECHNOLOGY				
Type of Course	SEC				
Semester	V				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2	1		3
Pre-requisites	essentials of Biotechnology,				
Course Summary	This graduate-level course offers a comprehensive exploration of the intersection between biotechnology and entrepreneurship. It is designed to equip students with the knowledge, skills, and mindset necessary to navigate the complex landscape of starting and managing biotech ventures. The course delves into various aspects of entrepreneurship within the biotechnology industry, including innovation, business models, financing, regulatory considerations, and ethical implications				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to entrepreneurship**	**9**
	1	Introduction to Entrepreneurship, characteristics of an entrepreneurship, types of entrepreneurships	
	2	Bio-entrepreneurship-concept and significance, objectives of bioentrepreneurship development, Strategy, and operations of bio-sector firms.	
	3	Promotion of entrepreneurship, Factors influencing entrepreneurship.	
II		**Development skills for bioentrepreneurship**	**9**
	4	Entrepreneurial skills types - team work and leadership skills, analytical and problem-solving skills, critical thinking skills, branding, marketing, and networking skills.	
	5	Features of a successful Bioentrepreneurship, essential bioentrepreneurial characteristics.	
	6	Startu ps- Definition and types. Role of entrepreneurship development programmes (EDP).	
III		**Bioentrepreneurship development & marketing**	**9**
	7	Business plan preparation including statutory and legal requirements, feasibility study and sensing the right business opportunity.	
	8	Organizational structure & Management, Capital management, novel product innovation technology and development	
	9	Concept of a Product - Product mix decisions, Brand Decision.	

	10	Marketing concepts, marketing process, social media for marketing, Marketing Research, and Importance of survey.	
IV		**Scope of bioentrepreneurship**	**9**
	11	Scope of Bioentrepreneurship in Agriculture, Food and Dairy, Biomedical and healthcare (Molecular diagnostics), biological data analysis and Management.	
	12	Scope of Bioentrepreneurship in Environmental Biotechnology (Biofertilizer, Biofuels, Biological waste management and waste water treatment) and Industrial biotechnology.	
	13	Funding agencies for entrepreneurship in Biotechnology. Regulations for biotech products.	
V		**Bioentrepreneurship challenges**	**9**
	14	Qualities and functions of Entrepreneurs, Use of IT & AI for business administration, Marketing, and management.	
	15	Various schemes promoting Bioentrepreneurship. Intellectual Property ,Regulatory and ethical challenges.	
	16	Industry Visits, Case Studies in Biotech Entrepreneurship, Developing a Biotech Business Plan and presentation and Feedback Sessions	

Suggested Reading.

1. David H Holt. Entrepreneurship: New Venture Creation. Pearson publications.
2. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand &Sons.
3. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge, Routledge Studies in Innovation,
4. Organizations and Technology (2018) Alberto Onetti, & Zucchella, A, CRC press, Taylor and Francis group.
5. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Craig Shimasaki, Academic Press, Elsevier.
6. The Dynamics of Entrepreneurial Development and Management. Vasant Desai,

   Himalaya Pub. House, ISBN: 9350244543.

Online Resources

Authentic web-based resources like NCBI, PubMed, e-pgpathshala, ScienceDirect etc.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive	PSO addressed

		Level	
CO-1	Explain entrepreneurship,bioentrepreneurship and its significance.	U, E	PSO5
CO-2	List out the skills required for the bioentrepreneurship.	An	PSO1,5
CO-3	Summarize the bioentrepreneurship development process and marketing strategies.	U	PSO5
CO-4	Discuss the Entrepreneurship scope in biological areas.	C	PSO5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Entrepreneurship in biotechnology Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain entrepreneurship	PSO5	U, E	F, C	L	
CO-2	List out the skills for the bioentrepreneurship.	PSO1,5	An	P	L	P
CO-3	Summarize the bioentrepreneurship development process	PSO5	U	F	L	P
CO-4	Discuss the Entrepreneurship scope	PSO5	C	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	-	-	-	-	3	-						
CO 2	1	-	-	-	3	-						
CO 3	-	-	-	-	3	-						
CO 4	-	-	-	-	3	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓

SEMESTER 6

Discipline Specific Core Level 300-399-
A9(P),A10,A11

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSCBIT304				
Course Title	ANIMAL BIOTECHNOLOGY				
Type of Course	DSC				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	Basic knowledge in Molecular biology, and rDNA technology				
Course Summary	This course deals with the application of biotechnological tools and techniques for the advancement of animal science, agriculture, and human welfare. This interdisciplinary field integrates principles from rDNA technology, molecular biology and reproductive biology to address various challenges and opportunities related to animal health, productivity, and sustainability				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Animal cell culture**	12
	1	Animal cell culture: History	
	2	Animal cell culture techniques, Primary cell cultures and secondary cell cultures, sub culture techniques Cell lines, Immortalized cell lines, transformed cell lines, Cell strains	
	3	Finite and continuous cell lines, Anchorage dependent and anchorage independent cells Characterization of cell lines	
II		**Animal Cell Culture - Requirements & Scale up**	12
	4	Basic requirements in animal cell culture lab- instruments and equipment	
	5	Media - Media components and physical parameters, Growth factors promoting proliferation of animal cell cultures	

		Principles of sterile techniques, Maintenance of animal cell culture, Cryopreservation, and transport of animal cell cultures Cell viability assays	
	6	Scale Up- Monolayer cultures and Suspension cultures, roller bottles and spinner flasks, Micro carrier attached growth. Bioreactors for large scale cultivation of animal cells	
III	**Gene transfer techniques & Stem cell technology**		12
	7	Gene transfer techniques- Direct methods, Indirect methods- Animal viral vectors	
	8	Transgenesis-Transgenic animals and its practical uses- Animals as Bioreactors	
	9	Stem cell technology: Types of stem cells, Stem cell culture and its clinical uses, Tissue engineered grafts	
	10	Gene therapy	
IV	**Application of Animal Cell Cultures**		12
	11	Products of animal cell cultures- hormones (Insulin, growth hormones), interferon, t-plasminogen activator, factor VIII, Factor IX	
	12	Production of vaccines in animal cells	
	13	Virus cultivation in animal cell cultures	
	14	Production of polyclonal and monoclonal antibodies-hybridoma technology	
V	**Bioethics and Biosafety**		12
	15	Ethical issues and concerns in Trasgenics Ethical use of animals in research - Justification for using animals, Considerations in selection of animal models, Alternatives to animal experimentation such as in vitro models, computer simulations etc.	
	16	Laboratory safety practices – importance of following standard operating procedures (SOPs) and safety protocols in animal cell culture laboratories, Personal protective equipment (PPE) requirements for researchers working with animal cells, Risk assessments to identify potential hazards, Mitigation strategies	

Suggested Readings

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications - 7th Edition (2016) - Freshney R I, Wiley-Blackwell
2. Animal Cell Culture: A Practical Approach, 3rd Edition (2000) - Masters J, OUP Oxford
3. Biotechnology-Fundamentals and Application, 3rd Edition (2002) - S S Purohit and S K Mathur, Agrobios, India.
4. Introduction to Genetic Engineering & Biotechnology (2010) - A J Nair, Jones & Bartlett Publishers, Boston, USA.
5. Modern concept of Biotechnology (1998) - H D Kumar; Vikas Publishing House Pvt. Ltd., New Delhi.

6. Biotechnology, 5th Edition (2009) - Smith JE, Cambridge University Press
7. Biotechnology (2015) - B D Singh, Kalyani Publishers

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the basic techniques involved in animal cell culture, characteristics, and maintenance of cell lines	U	PSO-1,2
CO-2	Explain the techniques involved in animal cell cloning and gene transfer methods	U, E	PSO3
CO3	Elaborate the applications of animal cell culture at various field	Ap	PSO1, PSO4
CO4	Discuss the problems associated with animal biotechnology and ethical issues	Ev	PSO2,5
CO5	Explain the basic requirements for the design of an animal cell culture laboratory	U	PSO-1

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Animal biotechnology Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the basic techniques involved in animal cell culture, characteristics, and maintenance of cell lines	PSO1,2 PO1	U	F, C	L	
CO-2	Explain the techniques involved in animal cell	PSO 3 PO2	An	F,C	L	

	cloning and gene transfer methods					
CO3	Elaborate the applications of animal cell culture at various field	PSO1,4 PO3	R,U	F	L	-
CO4	Discuss the problems associated with animal biotechnology and ethical issues	PSO2,5 PO8	U	F, C, M	L	-
CO5	Explain the basic requirements for the design of an animal cell culture laboratory	PSO-1 PO-1	U	F, C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	1	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	-	-	3	-	-	-	-	2	-	-	-	-	-	-
CO 3	1	-	-	3	-	-	-	-	2	-	-	-	-	-
CO 4	-	2	-	-	3	-	-	-	-	-	-	-	-	3
CO 5	3	-	-	-	-	-	2	-	-	-	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO5	✓	✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSCBIT305				
Course Title	PLANT BIOTECHNOLOGY				
Type of Course	DSC				
Semester	VI				
Academic Level	300 –399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Cell biology, plant physiology, molecular biology, rDNA technololgy				
Course Summary	This graduate-level course in Plant Biotechnology provides an in-depth exploration of the principles, techniques, and applications of biotechnology in the context of plant science. The course encompasses a blend of theoretical knowledge, laboratory practical sessions, and discussions on recent advancements in the field.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Plant Tissue Culture**	6
	1	Introduction to plant tissue culture: Basics of Plant Tissue Culture/Micropropagation, Importance of plant tissue culture, Basic set up of a plant tissue culture lab.	
	2	Fundamental principles of *in vitro* plant cultures: Major Tools and Instrumentation, Selection of explant, familiarization, and use of plant growth regulators Composition of tissue culture media- media components and its functions, various types of commercially available media. Sterilization Methods-Steam sterilization, Dry sterilization, Filter sterilization, surface sterilization of explants	
II		***Invitro* Cultures- Types &Applications**	10
	3	Types of *in vitro* cultures: Callus cultures, cell suspension cultures, organ cultures-root cultures, hairy root cultures, embryo cultures	
	4	Embryogenesis and organogenesis a brief understanding Clonal multiplication and micropropagation- meristem culture, axillary bud and shoot tip culture Anther and pollen culture- production of haploids and its uses	
	5	Plant secondary metabolites production through cell, tissue and organ cultures, Advantages, and disadvantages of in vitro methods	
III		**Somaclonal Variation and Somatic Hybridization**	10

	6	Somaclonal Variation: Possible reasons for somaclonal variations, Selection of soma clones. Applications of somaclonal variations in agriculture and Horticulture, Merits, and demerits of somaclonal variation	
	7	Protoplast-isolation and culturing of protoplast-principle and application, Regeneration of protoplasts, protoplast fusion and somatic hybridization-selection of hybrid cells	
IV		**Genetic engineering and Transgenic plants**	10
	8	Methods of gene transfer in plants–Physical, chemical, and biological methods (Agrobacterium mediated and Virus mediated)	
	9	Transgenic crops, Impact of transgenic plants in agriculture and Horticulture, Non-Agricultural applications of transgenic plants-Biopharming-production of therapeutic proteins in transgenic plants, edible vaccines, disease resistant, salt tolerant, pest resistant and stress tolerant crops	
	10	Metabolic engineering of plants for enhanced and controlled production of plant products	
V		**Recent advances and Ethical concerns in Plant Biotechnology**	9
	11	RNA Interference (RNAi) targeted gene regulation, CRISPR/Cas9 and other genome editing techniques for precise genetic modifications, Synthetic Biology approaches in plant engineering	
	12	Ethical Concerns : Transgene Containment, Loss of Diversity, Sterile Seed technology	

Practical (30Hrs)-[Essential Experiments (15Hrs),
Group/Individual Experiments (15 Hrs)]

Essential Experiments

1. Preparation of plant tissue culture medium, and sterilization, Preparation of stock solutions of nutrients for MS Media.
2. Preparation of MS Media
3. Surface sterilization of plant materials for inoculation (implantation in the medium)
4. Development of callus cultures and its sub-culturing
5. Organogenesis-shoot regeneration, root regeneration, somatic embryogenesis
6. Micropropagation of potato/tomato/-Demonstration
7. Familiarization of instruments and special equipment’s used in the plant tissue culture experiments- Laminar Airflow chamber,
8. Protoplast isolation and culturing–Demonstration

Suggested readings

1. Plant Biotechnology-Recent Advances (2000), P C Trivedi, Panima Publishing Corporation, New Delhi.
2. Introduction to Plant Biotechnology (2020), H S Chawla, Oxford & IBH publishing Co. Pvt. Ltd, New Delhi.

3. Basics of Biotechnology (2004), A J Nair; Laxmi Publications, New Delhi.
4. An Introduction to Plant Tissue Culture (2016), M K Razdan, Oxford &IBH Publishing Co. Pvt. Ltd., New Delhi
5. Role of Biotechnology in Medicinal and aromatic plants (2011), Irfan A Khan and Atiya Khanum, Ukaaz Publications, Hyderabad.
6. Plant Cell, Tissue, and Organ Culture-Fundamental Methods (2004) O L Gamborg, G C Phillips Narosa Publishing House, New Delhi.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand fundamentals of plant tissue culture and its tools	U	PSO-1
CO-2	Evaluate how plant tissue culture techniques is useful in research and agriculture	R, U	PSO3,PSO4
CO3	To understand genetic variation mechanisms and to evaluate its applications in agriculture	U, Ap	PSO-1
CO4	Evaluate how to improve the quality of plants through genetic engineering methods	E, Ap	PSO1,3
CO5	Understand the application of transgenic plants in various fields and awareness about basic ethical concerns related to it	U,AP	PSO2, 3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Plant biotechnology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand fundamentals of plant tissue culture and its tools	PSO1, 2 PO 1	U	F, C	L	P

CO-2	Evaluate how plant tissue culture techniques is useful in research and agriculture	PSO1, 4 PO1, 3	R, U	P	L	P
CO3	To understand genetic variation mechanisms and to evaluate its applications in agriculture	PSO1,4 PO3	U, Ap	P, M	L	
CO4	Evaluate how to improve the quality of plants through genetic engineering methods	PSO2, 3 PO 1,3	E, Ap	P, M	L	P
CO5	Understand the application of transgenic plants in various fields and awareness about basic ethical concerns related to it	PSO3,5 PO 6	U	C	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	1	-	-	-	-	2	-	-	-	-	-	-	-
CO 2	2	-	-	2	-	-	2	-	1	-	-	-	-	-
CO 3	2	-	-	2	-	-	-	-	2	-	-	-	-	-

CO4	-	2	2	-	-	-	3	-	2	-	-	-	-	-
CO5	-	-	2	-	2	-	-	-	-	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar/Midterm Exam
- Programming Assignments /Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓		✓
CO 4		✓	✓	✓
CO 5	✓	✓		✓

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSCBIT306				
Course Title	ENVIRONMENTAL BIOTECHNOLOGY				
Type of Course	DSC				
Semester	VI				
Academic Level	300 – 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1		4
Pre-requisites	Basic Biotechnology, Microbiology				
Course Summary	Environmental Biotechnology at the graduate level probes deeper into the application of biological principles and processes to address environmental issues and challenges. It encompasses various fields such as microbiology, biochemistry, genetics, and engineering to develop sustainable solutions for environmental conservation, pollution control, and resource management.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Ecosystem and Environment**	12
	1	Environment-Definition, components, and inter-relationships	
	2	Brief idea on Ecosystems and ecology	
	3	Ecads and Ecotypes	
	4	Biodiversity and Biosphere	
II		**Environment Pollution**	12
	5	Pollution: Sources and types General characteristics of domestic wastes, community wastes, agricultural wastes, electronic wastes-effect of solid wastes in the environment	
	6	Air Pollution: Natural and anthropogenic sources of pollution, Effect of air pollution, Control measures	
	7	Water pollution: Organic load in aquatic systems, Measuring BOD and COD, Assessing microbial quality of water	
	8	Biotechnology and pollution control: Biofiltration and bioreactors for air pollution control Monitoring and assessment of water and air quality using biotechnological tools Treatment of municipal wastes and hazardous industrial effluents - aerobic and anaerobic methods, Biofiltration, Biological Scrubbers/ bio trickling filters	

		Carbon sequestration techniques Biotechnological solutions for reducing greenhouse gas emissions	
III		**Renewable and Non-renewable Energy**	12
	9	Renewable and non-renewable energy resources: conventional fuels and their environmental impacts (fire wood, animal oils, coal, petroleum)	
	10	Non-conventional energy sources Biomass: utilization of biomass as energy source– application of microbes in production of fuels from biomass-biogas and methanogenic bacteria, microbial hydrogen production, production of bioethanol, and other types of chemicals from biomass and agricultural wastes, the gasohol experiment Algal biofuels: cultivation, harvesting, and processing Vegetable oils as engine fuels, energy crops-jojoba; Possibility of plant-based petroleum industry and biofuels.	
IV		**Bioremediation and Biodegradation**	12
		Microbial diversity and ecosystem functioning, Microbial interactions in natural and engineered environments, Microbial metabolism and nutrient cycling Types of pollutants and contaminants Bioremediation- strategies: bioaugmentation, biostimulation, phytoremediation, etc. Case studies of successful bioremediation projects . Biodegradation - microorganisms used for bioremediation, and applications ,Mechanism of pollutant degradation by microbes	
	11	. Biological control of pests and insects, Biopesticides- Bacillus thuringiensis, bioherbicides; Application of biotechnology in the production of biofertilizers and nitrogen fixation – nitrogen fixing microorganisms, mycorrhiza	
	12	Mineral Biotechnology- Enrichment of ores by microorganisms (bioaccumulation and biomineralisation); Bio-assessment of environmental quality	
V		**Environment Legislations**	12
	13	Environment laws: The Environment Protection act,1986 The wildlife preservation act,1982 The wildlife protection act,1972 The biological diversity act,2002	

		The biodiversity Rules,2004 National green tribunal act,2010	

Familiarize with the following Techniques

1. Microbiological assessment of drinking water- water from well, river, water supply department and packaged drinking water
2. Isolation of microbes from the environment- from air, soil, floor of the lab, from water.
3. Assessment of organic load in aquatic systems and factory effluent- Determination of BOD and COD.
4. Biogas production by methanogenic bacteria or by mixed culture in a biogas plant.
5. Isolation of nitrogen fixing bacteria from leguminous plants
6. Determination of NP and K in biofertilizers

Suggested Readings

1. Environmental Biotechnology (1999) - Alan H Scragg; Longman, England
2. Biotechnology-Fundamentals and Application (2002) - S S Purohit and S K Mathur; Agrobios, India
3. Biotechnology (2015) - B D Singh, Kalyani Publishers
4. Biological wastewater treatment (1998) - Grady C P L, G T Daigger, H C Lim; CRC Press
5. Environmental Issues and Options (2007) - Mishra C S; Daya Publishing House
6. Biodiversity- Status and Prospects (2005) - Pramod Tandon, Manju Sharma, Renu Swarup; Narosa Publishing House, New Delhi
7. Ecology (2006) - Subrahmanyam N S, A V S S Sambamurty; Alpha Science International Ltd.
8. Biotechnology (2020) - U Satyanarayana, Books and Allied (P) Ltd.
9. Microbiology (2007) - Prescott L. M., Harley, J. P., and Klein D. A; Mc Graw Hill, New York

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concept of environment, ecosystem, biodiversity, and biosphere	U	PSO-1,PSO-2

CO-2	Identify types and key sources of environmental pollution, and understand various biotechnological control measures for pollution	R, U	PSO 2, PSO- 5
CO3	Comprehensive understanding on various energy sources and evaluation of strategies for green energy production	U,E	PSO-3, PSO-5
CO4	Exploiting microbes as a solution for environmental problems as well as energy crisis	U, Ap	PSO3,PSO-5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Environmental biotechnology Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the concept of environment, ecosystem, biodiversity, and biosphere	PSO-1,2 PO 1	U	F, C	L	-
CO-2	Identify types and key sources of environmental pollution, and understand various biotechnological control measures for pollution.	PSO 2, 5 PO 8	R, U	C, P	L	P
CO3	Comprehensive understanding on various energy sources and evaluation of strategies for green energy production	PSO 3,5 PO 6	U, E	F	L	-
CO4	Exploiting microbes as a solution for environmental problems as well as energy crisis	PSO3,5 PO6	U, Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	-	-	-	-	3	-	-	-	-	-	-	-
CO 2	-	2	-	-	3	-	-	-	-	-	-	-	-	3
CO 3	-	-	2	-	2	-	-	-	-	-	-	2	-	-
CO 4	-	-	2	-	3	-	-	-	-	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓	✓	✓

Discipline Specific Elective courses 300-399, DSE5(P), DSE6

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT311				
Course Title	INDUSTRIAL REGULATORY AFFAIRS				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Fundamentals of biotechnology				
Course Summary	Designing a graduate-level course for regulatory affairs in biotechnology would entail covering various aspects critical to navigating the complex regulatory landscape.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to regulatory affairs**	**9**
	1	Introduction to Regulatory Affairs in Biotechnology Overview of regulatory bodies (FDA, EMA, etc.) Importance of regulatory compliance in biotechnology	
	2	Regulatory Frameworks and Guidelines Understanding regulatory pathways (e.g., 510(k), PMA, BLA) International regulatory harmonization efforts Key regulations governing biotechnology products	
II		**Preclinical processes**	**10**
	3	Preclinical Development and Good Laboratory Practice (GLP) Animal studies and toxicology testing GLP standards and compliance	

	4	Quality Systems and Good Manufacturing Practice (GMP) Manufacturing processes for biotech products Quality control and assurance GMP regulations and inspections	
	5	Regulatory Submissions and Documentation Preparation of Investigational New Drug (IND) applications New Drug Application (NDA) and Biologics License Application (BLA) Regulatory documentation requirements	
III		**Special Topics in Regulatory Affairs**	**10**
	6	Biosimilars and generics Advanced therapies (gene therapy, cell therapy) Emerging regulatory trends and challenges Regulatory Requirements for Biopharmaceuticals and medical devices,Regulatory Requirements for Agricultural Biotechnology Products	
	7	Regulatory Affairs in a Global Context Regulatory requirements in different regions Strategies for global market access	
	8	Regulatory Strategies for Product Development and Approval	
	9	Post Market Surveillance and Pharmacovigilance-Post-Market Regulatory Compliance Pharmacovigilance and adverse event reporting Post-market surveillance and monitoring Labeling and promotional material regulations	
		Case Studies and Regulatory Strategy	**7**
	10	Analyzing real-world regulatory challenges Developing regulatory strategies for product development	
	11	Ethical, Legal, and Social Implications (ELSI) Ethical considerations in biotechnology regulation Legal aspects and intellectual property rights	
V		**Practical Training**	**9**
	12	Hands-on experience with regulatory submissions Internship opportunities in regulatory affairs departments	

Practicals -30 Hours Esential Experimentsa-15 hours, Group/individual work -15 hours

Essential work

1. Study the regulatory bodies and agencies governing biotechnology products in your region (e.g., FDA in the US, EMA in Europe).
2. Understand the laws, directives, and guidelines that govern the approval process, manufacturing practices, labeling, and post-market surveillance.

3. Learn how to develop regulatory strategies for different types of biotechnological products (e.g., pharmaceuticals, biologics, medical devices).

4. Preapre regulatory submissions for product registration, including Investigational New Drug (IND) applications, New Drug Applications (NDAs), and Marketing Authorization Applications (MAAs).

5. Present about pharmacovigilance and adverse event reporting requirements for biotechnological products.

Suggested reading

1. `"Regulatory Affairs for Biopharmaceuticals" by Marilyn Morris
2. "FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics" by Douglas J. Pisano
3. "Regulatory Affairs Professionals Society (RAPS) Online Courses"
4. "Biotechnology Regulation and GMOs: Law, Technology and Public Contestations in Europe" by Fern Wickson and Telemaco Talbot
5. "Regulation of Agricultural Biotechnology: The United States and Canada" by Robert Wager and Stuart J. Smy

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the regulatory framework governing biotechnological products worldwide	U	PSO-3,4
CO-2	Analyze the regulatory requirements for different categories of biotechnological products, including pharmaceuticals, medical devices, and agricultural biotechnology.	R, U	PSO4
CO3	Evaluate the impact of regulatory compliance on the development, manufacturing, and marketing of biotechnological products.	U,An	PSO4
CO4	Develop regulatory strategies for the successful approval and commercialization of biotechnological products.	U,Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Industrial regulatory affairs Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the regulatory frameworks in biotechnology	PSO-3,4	U	F, C	L	
CO-2	Analyze the regulatory requirement	PSO4	R, U	P	L	
CO3	Evaluate the impact of regulatory compliance on the development,	PSO4	U,An	F	L	
CO4	Develop regulatory strategies for the successful approval	PSO3,4	U,Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	2	3	-	-						
CO 2	-	-	-	3	-	-						
CO 3	-	-	-	3	-	-						
CO 4	-	-	2	3	-	-						
CO 5			-	-	-	-						
CO 6			-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓	✓	
CO 5		✓		
CO 6			✓	

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT312				
Course Title	FOOD SAFETY, PRESERVATION AND QUALITY MANAGEMENT				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2	5
Pre-requisites	Microbiology,Biochemistry, Animal Physiology				
Course Summary	This course provides an in-depth exploration of the principles, practices, and challenges associated with ensuring the safety, preservation, and quality management of food products. It is designed to equip graduate students with advanced knowledge and skills necessary to address complex issues in the food industry, regulatory compliance, and consumer protection.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**food handling, adulteration and spoilage**	**9**
	1	Food hygiene and health: Concepts of personal hygiene in food handling, Modes of disease transmission through food, Good hygienic practices for food handling	
	2	Food adulterants: Types of food adulterants- intentional and incidental, metallic adulteration, Adulteration in important food items (milk, fat and oil, food grains, fruits and vegetables, spices, honey and beverages), food adulteration and public health	
	3	Food spoilage: Types -, physical, chemical and biological spoilage Microbial Food spoilage: Microorganisms in food spoilage, Factors affecting microbial growth in food, , Spoilage of canned food	
II		**food borne intoxications and infections**	**10**
	4	Overview of foodborne illnesses: definitions, scope, and significance	
	5	Routes of transmission: foodborne, waterborne, and zoonotic (transmitted from animals via food) Causes of foodborne illnesses - Physical hazards, Chemical Hazards and Biological Hazards	

	6	Major microbial pathogens: Bacteria (*Clostridium botulinum, Salmonella sp*.), Viruses (Hepatitis virus, Noro virus), Parasites (Tape worm, Hook worm) and Fungi (*Penicillium, Aspergillus*)	
	7	Foodborne infections- Cholera, Salmonellosis, Shigellosis, Typhoid fever, Brucellosis, E. coli Diarrhoea	
	8	Foodborne intoxications- Botulism, Staphylococcal food poisoning, Aflatoxins and Mycotoxins. Risk factors for foodborne illness susceptibility and severity Allergens and Food Sensitivities- Understanding food allergies, intolerances, and sensitivities, Biotechnological approaches for allergen detection and management	
III		**food additives, preservatives, and packaging**	**10**
	9	Food preservation –Importance and scope Conventional methods of food preservation (Smoking, Sun drying, Pickling/ Salting, Fermentation) Physical Methods of food preservation- High temperature, Low temperature, dehydration and Concentration, Cold pressing (Fruits, Oils), Ionizing radiation and microwave heating Chemical methods of food preservation – Classification of preservatives- Class I and Class II preservatives Biological methods of food preservation – Bio-preservation - Fermentation, Use of LAB, Enzymes (e.g. lysozyme)	
	10	Food Additives – Types – flavouring agents, texturing agents, colouring agents, and nutritional additives	
	11	Food packaging:GMP, Methods of food packaging, Types of food packaging materials, bio-packaging materials, nanomaterials and active biofilms. Shelf life analysis of packaged food products	
	12	Enzymes and their application in food industry	
IV		**food quality management**	**10**
	13	Total Quality Management (TQM) principles, Quality control and assurance methodologies,Statistical process control (SPC) and quality monitoring. Methods for detection of food adulterants – Physical, chemical/biochemical/immunological/molecular analysis	
	14	Indicator organisms: Food and water quality	
	15	Food labelling: Purpose and types of food labels	
	16	Food safety and quality control: Food laws and standards (PFA act, Overview of Codex alimentarius, Agmark, ISO, BIS, FSSAI, HACCP) Regulatory frameworks (FDA, USDA, Codex Alimentarius, etc.). HACCP (Hazard Analysis and Critical Control Points) principles and implementation Global food safety and quality standards (GFSI)	
	17	Major food research in India (CFTRI,CIFT,DFRL). Industries & career opportunities	
V		**general laboratory techniques**	**9**
	18	Genomic approaches for pathogen detection and characterization	
	19	Biosensors and rapid detection methods	
	20	Bioinformatics in food safety risk assessment and management	

Practical-30 hours,Essential Experiments-15 hours,Group/Individual work-15 hours

Essential Work

1. Introduction to ISO standards (e.g., ISO 22000, ISO 9001) for food safety and quality management.
2. Water quality analysis– MPN method
3. Isolation and identification of microbes from spoiled food– spoiled milk, meat, fish, vegetables, grains etc.
4. Perform Instrumental methods for measuring food quality parameters (e.g., pH, texture, color).
5. Perform chromatographic techniques (e.g., HPLC, GC) for analyzing food composition and contaminants.
6. Perform quality measuremenrt of food items using application of spectroscopic methods (e.g., NIR, FTIR)
7. Present case studies on foodborne illness outbreaks and their root causes.
8. Perform Hands-on experiments demonstrating food preservation techniques (e.g., canning, freeze-drying).
9. Field trips to food processing facilities to observe quality management practices in action.

Suggested reading

1. https://onlinelibrary.wiley.com/doi/full/10.1002/fsn3.3732
2. Food microbiology- MR Adams and MO Moss, 4th edition, Royal Society of Chemistry,2015
3. Industrial microbiology- L E Casida, JR, New Age International Publishers, 2019
4. Basic food microbiology – 2nd edition, George J Banwart, CBS Publishers, 2017
5, Food Microbiology – William C Frazier, 5th edition, McGraw Hill Education, 2017
6. Industrial Microbiology – A H Patel, 2nd edition, Laxmi Publications, 2022
7. Microbiology- L M Prescott, McGraw Hill, 2016

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the vital link between food & health	U	PSO-1

CO-2	Familiarize the microbial diversity associated with food & their role in spoilage/ preservation	R, U	PSO1
CO-3	Develop Knowledge on organisms identified as leading causes of food borne illness	An	PSO1
CO-4	Learn & implement important methods for food preservation for ensuring quality of processed food	Ap	PSO1,4
CO-5	Impart comprehensive overview of the scientific & technical aspects of food packaging	C,Ap	PSO4
CO-6	Instill knowledge on packaging systems, testing & regulations of packaging	E,C	PSO4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Food safety, preservation and quality management Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the vital link between food & health	PSO1	U	F, C	L	
CO-2	Familiarize the microbial diversity of food	PSO1	R, U	P	L	
CO-3	Develop Knowledge on food borne illness	PSO1	An	F	L	
CO-4	Learn & implement food preservation methods	PSO1,4	Ap	F	L	

CO5	Impart knowledge of food packaging	PSO4	C,Ap		L	
CO6	knowledge on testing & regulations of packaging	PSO4,5	E,C		L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	-	-	-	-						
CO 4	2	-	-	3	-	-						
CO 5	-	-	-	3	-	-						
CO 6	-	-	-	3	2	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

University of Kerala

iscipline	BIOTECHNOLOGY
Course Code	UK6DSEBIT313
Course Title	MICROBIOME STUDIES
Type of Course	DSE
Semester	VI
Academic Level	300 –399.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5

Pre-requisites	Microbiology, Biochemistry, animal Physiology
Course Summary	This graduate-level course delves into the intricate world of microbiomes and their profound impacts on human health. The human microbiome, comprising trillions of microorganisms inhabiting various body sites, has emerged as a key player in maintaining health and driving disease. Through a multidisciplinary approach, this course explores the dynamic interactions between microbiota and their host, encompassing topics such as microbial diversity, community structure, functional dynamics, and their implications for health and disease.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Microbiome concepts**	6
	1	History and classification of microbiome - Human microbiome. Brief description of animal/insect, soil, plant, water microbiome and polluted environment.	
	2	Techniques for studying microbiome.	
	3	Microbial taxonomy and phylogeny	
II		**Microbiome in Human life**	10
	4	Introduction to the human microbiome, the Holobiont theory of evolution. The gut, skin, oral cavity,vaginalbreast milkmicrobiome. The microbiome of the placenta and fetal tissues. The acquisition of the microbiome by the newborn and development in children, Microbiota functions in early life. Microbiome transplant. Diet, prebiotics, probiotics and the human microbiome. Antibiotics and Dysbiosis in gut microbiome , Human microbiota degradation: evidence consequences	
III		**Impact of microbiome**	10

	5	Host-microbe crosstalk: immune system modulation, nutrient metabolism, and barrier function. Microbial metabolites and its impact on human health, metabolic adaptation of microbes to different nutrient environment	
	6	Human microbiome in health and disease- Nutrition,gut microbiome and host immunity ,Gut microbiome changes in various diseases including liver diseases, obesity, diabetes, healthy longevity and other disorders.	
	7	Effects of diet and medications on the gut microbiome	
	8	The mycome and virome in health and disease. The interaction of the components of the microbiome including bacterial-phage interactions and bacterial-fungal interactions.	
	9	The gut microbiome and host immunity: animal models,Composition and function along the GI tract eg., stomach, ileum and stool. .	
IV	**Systems biology for human microbiome research**		10
	10	Understanding of culturable and non-culturable biome, culture-independent approaches, Viable but non-culturable (VBNC) organisms	
	11	Functional analysis of the microbiome from DNA sequence, meta transcriptome, metabolome, proteome, and glycome.	
	12	molecular profiling using 16S rRNA data analysis, shotgun metagenomics sequencing methods,multi-omics approach, datamining strategy	
V	**Microbiome management**		9
	13	The dysbiosis concept of disease and strategies to shift a dysbiotic flora to one compatible with health. b) Designing an effective probiotic, e.g., spores, encapsulation. c) Selecting and testing prebiotics that foster a healthy microbiome	

Practicals (30 hours)- (Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Isolation of Gut microflora SPC method insect/fishes/ plant root / earthworm / human oral
2. Isolation of microbiome from water
3. Demonstration of DNA extraction from microbial samples.
4. Introduction to bioinformatics tools for analyzing microbial diversity (QIIME, mothur, etc.).
5. Analysis of 16S rRNA sequencing data to assess alpha and beta diversity.
6. Hands-on session on functional annotation using tools like KEGG.
7. Make a reprographic slide presentation on Microbiome approaches

Suggested Reading

1.Dylan Parks, Arlington, TexasMicrobiomes: Health and the Environment2022

2.Angela E. DouglasFundamentals of Microbiome Science: How Microbes Shape Animal Biology 2021

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concepts of microbiome on human , environment and other organisms	U	PSO-1,2
CO-2	Identify the importance of holobiont concept in human health	R, U	PSO4,5
CO3	Evaluating the microbiome modulation by different factors and its impact on heath and diseases	U , E	PSO3
CO4	Analysing the different approaches to study microbiome community and its management	U, An	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Microbiome studies Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the concepts of microbiome	PSO-1,2	U	F, C	L	
CO-2	Understand the concept of Holobiont and Human Health	PSO4,5	R, U	P	L	
CO3	Evaluated the factors of Microbiome modulation	PSO3	U , E	P	L	P

CO4	Evaluate the methods to study microbiome	PSO3,4	U, An	P	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	-						
CO 2	-	-	-	3	3	-						
CO 3	-	-	2	-	-	-						
CO 4	-	-	2	2	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY

Course Code	UK6DSEBIT314				
Course Title	MICROBIAL METABOLITES				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	Microbiology, Biochemistry,Physiology				
Course Summary	This graduate-level course delves into the diverse array of metabolites produced by microorganisms, exploring their roles in various biological processes and their applications in industry, medicine, and environmental remediation. Through a combination of lectures, seminars, and practical exercises, students will gain a comprehensive understanding of microbial metabolism, the pathways involved in metabolite production, and the factors influencing metabolite synthesis.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to microbial secondary metabolism**	**12**
	1	Microbial products as primary and secondary metabolites; trophophase-Idiophase relationships in production of secondary metabolite; features of secondary metabolites, Role of secondary metabolites in physiology of organisms producing them. Application of secondary metabolites.	
	2	Pathways for the synthesis of primary and secondary metabolites of commercial importance. intermediates from primary metabolism and their secondary metabolite derivatives	
	3	Metabolic control mechanisms: substrate induction; catabolic regulation; feedback regulation . quorum sensing in microbes, amino acid regulation of RNA synthesis	
	4	Energy charge regulation and permeability control; Bypassing/ disorganization of regulatory mechanisms for overproduction of primary and secondary metabolites	
II		**Production of industrially important organic materials**	**12**
	5	secondary metabolites of actinobacteria, bacillus sps.pseudomonassps. source and biological activities of metabolites from actinobacteria Organic feedstock: ethanol; Acetone Organic acids: Production of Citric acid; Acetic acid; Lactic acid; Gluconic acid; Kojic acid; itaconic acid;	
	6	Amino acids: Use of amino acids in industry; methods of production; Production of individual aminoacids (L-Glutamic acid; L Lysin; L-Tryptophan)	

III		**Microbial enzyme and enzyme inhibitors**	**12**
	7	Enzymes: commercial applications; production of Amylases; Glucose Isomerase; L Asparaginase Proteases Renin; Penicillin acylases; Lactases; Pectinases; Lipases; Important enzyme inhibitors and common targets	
	8	Structure and biosynthesis Nucleosides Nucleotides and related compounds.	
IV		**Microbial enzyme production of vitamins**	**12**
	9	Vitamins- Vitamin B12; Riboflavin; B carotene Antibiotics: beta-Lactam antibiotics; aminoacid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline and antracyclines; Nucleoside antibiotics; Aromatic antibiotics; bioplastics (PHB; PHA); biotransformation of steroids.	
	10	Bioactive Microbial Metabolites, nutraceutical agents	
	11	Medical Applications and Drug Discovery, Antitumor agents, pharmacological, other therapeutic agents	
	12	Environmental Roles of Microbial Metabolites	
V		**Microbial secondary metabolites and taxonomy**	**12**
	13	Microbial secondary metabolites and taxonomy	
	14	Methods for Isolation and Analysis	
	15	Metabolic Engineering of Microorganisms	

Familiarize with the following techniques

1. Inoculation of microbial cultures onto appropriate media.

Incubation at suitable conditions (temperature, pH, etc.

Harvesting microbial biomass by centrifugation or filtration.

Extraction of metabolites from biomass using suitable solvents.

Measurement of microbial growth (OD measurement or viable cell count).

Quantification of metabolites using spectrophotometric methods or other assays.

Production of industrially important organic materials

Isolation of secondary metabolites of actinobacteria,

Estimate the effect of various carbon source on production of ethanol from yeast

Suggested Readings:

1. Biotechnology. A Textbook of Industrial Microbiology, by W. Crueger and A. Crueger. Publisher : Sinauer Associates.

2. Industrial microbiology by G. Reed, Publishers: CBS

3. Biology of Industrial microorganisms By A. L. Demain.

4. Stanbury P.F.A. Whitaker and Hall. Principles of fermentation technology

5. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation/ Noyes Publications.

6. New Products and New Areas of Bioprocess Engineering (Advances in Biochemical Engineering/Biotechnology, 68) by T. Scheper. Publisher : Springer Verlag

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand microbial secondary metabolism and regulatory pathways involved in important bioactive compounds	U	PSO-1,3
CO-2	To develop critical and analytical attitude on the use of microbial bioactive compounds for industrial purpose	R, U, An	PSO4,5
CO3	Learn and practice basic principles of secondary metabolite production of microbial origin	An, U,E	PSO3,PSO4
CO4	To develop skills for conducting simple biotechnological process of production of biologically active compounds	U ,C, An, Ap	PSO 3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Microbial metabolites Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand microbial secondary metabolism	PSO-1,3	U	F, C	L	-
CO-2	Identify the application of microbial	PSO4,5	R, U, An	P	L	P

	bioactive compounds for industrial purpose					
CO3	Learn and practice basic principles of secondary metabolite production of microbial origin	PSO3,PSO4	An, U,E		L	P
CO4	simple biotechnological process of production of biologically active compounds	PSO 3,4	U ,C, An, Ap		L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	-	3	-	-	-						
CO 2	-	-	-	3	5	-						
CO 3	-	-	2	3	-	-						
CO 4	-	-	3	3	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓		✓	✓
CO 4		✓	✓	✓

Course Code	UK6DSEBIT315				
Course Title	CANCER THERAPEUTICS				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	Cell Biology, Genetics, Molecular Biology, Cancer Biology				
Course Summary	This course explains how current medicines against cancer work and how we find new ones. The stages involved in the discovery and development process of a new drug is explained starting with the identification and validation of a therapeutic target, the identification of an inhibitor of the target and its subsequent preclinical and clinical development until its approval by regulatory authorities.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction**	12
	1	Why is cancer so difficult to cure?	
	2	Complexity and heterogeneity of cancer	
	3	Fundamental concepts in clinical pharmacology	
	4	Cancer drug resistance and side effects	
II		**preclinical drug development**	12
	5	Target Identification and validation	
	6	Lead discovery and optimization	
	7	Pharmacodynamic studies	
	8	Pharmacokinetic studies	
	9	Toxicological studies	
	10	*In vitro* and *in vivo* models for preclinical studies.	
III		**clinical drug development**	12
	11	Phase I, Phase II, Phase III clinical trials with anticancer agents	
	12	Role of Food and Drug Administration in cancer drug development	
	13	Post marketing phase IV studies	
	14	Challenges in developing effective anticancer agents	
IV.		**anticancer agents**	12
	15	Cancer chemoprevention, Cytotoxic agents	

	16	Targeted therapeutics, cancer vaccines, Oligonucleotide therapeutics, Antibodies as treatment for cancer	
	17	Classification of anticancer agents- alkylating agents (platinum Containing agents), antimetabolites, natural products (Taxanes and Vinca Alkaloids), hormones and antagonists	
V		**delivery of anticancer drugs**	12
	18	Polymeric Carriers for Anticancer Drugs	
	19	Receptor Mediated Delivery of Proteins and Peptides to Tumor	
	20	Protein Transduction Domain Mediated Delivery of Anticancer Agents	
	21	Application of Nanobiotechnology in cancer Therapeutics	

Familarize with the following techniques

1. Preliminary screening for cytotoxic agents.
2. Analysis of cytotoxic compounds on bacterial cell
3. Analysis of cytotoxic compounds on cancer cell line
4. MTT assay,
5. Cell cytotoxicity assay,
6. Mitochondrial membrane potential assay,
7. Apoptosis Assay
8. ROS generation assay

Suggested Readings

1. Anticancer Drug Development Guide Preclinical Screening, Clinical Trials, and Approval., Beverly A. Teicher., 2013., Publisher:Humana Press
2. Principles of Anticancer Drug Development., Elizabeth Garrett-Mayer, Manuel Hidalgo, Manuel Hidalgo (MD.), Neil J. Clendeninn, S. Gail Eckhardt., 2010., ublisher: Springer New York
3. Principles of Cancer Treatment and Anticancer Drug Development., Wolfgang Link., 2019., Publisher: Springer International Publishing
4. Cancer Drug Discovery Science and History., Kyu-Won Kim, Jae Kyung Roh, Hee-Jun Wee, Chan Kim.,2018., Publisher:Springer Netherlands
5. Pharmaceutical Perspectives of Cancer Therapeutics., Ram I. Mahato, Yi Lu., 2009., Publisher: Springer New York

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Explain why cancer is considered as a disease which is difficult to manage due to various factors and mechanisms of anti-cancer drug resistance and strategies to overcome it.	R, U	PSO-1, 5
CO-2	Define each stage of preclinical and clinical testing, *in vivo* and *in vitro* methods to identify molecules of interest explain the factors influencing the testing and outline the requirements for FDA approval.	R, U, An	PSO-2
CO3	Able to categorise various anticancer agent which is considered as potential therapeutic agent based on its mechanism of action.	U, An	PSO-4
CO4	Able to perform preclinical drug testing using *in vitro* models	U, Ap.	PSO-3, 4
CO5	Able to summarize current progress and state of the art of cancer therapeutics, while focusing on the novel ideas that are being explored to overcome existing challenges.	U, An, Ap	PSO-1, 5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Cancer therapeutics Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain why cancer is considered as a difficult disease	PO-1 PSO-1, 5	R, U	F, C	L	
CO-2	Define each stage of preclinical and clinical testing to identify molecules of interest	PO-2 PSO-2	R, U, An	F, C	L	

CO3	Able to categories various anticancer agent	PO-1, 2 PSO-4	U, An	F, C, M	L	
CO4	Able to perform preclinical drug testing using *in vitro* models	PO-6 PSO-3, 4	U, Ap	p		p
CO5	Able to summarize current progress and state of the art of cancer therapeutics,	PO-1, 2 PSO-1, 5	U, Ap,An			

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	3	-	2					
CO 2		2	-	-	-	-		2				
CO 3	-	-		3	-	-	3	3				
CO 4	-	-	3	2	-	-						3
CO 5	3		-	-	3	-	2	2				
CO 6	-	-	-		-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓			✓
CO 5	✓			✓
CO 6				

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT316				
Course Title	TUMOR IMMUNOLOGY				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Cell Biology, genetics , Molecular Biology, rDNA technology				
Course Summary	This course provides in depth overview of the mechanism of tumor immunity, the role of various immune cells in the immune response to cancerand the potential for immunotherapy for cancer treatment. Also describes various immunotherapy regimens, including tumor vaccines				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Tumor immune system**	6
	1	Role of human immune system on cancer	
	2	Tumor antigen, Unique tumor-specific antigens	
	3	Adaptive immune response, T cells, Cytotoxic cells, Regulatory T cells, NK Cells, Macrophages	
	4	Immune evasion, Immunosurveillance, Immune cell trafficking	
II		**Tumor microenvironment**	10
	5	Immune cells in the tumor microenvironment- Tumor infiltrating T Cells, Macrophages, Dendritic cells, B cells, NK cells and other Leucocytes in the tumor microenvironment	

	6	Interactions between the tumor and infiltrating leukocytes - Inflammation in the tumor microenvironment, The role of tumor cells in their local environment	
	7	Immunomodulatory molecules of the immune system- Co-stimulatory molecules -CD28/B7 family and TNF family, Cytokines- Activating cytokines and Immunosuppressive cytokines	
III		**Immunotherapy**	10
	8	History, and Principles of cancer Immunotherapy, Evidence of efficacy of immune therapy	
	9	Monoclonal antibody therapy of cancer- Strategies for monoclonal antibody therapy of cancer, Antibody pharmacokinetics, Radioimmunotherapy.	
	10	Vaccines against cancer- Development of vaccine-based immunotherapy for human cancer, Protein vaccines, DNA vaccines, Dendritic cell vaccines, Carbohydrate vaccines against cancer, Whole cell vaccine, Vaccine for cancer prevention	
IV		**Opportunities in immunotherapy**	10
	11	Interferon therapy	
	12	Adoptive cellular therapy for the treatment of cancer	
	13	Checkpoint blockade and combinatorial immunotherapies - Immunological checkpoints, Therapeutic inhibition of T cell intrinsic checkpoints: CTLA-4 blockade	
	14	Challenges and future trends in immunotherapy	
V		**Tumor Immunotherapy- self learning Approaches**	9
	15	Case study on different tumor immunotherapy approaches such as checkpoint inhibitors, adoptive cell therapy, and cancer vaccines.	
	16	Students can learn techniques for culturing T cells, genetic modification of immune cells through virtual Labs	

Practicals (30 hours)-(Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Tumor tissue handling.
2. Tumor tissue processing, Fixation and Sectioning
3. Antigen retrieval procedure
4. Blocking proteins of tumor tissue sections
5. Immunohistochemistry of tumor tissues. Protocol.
6. IHC Image analysis

7. Organize site visits to cancer research institutes or biotech companies working on tumor immunology.

Suggested Readings

1. Tumor Immunology and Immunotherapy., Robert C. Rees., 2014.,Publisher:Oxford University Press
2. Tumor Immunology Immunotherapy and Cancer Vaccines ., A. G. Dalgleish, M. J. Browning., 1996., Publisher: Cambridge University Press
3. Advances in Tumor Immunology and Immunotherapy., Augusto Ochoa, Eckhard R. Podack, Glen N. Barber, Joseph D. Rosenblatt., 2013., Publisher: Springer New York
4. Immune Modulation in Tumor Microenvironment: New Perspectives for Cancer Immunotherapy., Jian Cao, Qian Xiao, Xuejun Sun, Zimu Deng., 2023., Publisher: Frontiers Media SA
5. The Basics of Cancer Immunotherapy., Haidong Dong, Svetomir N. Markovic., 2018.,Publisher: Springer International Publishing

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understanding fundamental of tumor immunity and the dynamic interactions between tumors and the immune microenvironment.	R, U	PSO-1
CO-2	Learn the mechanism of adaptive immunity and various immune cells which play a significant role in immune evasion and immune surveillance.	R, U, An	PSO-1
CO3	Gives introduction to cancer immunotherapy, unique features of cancer immunotherapy and various strategies of immune modulation as new approach for cancer treatment by boosting the patient's own immune system to fight cancer.	R, U	PSO-1, 2, 5
CO4	Practice method of immunohistochemistry for the identification of various tumor tissue antigens	U, Ap.	PSO-3, 4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Tumor immunology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understanding fundamental of tumor immunity	PO-1 PSO-1	R, U	F, C	L/T	
CO-2	Learn the mechanism of adaptive immunity and various immune cells	PO-1 PSO-1	R, U, An	F, C	L/T	
CO3	Gives introduction to cancer immunotherapy, and its unique features	PO-2 PSO-1, 2, 5	R, U	F, C	L/T	
CO4	Practice method of immunohistochemistry	PO-6 PSO-3, 4	U, Ap	P		P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-	3					
CO 2	2	-	-	-	-	-	2					
CO 3	2	2		-	3	-		3				
CO 4	-	-	3	3	-	-						3

CO 5	-		-	-	-	-						
CO 6	-	-	-		-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4	✓	✓		✓
CO 5				
CO 6				

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT317				
Course Title	PHARMACOGENOMICS AND PHARMACOVIGILANCE				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3	1		4
Pre-requisites	Molecular Biology, rDNA technology, fundamentals of datascience				
Course Summary	This course provides an in-depth exploration of pharmacogenomics, focusing on its principles, applications, and implications in biotechnology. Students will examine the genetic basis of drug responses, pharmacogenomic technologies, personalized medicine, and ethical considerations.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Pharmacogenomics**	**8**
	1	Definition and scope of pharmacogenomics, Historical overview	
	2	Importance of pharmacogenomics in biotechnology	
II		**Fundamentals of Pharmacogenomics**	**10**
	3	Genetic variability in drug response	
	4	Pharmacokinetics vs. pharmacodynamics	

	5	Genetic polymorphisms and drug metabolism, Pharmacogenomic biomarkers,	
III	**Personalized Medicine**		**9**
	6	Concept and principles, Case studies in personalized medicineClinical implementation of pharmacogenomic testing	
	7	Role of pharmacogenomics in drug target identification Pharmacogenomics in preclinical and clinical trials Drug repurposing and pharmacogenomics	
IV	**Pharmacovigilance.**		**9**
	8	An overview of Drug development process and pharmacovigilance. Adverse Event Reporting System (ADRs).	
	9	Pharmacovigilance Reporting Database, Risk Assessments &Managements, Guidelines in Pharmacovigilance.	
V	**Guidelines &Regulations**		**9**
	10	ICMR guidelines for Biomedical Research on Human Subjects	
	11	Regulatory aspects in pharmacovigilance.	
	12	Regulation in Clinical Research- Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities	

Suggested Readings

1. Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation" by
2. Urs A. Meyer and Werner Kalow
3. Pharmacogenomics: An Introduction and Clinical Perspective" by Mark A. Marinac
4. Pharmacogenomics: Methods and Protocols" edited by Federico Innocenti

5. Lawrence MF, Curt DF, David LD (2010) Fundamentals of clinical trials Tom Brody.

6. **Clinical Research Principles Practices Perspectives by Mittal and Niti and Bikash Medhi, BSP Books**

7. **Clinical Trials by Alice Kuruvila, Paras Medical Publisher.**

8. An introduction to clinical research by Piers Page, James Carr, OUP oxford Publication

9. Textbook of Clinical Research by Vikas Dhikav AITBS Publishers.

10. **Textbook On Clinical Research A Guide for Aspiring Professionals and Professionals by Guru Prasad Mohanta, Pharmamed Press.**

11. National ethical guidelines for Biomedical and Health research involving human participants, 2017.

Online Resources

Authentic web-based resources like NCBI, PubMed, e-pgpathshala, ScienceDirect etc.

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the principles of pharmacogenomics and genetic basis of drug responses.	U	PSO3,4
CO-2	Evaluate the applications of pharmacogenomics in biotechnology and medicine.	U, E	PSO1,4
CO-3	Explore the role of pharmacogenomic in Personalized Medicine	An	POS1
CO-4	Explain pharmacovigilance and its guidelines	Ap	PSO4
CO5	.Explain the regulatory aspects in pharmacovigilance.	U, E	PSO

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: pharmacogenomics and pharmacovigilance **Credits: 3:1:0 (Lecture:Tutorial:)**

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial**	**Practical (P)**

					(T)	
CO-1	Understand the principles of pharmacogenomics and genetic basis of drug responses.	PSO3, 4	U	F, C	L	
CO-2	Evaluate the applications of pharmacogenomics in biotechnology and medicine.	PSO1, 4	U, E	P	L	
CO-3	Explore the role of pharmacogenomic in Personalized Medicine	POS1	An	F	L	
CO-4	Explain pharmacovigilance and its guidelines	PSO4	Ap	C	L	
CO5	.Explain the regulatory aspects in pharmacovigilance.	PSO5	U, E	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	-	-	2	2	-	-						
CO 2	2	-	-	3	-	-						

CO 3	1	-	-	-	-	-						
CO 4	-	-		2	-	-						
CO 5	-	-	-	-	2	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT318				
Course Title	PHARMABIOLOGICS				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Genetic engineering, fermentation technology, enzymology, Basic Pharmaceutical Biology				
Course Summary	Biotechnology has a long promise to revolutionize the biological sciences and Biotechnology is leading to new biological revolutions in diagnosis, prevention Scientific application of biotechnology in the field of genetic engineering, medicine and fermentation technology makes the subject interesting. technology. Biotechnology has already produced transgenic crops and animals and the future and cure of diseases, new and cheaper pharmaceutical drugs. It is basically a research-based subject promises lot more.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Brief introduction to Biopharmaceuticals**	9
	1	Brief introduction to Biotechnology with reference to Pharmaceutical Sciences from DNA to Therapeutic proteins, Major classes of Biotherapeutics	
	2	Production and purification of therapeutic proteins, characteristics of therapeutic proteins, Formulation of Pharma Biologics, Dispensing biotechnology products-handling, product information and professional education, immunogenicity of therapeutic proteins	

	3	Prokaryotic and eukarytotic cells in Biotech production, biopharmaceuticals expressed in plants	
	4	Use of Bioproducts-Genetic privacy and laboratory prognostics Testing	
II		**Brief introduction to Basic technologies for pharmaBiologics**	10
	5	Brief introduction to Basic technologies for Biotechnological process-monoclonal antibody,bioprocess technology, cell culture, tissue engineering, rDNA in medicine,Protein engineering, antisense RNA technology,Chip DNA	
	6	Genomics and other omics technologies, precision medicine	
		Enzyme Biotechnology- Methods of enzyme immobilization and applications.	
	7	Biosensors- Working and applications of biosensors in Pharmaceutical Industries	
	8	Biosimilars ,biologics, biobetters	
III		**PharmaBiologics- Vaccine technology**	10
	9	Types of immunity- humoral immunity, cellular immunity , Structure of Immunoglobulins , Structure and Function of MHC , Hypersensitivity reactions, Immune stimulation and Immune suppressions. General method of the preparation of bacterial vaccines, toxoids, viral vaccine- hepatitis- B , antitoxins, serum-immune blood derivatives and other products relative to immunity. Nucleic acid Vaccines Storage conditions and stability of official vaccines and blood prodcuts	
	10	Hybridoma technology- Production, Purification and Applications , Engineering Monoclonal antibodies-therapeutic approaches in cancer	
	11	antibody mediated biotherapeutics in inflammatory diseases	
	12	Blood products and Plasma Substituties, and production of: i) Interferons and interleukins ii) Hormones-Insulin.	
	13	biogeneric drugs,oligonucleotides	
IV		**Biologics used for Targeted therapies**	7
	14	Cell based and recombinant DNA therapies, human stem cell therapy Somatic gene therapy,xenotransplantation	
	15	Identification and cloning of antigen with vaccine potential,analysis of vaccine antigen and Bcell / T cell epitope interaction, protein or cytokine-recombinant antibodies,	
V		**Diagnostics**	9
	16	Regulatory issues and drug product approval for biopharmaceuticals	
	17	CS- Follicle stimulating hormone,Human growth hormone,Recombinant coagulation factors and thrombolytic agents, haematopetic growth factors	

	18	Production of Enzymes- General consideration - Amylase, Catalase, Peroxidase, Lipase, Protease, Penicillinase. f) Basic principles of genetic engineering	

Practicals(30 hours)- (Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Hands-on experience in formulation development (e.g., lyophilization, encapsulation).
2. Presentation of current research articles or industry reports on cutting-edge biologics technologies.
3. Group discussion on the potential impact of emerging trends on the pharmaceutical industry.
4. Case studies: Analyzing and evaluating various delivery systems for specific biologics.
5. Understand the regulatory requirements for the development and approval of biologics.
6. Discuss ethical considerations in biologics research and development.
7. Learn about manufacturing processes and scale-up considerations for biologics.
8. **Virtual tour of a biologics manufacturing facility (if available).**

Suggested reading

1.Pharmaceutical Biotechnology, Fundamentals and applications. Daan J Crommelin, Robert D Sindelar,Bernd Meibohm, Springer

2. Pharmaceutical Biotechnology A Focus onindustrial application, Adalberto Pessoa,jr,Michele vitolo, Paul Long,2021

3. Pharmaceutical Biotechnology: Drug discovery and clinical applications, Oliver Kayser, Rainer H Muller, 2004, Wiley

4.Biologics, Biosimilars, biobetetrs: An introduction to Pharmacists, Physicians and other health practioners,iqbal ramzan ,2020 Wiley

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Familiarize with production of biopharmaceuticals and formulations	U	PSO-1

CO-2	Understand Basic technologies used for production of pharmaBiologics	R, U	PSO1,3
CO3	Familiarize with vaccine technology and techniques involved in other Blood related products	U,Ap	PSO3,4
CO4	Describe how targeted approaches could apply for effective implementation of Biologics in Targeted therapies	U,Ap	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Pharmabiologics Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Familiarize with production of biopharmaceuticals	PSO-1	U	F, C	L	
CO-2	Understand Basic technologies	PSO1,3	R, U	P	L	P
CO3	Familiarize with vaccine technology	PSO3,4	U,Ap	F	L	
CO4	Describe targeted approaches	PSO3	U,Ap	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						

CO 2	2	-	3	-	-	-						
CO 3	-	-	1	1	-	-						
CO 4	-	-	2	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT319				
Course Title	MARINE BIODIVERSITY				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Basic Understanding of Microbiology , ecology				
Course Summary	This course aims to provide a comprehensive understanding of marine biodiversity, encompassing the rich variety of life forms in marine ecosystems, their interactions, and the factors influencing their distribution and abundance. Through a combination of lectures, fieldwork, and laboratory sessions, students will explore the intricate web of life in the oceans, the importance of marine biodiversity for ecosystem functioning, and the various threats it faces.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Marine Biodiversity**	**6**
	1	Definition and significance of marine biodiversity	

		Historical perspectives and major discoveries Methods for studying marine biodiversity	
	2	Taxonomy and Classification- Classification systems and phylogenetic relationships Major marine taxa: plankton, nekton, coral reef, deep sea benthos, deep sea sediments Functional groups and ecological roles	
	3	Pelagic biodiversity, biological diversity in macrozooplankton,	
	4	Diversity and structure of tropical communities	
II	**Marine Ecosystems**		**10**
	5	Molecular ecology and systematic on microbial biodiversity, Photosynthetic and nonphotosynthetic bacteria,algal symbionts Microeukaryotes, Piezophilic bacteria marine microbial diversity as a sources of bioactive compounds-cold active enzymes	
	6	Coastal ecosystems: coral reefs, mangroves, estuaries Pelagic ecosystems: open ocean, upwelling zones Deep-sea ecosystems: hydrothermal vents, abyssal plains	
	7	Drivers of Marine Biodiversity Patterns Natural environment variability and marine biodiversity, Abiotic control of communities and ecosystem,Physical factors: temperature, salinity, currents Biological interactions: competition, predation, symbiosis Geological and climatic influences	
	8	Phytoplankton seasonality	
III	**Human Impacts on Marine Biodiversity**		**10**
	9	Overfishing and bycatch Pollution: plastics, oil spills, chemical contaminants Habitat destruction: coastal development, trawling, dredging	
	10	endangered marine invertebrates(CS), marine biodiversity change	
	11	Conservation of Marine Biodiversity,Marine protected areas: design and effectiveness, Sustainable fisheries management Community-based conservation initiatives	
IV	**Emerging Issues in Marine Biodiversity**		**10**
	12	Marine biodiversity through time,Ocean biomass and Climate change and ocean acidification,Invasive species Technological innovations in marine conservation	

	13	The marine biodiversity observation network(MBON)	
V		**Case Studies and Group Projects**	**9**
	14	Analysis of real-world conservation challenges Presentations and discussions on proposed solutions	
	15	Field trips to local marine habitats and guest lectures by experts in marine science will complement classroom learning throughout the course.	

Practicals(30 hours)- (Essential Experiments -15 hours, Group/Individual work -15 Hours)

1. **Essential Experiments**
2. Field trip to a nearby coastal area with intertidal zones.
3. Students collect specimens of different marine organisms such as algae, mollusks, crustaceans, and echinoderms.
4. Use microscopes and identification keys to classify collected specimens to the phylum, class, and species levels.
5. Extract DNA from collected samples
6. observe genomic DNA using gel electrophoresis
7. Introduce students to oceanographic data sets (e.g., temperature, salinity, nutrient levels) from different marine environments.
8. Hands-on activities such as culturing marine microorganisms.
9. Students explore virtual reefs, seagrass beds, and deep-sea habitats, identifying different species and learning about their ecology.

Suggested Reading

1. Textbook: "Marine Biology: Function, Biodiversity, Ecology" by Jeffrey Levinton

2. John S Gray, Marine biodiversity,Cambridge university press

3. The marine Environment and biodiversity, Michaei Kent, oxford university press

4. Biodiversity of marine microbes, Sawvvas Genitsaris, MDPI books

5. Marine microbial diversity:the key to earths habitatability,Jennie Hunter-Cevera,David Carl, Merry Buckley,NIH

6. Marine Microbial Diversity as Source of Bioactive compounds. Khaled A Shaaban,MDPI

7. Scientific articles and journals

• Documentaries and videos on marine biodiversity

• Online databases and interactive tools for exploring marine life

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concept of biodiversity and its relevance to marine ecosystems.	U	PSO-1,2
CO-2	Identify key marine taxa and their ecological roles.	R, U	PSO4
CO3	Analyze the drivers of marine biodiversity patterns.	An,U	PSO3
CO4	Evaluate the impacts of human activities on marine biodiversity and explore conservation strategies for the protection of marine biodiversity.	U,E	PSO2,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Marine biodiversity Credits: 2:1:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the concept of marine biodiversity.	PSO-1,2	U	F, C	L	
CO-2	Identify key marine taxa	PSO4	R, U	P	L	
CO3	Analyze the drivers of marine biodiversity patterns.	PSO3	An,U	F	L	P
CO4	Evaluate the impacts of human activities on marine biodiversity.	PSO2,5	U,E	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	-						
CO 2	-	-	-	3	-	-						
CO 3	-	-	3	-	-	-						
CO 4	-	2	-	-	3	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT320				
Course Title	MARINE NATURAL PRODUCTS				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Ecology, Microbiology,Bioinstrumentation				
Course Summary	This course delves into the fascinating world of marine natural products, offering an in-depth exploration of the diverse compounds derived from marine organisms. Students will learn about the methods and techniques employed in the discovery, isolation, characterization, and application of these compounds, which hold immense potential in various industries including pharmaceuticals, biotechnology, and cosmetics. Through a combination of lectures, laboratory work, case studies, and field trips, students will gain a comprehensive understanding of the significance of marine natural products in drug discovery, ecological interactions, and sustainable development.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Marine Natural Products**		**6**
	1	Definition and classification Importance and relevance	

		Historical perspective	
	2	Biodiversity of Marine Organisms, Overview of marine habitats Major taxonomic groups Adaptations for natural product synthesis	
II	3.	Methods in Discovery and Isolation	**10**
	3	Collection and preservation of marine specimens Extraction techniques Chromatographic separation methodsSpectroscopic analysis	
	4	Isolation and synthesis of water soluble low weight molecular compounds	
	5	Saxitoxins (CS)	
III		**Chemical Diversity of Marine Natural Products**	**10**
	6	Chemical Diversity of Marine Natural Products Terpenes and terpenoids Polyketides Peptides and proteins Alkaloids Other classes of compounds Macrolides, cyclic peptides , Desipeptiides, marine steroids	
	7	Natural products from marine bacteria and Actinomycetes, antimicrobials from marine bacteria(CS),antimicrobial peptides	
	8	Manzamines: Marine bioactive Heterocycles , total synthesis (CS)	
	9	Marinebiolumunscence by dehydrocoelenterazine (CS)	
	10	Siderophores from fish pathogens	
	11	Aminocoumacin	
IV		**Applications of Marine Natural Products**	**10**
	12	Ecological and Evolutionary Significance Chemical ecology Defensive mechanisms: Marine Bacterial viruses(literature survey) Symbiotic relationships Evolutionary drivers Applications of Marine Natural Products Pharmaceutical drug discovery Biotechnological applications Cosmeceuticals and nutraceuticals Environmental and industrial applications	
	13	Sample preparation and extraction Thin-layer chromatography (TLC) High-performance liquid chromatography (HPLC)	
	14	Case Studies and Current Research Successful drug discoveries from marine natural products Bioprospecting expeditions and collaborations Emerging trends and breakthroughs	
	15	Total synthesis of Dictyodendrins(CS)	

V	**Ethical and Sustainability Considerations**		**9**
	16	Conservation of marine biodiversity Access and benefit-sharing issues Responsible research and development practices Future Directions and Challenges Opportunities for innovation Overcoming barriers to commercialization Interdisciplinary approaches and collaborations	

Practicals(30 hours)-(Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Extraction Methods: Demonstration and hands-on practice of extraction techniques including maceration, Solvent extraction
2. Isolation Techniques: Introduction to chromatographic techniques such as thin-layer chromatography (TLC), and high-performance liquid chromatography (HPLC).
3. Purification of Extracts: Purification of crude extracts using solvent partitioning and chromatographic methods.
4. Spectroscopic Techniques: Introduction to spectroscopic methods UV,IR
5. Introduction to software tools for predicting and analyzing spectroscopic data.
6. Preparation of sample solutions for bioassays using appropriate solvents and concentrations.
7. Bioprospecting Case Studies: Presentation and discussion of case studies highlighting successful bioprospecting projects and commercialization of marine natural products.

8.Hands-on Activity (if feasible): Demonstration or hands-on activity related to marine biotechnology techniques such as marine microbial fermentation or marine bioplastic production.

Suggested Reading

1. Marine natural products, Hiromasa Kiyota, Springer,2021
2. Recent Advances in the application of Mariine Natural Products as Antimicrobial Agents.Arumugam Veera Ravi,Ramanathan Srinivasan, Arunachalam Kannappan. Bentham Books. 2023
3. Marine Natural Products. Chemical and biological Perspectives.Paul J Scheuer.Science Direct

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the biodiversity of marine organisms and their role in producing natural products.	U	PSO-1,3,4
CO-2	Learn the techniques and methodologies involved in the discovery and isolation of marine natural products.	R, U	POS1,3
CO3	Explore the chemical and structural diversity of marine natural products and their potential applications.	U, E	POS3,4
CO4	Develop practical skills in laboratory techniques for the isolation, purification, and analysis of marine natural products.	U, Ap	PSO3
CO5	Analyze case studies and current research in the field of marine natural product discovery and utilization. Discuss ethical considerations, conservation efforts, and sustainability issues related to the exploitation of marine resources	U	PSO2,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Marine natural products Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the biodiversity of marine organisms	PSO-1,3,4	U	F, C	L	
CO-2	Learn the techniques and methodologies	POS1,3	R, U	P	L	P
CO3	Explore the chemical and structural diversity of marine natural products	POS3,4	U, E	P	L	

CO4	Develop practical skills	PSO3	U, Ap	P	L	
CO5	Analyze case studies and current research in the field of marine natural product	PSO2,4,5	U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	3	3	-	-						
CO 2	2	-	3	-	-	-						
CO 3	-	-	3	3	-	-						
CO 4	-	-	2	-	-	-						
CO 5	-	2	-	2	2	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK6DSEBIT321
Course Title	MARINE BIOREMEDIATION
Type of Course	DSE
Semester	VI
Academic Level	300 - 399.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5

Pre-requisites	Basic understanding of microbiology, ecology, and environmental science is recommended
Course Summary	Marine bioremediation offers sustainable and environmentally friendly solutions for mitigating pollution in marine ecosystems. This course delves into the principles, techniques, and applications of bioremediation, focusing on its role in restoring marine environments contaminated by various pollutants. Through lectures, laboratory exercises, case studies, and fieldwork, students will explore the potential of microorganisms and plants to degrade, detoxify, and sequester pollutants in marine habitats.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Marine Bioremediation**	**6**
	1	Definition and scope of bioremediation Historical developments and current trends Advantages and limitations of bioremediation approaches	
	2	Marine Pollutants and Their Effects Types of marine pollutants: hydrocarbons, heavy metals, nutrients, plastics Sources and pathways of contamination Ecological impacts on marine organisms and ecosystems	
II		**Microbial Diversity and Metabolism**	**10**
	3	Role of microorganisms in bioremediation Diversity of marine bacteria, archaea, and fungi Metabolic pathways for pollutant degradation and detoxification	

III		**Bioremediation Techniques**	**10**
	4	Biostimulation: nutrient addition, oxygenation Bioaugmentation: introduction of specialized microbial consortia Phytoremediation: use of plants for pollutant uptake and degradation	
	5	Phycoremediation, microalgae immobilization and bioremediation	
	6	Bioremediation markers in marine environment	
	7	Mercury remediation(CS)	
IV		**Emerging Technologies and Future Directions**	**10**
	7	Genetically engineered microorganisms for targeted bioremediation- Engineering enzymes for xenobiotic degradation. Bioremediation of oil spills Nanotechnology applications in pollutant removal Integration of bioremediation with other remediation strategies	
	8	Fieldwork and Laboratory Sessions Collection and analysis of marine samples Isolation and characterization of pollutant-degrading microorganisms Designing and monitoring bioremediation experiments	
V		**Case Studies in Marine Bioremediation**	**9**
	9	Exxon Valdez oil spill Deepwater Horizon oil spill Coastal and estuarine pollution hotspots Successes and challenges in bioremediation efforts	
	10	Field trips to contaminated marine sites will provide practical insights and real-world perspectives throughout the course.	

Practicals(30 hours)

(Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Collect Various marine pollutants (simulated or real), such as crude oil, heavy metals, or organic contaminants.
2. Isoaltion of marine microorganisms cultures (bacteria, fungi, algae) for their bioremediation potential.
3. Collect Marine sediment samples contaminated with pollutants (if available).
4. monitor the bioremediation process over time by measuring parameters such as pollutant concentration, microbial growth, oxygen levels, and other relevant indicators.
5. Analyzing the effectiveness of the different bioremediation strategies.
6. compare pollutant degradation rates, microbial activity, and any other relevant parameters between treatments and controls.

Suggested Reading

1."Bioremediation: Principles and Applications" by Ronald L. Crawford and Don L. Crawford
2. Marine microbial remediation. Anjana K Vala, Dushyant R Dudhagara, Bharti P Dave. Routledge, Taylor and Francis
3. Recent advances in Marine biotechnology, vol 8. Miilton Fingerman, R Nagabhushanam. Routledge, Taylor and Francis, 2003

Additional Resources:

- Research articles and reviews on marine bioremediation
- Environmental impact assessments and regulatory guidelines
- Online databases for accessing microbial genome sequences and metabolic pathways

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concept of bioremediation and its significance in marine pollution management.	U	PSO-1,2,4,5
CO-2	Identify key pollutants in marine environments and their impacts on ecosystem health.	R, U	PSO1
CO-3	Explore the diversity and metabolic capabilities of microorganisms involved in marine bioremediation.	U	PSO1,3
CO-4	Evaluate bioremediation techniques and their applicability to different types of marine pollution.	U,Ap	PSO3
CO-5	Analyze case studies of successful bioremediation projects and lessons learned. 5. Develop practical skills in designing and implementing bioremediation experiments	U,An	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Marine bioremediation, **Credits: 2:1:2 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)

CO-1	Understand the concept of bioremediation.	PSO-1,2,4,5	U	F, C	L	
CO-2	Identify key pollutants in marine environments	PSO1	R, U	P	L	
CO-3	the diversity and metabolic capabilities of microorganisms involved in marine bioremediation.	PSO1,3	U	C	L	P
CO-4	Evaluate bioremediation techniques	PSO3	U,Ap	C	L	
CO-5	Analyze case studies of successful bioremediation projects	PSO3,4	U,An	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3-	-	2	3	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	3	-	-	-						
CO 4	-	-	2	-	-	-						
CO 5	-	-	3	2	-	-						

Correlation Levels:

Level	Correlation

-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK6DSEBIT322

Course Title	VACCINE TECHNOLOGY				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	Cell Biology, Animal Physiology, molecular Biology, rDNA technology				
Course Summary	This course on Vaccine Technology delves into the science, development, manufacturing, and regulation of vaccines.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Immunology**	**12**
	1	Immune response to infection: Innate and acquired immune response; Humoral and Cell mediated Responses, Antigen presentation and Role of Antigen presenting cells, Primary and Secondary immune responses during infection;	
	2	Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.	
II		**Vaccine types & design**	**12**
	3	Vaccine types & design: History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.	
	4	Vaccine technologies: New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; Engineering virus vectors for vaccination; Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika)	
III		**Immune response to vaccination**	**12**
	5	Immune response to vaccination: Vaccination and immune response; Vaccine design and development: Epitope identification; Vaccine efficacy,	
	6	Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants,Liposomal and Microparticles as delivery systems; Chemokines and cytokines;	

		Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.	
IV	**Next-generation vaccines**		**12**
	7	Next-generation vaccines: Human Immunome project; Human antibodies as vaccines Production techniques used for vaccines , Storage and preservation of vaccines	
	8	Delivery methods: Vaccines for targeted delivery (Vaccine Delivery systems),microspheres, nanoparticles; ISCOMS and immunomodulators	
V	**Regulatory issues in vaccine production**		**12**
	9	Regulatory issues in vaccine production: OIE guidelines for production and seed lot management; Manufacturing recommendation; Final product release tests	

Familiarize with the following techniques

1. Introduction to analytical techniques for vaccine characterization (e.g., ELISA, Western blotting, mass spectrometry
2. Hands-on practice with bioinformatics tools for antigen prediction.
3. Virtual Lab/ visit nearby Lab
4. Demonstration - Antigen Identification
5. Demonstration of techniques such as antigen screening, sequencing, and structural analysis.
6. Hands-on experience with cell culture techniques using mammalian or microbial cells.
7. Inoculation, growth monitoring, and harvest of vaccine antigens.
8. Presentation on Vaccine Formulation (45 minutes):
9. Overview of vaccine adjuvants, stabilizers, and formulation strategies.
10. Discussion on vaccine delivery systems such as nanoparticles, liposomes, and microneedle patches.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Evaluate the broad spectrum of Immune response to infection	U	PSO-1
CO-2	Learn the principles of immunological memory	R, U	PSO1

CO3	Learn to design an effective vaccine preparation	U	PSO1,4
CO4	Understand new trends in vaccine generation	U,E	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Vaccine technology **Credits: 3:1:0 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Evaluate the broad spectrum of Immune response to infection	PSO-1	U	F, C	L	
CO-2	Learn the principles of immunological memory	PSO1	R, U	P	L	
CO3	Learn to design an effective vaccine preparation	PSO1,4	U	F	L	
CO4	Understand new trends in vaccine generation	PSO3,4	U,E	P	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	2	-	-	2	-	-						
CO 4	-	-	3	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK6DSEBIT323
Course Title	ADVANCED STUDIES IN ANTIVIRALS

Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Undergraduate coursework in biology, biochemistry, and pharmacology Basic understanding of molecular biology and immunology				
Course Summary	This course provides an in-depth exploration of antiviral agents, their mechanisms of action, development process, and clinical implications. Students will examine the principles of virology, pharmacology, and drug design as they apply to antiviral therapy				

Detailed Syllabus:

Module	Unit	Content	Hrs
I	**Introduction to Virology**		**6**
	1	Overview of viruses and viral replication cycles	
	2	Viral pathogenesis and host interactions	
	3	Viral diversity and classification	
	4	CS –outbreaks	
II	**Mechanisms of Antiviral Action**		**10**
	5	Principles of antiviral drug targeting	
	6	Inhibition of viral entry, replication, and assembly	
	7	Resistance mechanisms and strategies to overcome resistance	
III	**Antiviral Drug Classes**		**10**
	8	Nucleoside analogs and nucleotide analogs	
	9	Protease inhibitors, polymerase inhibitors, and fusion inhibitors	
	10	Immunomodulatory agents and therapeutic vaccines Case studies highlighting successful antiviral therapy outcomes	
IV	**Antiviral Drug Development**		**10**
	11	Drug discovery strategies and screening methodologies	
	12	**Pharmacology of Antiviral Agents** Pharmacokinetic properties of antiviral drugs,Drug metabolism, distribution, and elimination, Drug-drug interactions and adverse effects	
	13	Advances in antiviral drug delivery and formulation	

		Novel targets and therapies in antiviral research	
	14	**Case Studies** Therapeutic approaches for specific viral infections (e.g., HIV, hepatitis, influenza)	
	15	Management of viral infections in special populations (e.g., immunocompromised patients, pregnant women)	
V		**Emerging Trends and Future Directions**	**9**
	16	Preclinical and clinical phases of drug development	
	17	Regulatory considerations and approval process	
	18	Antiviral drug resistance surveillance and management strategies	
	19	Assess by Research papers or literature reviews on specific antiviral agents or topics Case study analyses of antiviral drug development or clinical applications Group presentations on emerging trends or future directions in antiviral therapy	

Practicals (30 hours)- (Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Virtual lab simulation: Explore the interaction between antiviral drugs and viral targets using molecular docking software
2. Case study analysis: Examine the timeline and key milestones in the development of a specific antiviral drug (e.g., HIV protease inhibitors).
3. In silico drug design exercise: Utilize computational tools to design and optimize potential antiviral drug candidates based on known viral targets.
4. Use simulation software to predict drug concentrations over time and assess dosing regimens for optimal antiviral efficacy.
5. Analyze published clinical trials evaluating the efficacy and safety of antiviral drugs using evidence-based medicine principle and submit report.
6. Evaluate various delivery systems for enhancing the bioavailability and targeting of antiviral drugs using in vitro models.

Suggested Reading

1. Textbooks on virology, pharmacology, and antiviral drug development

2. Scientific journals (e.g., Journal of Virology, Antiviral Research, Journal of Medicinal Chemistry)

3. Online databases for antiviral drug information and clinical trials

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the fundamental concepts of virology and viral pathogenesis.	U	PSO-1
CO-2	Explore the mechanisms of action of different classes of antiviral drugs.	R, U	PSO3
CO3	Analyze the process of antiviral drug discovery and development.	U,An	PSO3,4
CO4	Evaluate the pharmacokinetics and pharmacodynamics of antiviral agents. Discuss the clinical applications of antiviral therapy and emerging trends in the field.	U	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Advanced studies in antivirals Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the fundamental concepts of virology and viral pathogenesis	PSO-1	U	F, C	L	
CO-2	Explore the mechanisms of action of different classes of antiviral drugs.	PSO3	R, U	P	L	

CO3	Analyze the process of antiviral drug discovery and development.	PSO3,4	U,An	F	L	
CO4	Evaluate the pharmacokinetics and pharmacodynamics of antiviral agents.	PSO3,4	U	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	-						
CO 2	-	-	3	-	-	-						
CO 3	-	-	2	4	-	-						
CO 4	-	-	2	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT324				
Course Title	ADVANCED FOOD PRESERVATION TECHNOLOGY				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4

Pre-requisites	Basic knowledge of food science, microbiology, and chemistry is recommended.
Course Summary	This course offers a deep dive into the principles, techniques, and applications of food preservation technology, focusing on both traditional and advanced methods. Students will explore the science behind food deterioration, the role of preservation in maintaining food quality and safety, and the latest innovations in the field. Through lectures, laboratory experiments, and case studies, students will develop practical skills in selecting appropriate preservation methods, optimizing processing parameters, and ensuring regulatory compliance

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Food Preservation**	**12**
	1	Definition and importance of food preservation	
	2	Factors affecting food deterioration, Microbial, enzymatic, and chemical deterioration processes, Microbial spoilage: bacteria, fungi, yeasts, Enzymatic browning and oxidation Biochemistry of food spoilage, Understanding the kinetics of food degradation	
	3	Historical perspective and evolution of preservation techniques	
II		**Principles of Food Preservation**	**12**
	4	Traditional Preservation Methods-Physicl, Chemical and Biological foor preservation methods, standards for food preservation Methods, Thermal processing: Blanching, canning, pasteurization, sterilization,Drying and dehydration, Fermentation: pickling, curing,Salt and sugar preservation	
	5	Biopreservation Techniques- Use of probiotics and starter cultures, Bacteriocins and antimicrobial peptides Fermentation and controlled microbial growth, Encapsulation techniques	
	6	Modern Preservation Technologies,High-pressure processing (HPP) Pulsed electric field (PEF) treatment,Irradiation,Modified atmosphere packaging (MAP), Microwave processing,Radiofrequency heating,Infrared heating, Ohmic heating, Osmotic dehydration ,Supercritical fluid extraction	
III		**Non-Thermal Preservation Techniques**	**12**
	7		

		Cold pasteurization: ultraviolet (UV) treatment, ozone,High-intensity light pulses (HILP) , Cold plasma technology	
	8	Membrane filtration: microfiltration, ultrafiltration, Food preservatives	
		Novel Approaches in Preservation of Specific Food Categories Preservation of dairy products, meat and seafood, fruits and vegetables, ,beverages (juices, wines, etc.), bakery and confectionery products, Microencapsulation of bioactive compounds-Controlled release systems for preservatives, Nanoemulsions and liposomes	
IV		**Quality and Safety Considerations**	**12**
	9	Shelf-life determination and predictive modelling,Microbiological and chemical analysis,Regulatory requirements and food safety standards	
	10	Emerging Trends and Future Directions,Nanotechnology applications in food preservation, Ultrasound-assisted preservation, Magnetic field processing , 3D printing in food preservation,Active and intelligent packaging,Sustainable preservation methods	
	11	Effects of advanced preservation techniques on food quality attributes (texture, color, flavor, nutrients), Microbiological safety aspects Chemical safety concerns (formation of undesirable compounds)	
V		**Case Studies and Industry Applications**	**12**
	12	Regulatory aspects and food safety standards Success stories in food preservation .Challenges and opportunities in different food sectors	
	13	students will have the opportunity to apply various preservation techniques to different food matrices. Guest lectures by experts from academia and industry will provide insights into current research trends and practical applications in food preservation technology. Field trips to food processing facilities may be organized to further enhance students' understanding of industrial-scale operations and challenges.	

Familiarize with the following techniques

1. Explanation of how HPP works and its applications.
2. Vacuum Packaging and Modified Atmosphere Packaging (MAP)
3. Introduction to vacuum packaging and MAP principles.
4. Overview of UV light sterilization and its effectiveness in food preservation.
5. Explanation of freeze-drying process and its advantages.
6. Demonstration of freeze-drying apparatus operation.
7. Practical application: Preparing and freeze-drying food samples.

Suggested Reading

1. "Food Preservation Techniques" by Nicholas J. Binsi
2. Advanced Food Preservation" by Y. H. Hui
3. "Emerging Technologies for Food Processing" by Da-Wen Sun
4. "Handbook of Food Preservation" edited by M. Shafiur Rahman
5. "Food Preservation Techniques" edited by S. R. Patel and R. K. Kothari
6. Journal articles and research papers from reputable scientific journals in food science and biotechnology.

Online databases for accessing preservation equipment specifications and guidelines

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the principles of food deterioration and the need for preservation.	U	PSO1,4
CO-2	Explore various preservation methods, including thermal, non-thermal, and emerging technologies.	R, U	PSO3,4
CO-3	Learn about the factors influencing food shelf-life and quality.	U	PSO4
CO 4	Gain hands-on experience in applying preservation techniques and monitoring product stability.	Ap	PSO4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Advanced food preservation technology **Credits: 3:1:0 (Lecture:Tutorial:Practical)**

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understand the principles of food deterioration.	PSO1,4	U	F, C	L	P

CO-2	Explore various preservation methods,	PSO3,4	R, U	P	L	
CO-3	Learn about the factors influencing food shelf-life and quality.	PSO4	U	F	L	
CO 4	Gain hands-on experience in applying preservation techniques	PSO4	Ap	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	2	-	-						
CO 2	-	-	2	2	-	-						
CO 3	-	-	-	2	-	-						
CO 4	-	-	-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments

- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT325				
Course Title	FUNCTIONAL FOODS, NUTRACEUTICALS, AND NUTRIGENOMICS				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week

	4	2hours	2	-	4
Pre-requisites	Food microbiology, Biochemistry, molecular biology techniques				
Course Summary	Functional foods and nutraceuticals are gaining significant attention for their potential health benefits beyond basic nutrition. This course delves into the science behind functional foods and nutraceuticals, exploring their composition, mechanisms of action, and role in promoting health and preventing diseases. Additionally, the course examines nutrigenomics, the study of how nutrients interact with genes and influence gene expression, and its implications for personalized nutrition and disease management.				

Detailed Syllabus:

Module	**Unit**	**Content**	**Hrs**
I	**Introduction to Functional Foods and Nutraceuticals**		**6**
	1	Definition and classification of functional foods and nutraceuticals	
	2	Historical perspective and market trends	
	3	Health claims and regulatory considerations	
II	**Bioactive Components of Functional Foods**		**10**
	4	Phytochemicals: polyphenols, flavonoids, carotenoids Omega-3 fatty acids and other essential nutrients Probiotics, prebiotics, and dietary fiber, Functional proteins and peptides	
	5	Principles of extraction of Bioactive compounds-solvent extraction, supercritical fluid extraction, etc. Extraction of bioactive compounds from natural sources (plants, marine organisms, etc.) Purification and characterization of bioactive compounds	
	6	Mechanisms of Action and Health Benefits Antioxidant and anti-inflammatory properties,Gut microbiota modulation, Microbial fermentation for the production of functional foods Role of probiotics and prebiotics in functional food fermentation	
III	**Nutrigenomics: Principles and Applications**		**10**
	7	Basics of genetics and gene expression regulation,Nutrient-gene interactions and epigenetic modifications,Personalized nutrition and dietary recommendations,Nutrigenomic approaches to disease prevention and treatment	
	8	Nutrigenomic Tools and Techniques,Genome-wide association studies (GWAS), Transgenic plants and animals for functional food production, Genome editing techniques (CRISPR/Cas9) in functional food development	
	9	Transcriptomics, proteomics, and metabolomics,Bioinformatics and data analysis in nutrigenomics research	

IV	**Clinical Applications of Nutrigenomics**		**10**
	10	Nutrigenomics in chronic disease management (e.g., cardiovascular disease, diabetes, cancer), Cognitive function and brain health, Immune modulation and cancer prevention Pharmacogenomics and personalized medicine,Nutrigenomic testing and ethical considerate,	
	11	CS- Clinical trials and observational studies,Assessing safety, efficacy, and quality of functional food products	
V	**Emerging trends in functional food research and product development**		9
	12	Regulatory harmonization and international standards Addressing consumer perceptions, Case studies highlighting successful applications of biotechnological methods in functional food development	
	13	Literature reviews, research critiques Presentations: Oral presentations on selected topics in functional foods, nutraceuticals, and nutrigenomics	

Practicals(30 hours)-(Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments

1. Discussion on formulating different types of nutraceutical products (e.g., capsules, tablets, powders, beverages).
2. factors influencing formulation design such as stability, bioavailability, and dosage forms.
3. Laboratory session on quality control tests for nutraceutical products.
4. Hands-on experience in conducting tests for identity, potency, purity, and microbial contamination.

Suggested Reading

1. "Functional Foods: Biochemical and Processing Aspects" by J.M. Alvarez

2. Gibson, Glenn R., and Christine M. Williams. Functional Foods: Concept to Product. CRC Press, 2018.

3. Bagchi, Debasis, and Anand Swaroop. Nutraceutical and Functional Food Regulations in the United States and Around the World. Academic Press, 2019.

4. Mozafari, Mohammad Reza, et al. Nanotechnology-Based Approaches for Targeting and Delivery of Drugs and Genes. Academic Press, 2017.

5. Shahidi, Fereidoon, and Marian Naczk. Functional Foods: Biochemical and Processing Aspects. CRC Press, 2017.

6. De Vrese, Michael, and J. Schrezenmeir. Probiotics, Prebiotics, and Synbiotics: Bioactive Foods in Health Promotion. Academic Press, 2015.

- Scientific articles and research papers
- Online databases and resources on functional foods, nutraceuticals, and nutrigenomics
- Nutrigenomics software and tools for data analysis

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the concept of functional foods and nutraceuticals and their significance in promoting health and preventing diseases.	U	PSO 1,3
CO-2	Explore the composition, bioavailability, and physiological effects of key functional food components and nutraceuticals.	R, U	PSO1
CO3	Examine the principles and applications of nutrigenomics in understanding the interplay between diet, genetics, and health outcomes.	An	PSO3,4
CO4	Analyze the role of functional foods, nutraceuticals, and nutrigenomics in personalized nutrition and disease management.	An	PSO3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Functional foods, nutraceuticals, and nutrigenomics **Credits: 2:1:2 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the concept of functional foods	PSO 1,3	U	F, C	L	
CO-2	Explore the composition, functional food	PSO1	R, U	P	L	P

CO3	Examine the interplay between diet, genetics, and health outcomes.	PSO3,4	An	C	L	
CO4	Analyze the role of functional foods	PSO3,4	An	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	-	2	-	-	-						
CO 2	2	-	-	-	-	-						
CO 3	-	-	2	2	-	-						
CO 4	-	-	3	3	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam

- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT326				
Course Title	DATASCIENCE AND BIOTECHNOLOGY				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	-	4
Pre-requisites	Essentials of Biotechnology, Basic IT				
Course Summary	This graduate-level course provides an interdisciplinary exploration of the intersection between data science and biotechnology. It covers fundamental principles, techniques, and applications relevant to leveraging data analytics in the field of biotechnology. Students will gain a comprehensive understanding of how data science methodologies can be applied to biological data for insights, innovation, and problem-solving in various domains within biotechnology.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Data Science and Biotechnology.**	**12**
	1	Overview of data science and its applications in biotechnology	
	2	introduction to biotechnology and its subfields (e.g., genomics, proteomics, metabolomics. Biological Data Types and Sources	
	3	Basic concepts in statistics and probability relevant to data analysis in biotechnology.	
	4	Introduction to programming languages such as Python or R for data manipulation and analysis in biotechnology applications	
II		**Data Handling and Analysis in Biotechnology.**	**12**
	5	Biostatistics and Data Analysis -Descriptive statistics and data visualization techniques,Probability distributions and hypothesis testing, Regression analysis and correlation in biological data , Exploratory data analysis (EDA) for understanding the characteristics of biological datasets	
	6	Data acquisition and sources in biotechnology (e.g., next-generation sequencing data, microarray data, mass spectrometry data) Database management systems for biological data	
	7	- Data cleaning, preprocessing, and quality control techniques specific to biotechnological datasets.	
	8	Advanced data analysis techniques for omics data integration and interpretation.	
III		**Machine Learning and Predictive Modeling in Biotechnology.**	**12**
	9	Machine Learning and Deep Learning in Biomedical Data Analysis. Introduction to machine learning algorithms and their applications in biotechnology.	
	10	Supervised learning techniques for classification and regression tasks in biotechnological data analysis. Unsupervised learning methods for clustering and dimensionality reduction in biotechnology datasets	
	11	Feature selection and model evaluation techniques specific to biotechnological applications	
IV		**Advanced Topics in Data Science and Biotechnology.**	**12**
	12	Network analysis and systems biology approaches for understanding biological systems at the molecular level.	
	13	Genomics and Bioinformatics,Proteomics and Metabolomics Data Analysis, Applications of Data Science in Genomics- Genome sequencing technologies and data analysis,Variant calling, genome assembly, and annotation, Application of data science techniques in drug discovery, Pharmacogenomics and personalized medicine and Precision Biotechnology	

	14	Sequence alignment and similarity searching, Systems biology and network analysis	
	15	Structural bioinformatics: prediction of protein structures and molecular modelling,and prediction of functions using computational methods.	
	16	Overview ofchemical informatics, Drug target identification and validation Data Visualization and Interpretation in Biotechnology	
V		**Ethical considerations**	**12**
	17	Ethical considerations and challenges in the intersection of data science and biotechnology	

Suggested Reading

1. Biostatistics for Biomedical and Health Researchers" by Qian Liu
2. Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools" by Vince Buffalo.
3. Data Science for Biomedical Engineering and Bioinformatics" by Sébastien C. H. Bauget and Stefan W. Toth.
4. Biotechnology for Beginners" by Reinhard Renneberg, Arnold L. Demain, and Dieter Antranikian.
5. Introduction to Bioinformatics" by Arthur M. Lesk.
6. Machine Learning in Medicine – a Complete Overview" by Ton J. Cleophas and Aeilko H. Zwinderman.
7. Biological Data Analysis: A Practical Approach by C. Shamim Ahmed.
8. Python for Biologists: A complete programming course for beginners by Martin Jones
9. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids" by Richard
10. Durbin, Sean R. Eddy, Anders Krogh, and Graeme Mitchison.
11. Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking by Foster Provost and Tom Fawcett.
12. Introduction to Data Science" by Jeffrey Stanton
13. Bioinformatics Algorithms: An Active Learning Approach by Phillip Compeau and Pavel Pevzner
14. Machine Learning Yearning" by Andrew Ng

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed

CO-1	Understand basic concepts in statistics, probability, and programming languages with applications in biotechnology.	U	PSO-1,3
CO-2	Learn data handling, cleaning, preprocessing, and advanced analysis techniques specific to biotechnological datasets	R, U	PSO-1,3,4
CO-3	Master supervised and unsupervised machine learning techniques for biotechnological data analysis	U	PSO3,4
CO-4	Apply data science techniques in network analysis, structural bioinformatics, drug discovery, and personalized medicine	L	PSO3,4
CO-5	Grasp ethical considerations and challenges in integrating data science with biotechnology for a responsible and fair practice.	U	PSO4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Datascience and biotechnology **Credits: 3:1:0 (Lecture:Tutorial:Practical)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand basic concepts of statistics in biotechnology.	PSO-1,3	U	F, C	L	
CO-2	Learn data handling, cleaning, and processing	PSO-1,3,4	R, U	P	L	
CO-3	machine learning techniques for biotechnological data analysis	PSO3,4	U	F	L	
CO-4	Apply data science techniques in Biotechnology	PSO3,4	L	C	L	
CO-5	Grasp ethical considerations and challenges in	PSO4,5	U	C	L	

	integrating data science with biotechnology					

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	3	-	-	-						
CO 2	2	-	2	2	-	-						
CO 3	-	-	2	3	-	-						
CO 4	-	-	3	2	-	-						
CO 5	-	-	-	3	3	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT327				
Course Title	CLINICAL RESEARCH AND DATA MANAGEMENT				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2	1	2	5
Pre-requisites	basics of Clinical Practices,fundamentals of Clinical Data Management				
Course Summary	This course provides an in-depth exploration of the principles and practices of clinical research and data management within the context of healthcare and				

	pharmaceutical industries. It covers the essential components of planning, conducting, and analyzing clinical trials, as well as the management of data generated throughout the research process. Students will gain practical skills in designing protocols, collecting and managing data, ensuring regulatory compliance, and interpreting results.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Clinical Research & Trials**	**6**
	1	An overview of clinical Research, clinical trials, study designs and phases of clinical trials, Introduction to biotechnology applications in clinical research	
	2	Clinical trial protocols, stake holders in clinical trial projects, Serious adverse events.	
	3	Ethics Committee role in reviewing research proposals and ensuring ethical conduct.	
II		**Good clinical Practices**	**10**
	4	Good Clinical Practices: Comprehending the principles of ICH GCP, including participant protection, data quality and ethical conduct.	
	5	ICMR guidelines for Biomedical Research on Human Subjects	
	6	Responsibility of Clinical Research Professionals: (Investigator, Project Manager, Regulatory Affairs Associate, Medical Writer, Clinical Research Associate, Clinical Research Coordinator and Safety Report Associate).	
III		**Clinical Research Regulations**	**10**
	7	Regulation in Clinical Research- Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities	
	8	Clinical Research Regulatory Submission & approval Process- DCGI submission procedure.	
	9	Other Regulatory authorities- EMEA, MHRA, PhRMA.	
	10	An overview of Drug development process and pharmacovigilance	
IV		**Clinical Data Management**	**10**
	11	Data Collection Methods and Instruments - Clinical Trial Design and Protocol Development- Phases of clinical trials, Study design: randomized controlled trials, observational studies, etc. Protocol development and study endpoints, Sample size determination and statistical considerations Clinical data management systems- Electronic data capture, System validation, Test procedures, change control, coding dictionaries, Migrating and archiving Legacy Data.	
	12	**Clinical Data Management process**- Data management Plan, CRF design considerations, Database design considerations, Study setup, Entering Data, Tracking CRF pages, cleaning data, Managing Lab	

		Data, Identifying and Managing the discrepancies, Collecting Adverse Event Data, Coding Reported terms, creating report and Transferring data, Closing study.	
V	**Biostatistics & Pharmacovigilance.**		**9**
	13	Regulatory Requirements and Ethical Considerations Data Management and Quality Assurance .Biostatistics in Clinical Studies and Data analysis.	
	14	Drug development phases, Quality control and quality assurance of clinical research procedures	
	15	Safety specification and risk management palan, Guidelines in Phamacovigilance.	

Practical 30Hours-Essential Experiments-15 hours,Group/Individual work-15 hours

Essential Experiments

1. Design a mock clinical trial for a hypothetical drug or therapy. outline inclusion/exclusion criteria, endpoints, randomization procedures, sample size determination, and ethical considerations.
2. create a detailed protocol including study objectives, study population, intervention, study procedures, and statistical analysis plan.
3. Familiarize with electronic data capture (EDC) systems commonly used in clinical trials. ,enter mock patient data into these systems.
4. design case report forms (CRFs) for data collection, emphasizing the importance of clear and consistent data entry.
5. Provide datasets from past clinical trials and ask students to perform basic statistical analysis using software like R or SPSS

Suggested Readings

1. An introduction to clinical research by Piers Page, James Carr, OUP oxford Publication

2. Lawrence MF, Curt DF, David LD (2010) Fundamentals of clinical trials Tom Brody.

3. Clinical Research Principles Practices Perspectives by Mittal and Niti and Bikash Medhi, BSP Books

4. Clinical Trials by Alice Kuruvila, Paras Medical Publisher.

5. Textbook of Clinical Research by Vikas Dhikav AITBS Publishers.

6. Textbook On Clinical Research A Guide for Aspiring Professionals and Professionals by Guru Prasad Mohanta, Pharmamed Press.

Online Resources

Authentic web-based resources like NCBI, PubMed, e-pgpathshala, ScienceDirect etc.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Summarize clinical research and phases of clinical trials	U	PSO4
CO-2	Outline the good clinical practices and explain the drug development process.	U, E	PSO4,5
CO-3	Categorize the responsibility of clinical research professionals.	A	PSO2
CO-4	Develop knowledge on basics of clinical data management process and clinical research regulations	A	PSO2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Clinical research and data management Credits: 3:1:2 (Lecture:Tutorial:)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Summarize clinical research and phases of clinical trials	PSO4	U	F, C	L	
CO-2	Outline the good clinical practices and explain the drug development process.	PSO4,5	U, E	P	L	
CO-3	Categorize the responsibility of	PSO2	A	F	L	

	clinical research professionals.					
CO-4	Develop knowledge on basics of clinical data management process and clinical research regulations	PSO2	A	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	-	2	-	-						
CO 2	-	-	-	2	2	-						
CO 3	-	2	-	-	-	-						
CO 4	-	2	-	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments

- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT328				
Course Title	FORENSIC BIOTECHNOLOGY				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites					

Course Summary	Forensic biotechnology is an interdisciplinary field that applies principles of biology, genetics, and technology to analyze evidence in criminal investigations. This graduate-level course covers advanced topics in forensic biotechnology, including DNA analysis, bioinformatics, forensic pathology, and molecular techniques used in crime scene investigation.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Forensic Biotechnology**	6
	1	Overview of forensic science and its applications,Historical development and significance of forensic biotechnology Ethics and legal issues in forensic investigations	
	2	Mendelian inheritance patterns Population genetics and forensic DNA databases	
	3	Kinship analysis and paternity testing Genetic markers for individual identification	
II		**DNA Analysis Techniques**	10
	4	Polymerase chain reaction (PCR) and its applications in forensic DNA analysis Short tandem repeat (STR) analysis and DNA profiling Mitochondrial DNA analysis and its role in forensic identificationy,Y-chromosomal and mitochondrial DNA analysis Next-generation sequencing (NGS) in forensic genomics, Forensic **Epigenetics,Microbial signatures in forensic investigations**	
	5	Molecular Techniques in Crime Scene Investigation Forensic analysis of biological fluids: blood, saliva, semen, and urine Hair and fiber analysis using molecular techniques Forensic odontology and its role in human identification Case studies and practical applications of molecular techniques in crime scene investigation	
	6	Comparison of traditional and advanced DNA extraction techniques	
	7	Mass spectrometry techniques in forensic proteomics Protein profiling for identification and characterization, bioterrorism detection	
III		**Bioinformatics in Forensic Investigations**	10
	8	Introduction to bioinformatics tools and databases Sequence alignment and analysis for forensic DNA identification Computational methods for forensic DNA profiling and ancestry inference	
	9	Principles and applications of Next generation sequencing in forensic genetics	

		Targeted sequencing vs. whole-genome sequencing Data analysis and interpretation in forensic NGS,: Forensic DNA Profiling Techniques	
IV		**Forensic Pathology and Serology**	**10**
	10	Understanding the role of forensic pathology in criminal investigations Postmortem changes and estimation of time since death Bloodstain pattern analysis and serological techniques Forensic entomology and its application in estimating time of death	
	11	Advanced Topics in Forensic Biotechnology Forensic DNA databases and their role in criminal investigations Emerging technologies in forensic biotechnology: single-cell analysis, microfluidics, and nanotechnology Forensic epigenetics: DNA methylation analysis for forensic applications Ethical considerations and controversies in forensic biotechnology research	
V		**Emerging Trends and Technologies in Forensic Molecular Biology**	**9**
	12	CRISPR-based forensic applications,Nanotechnology in forensic analysis	
	13	Ethical implications and future directions in forensic molecular biology	
	14	Analytical techniques for detecting drugs and poisons	
	15	Insect evidence in crime scene analysis	

Practicals-30 hours, Essential Experiments-15 hours, Individual /Group work-15 Hours

Essential Experiments

1. Introduce students to bioinformatics tools and databases for analyzing DNA sequences.
2. analyze DNA sequences and compare them to reference sequences in databases.
3. Explore the use of computational methods for predicting phenotype from genotype (e.g., eye color, ancestry).
4. Perform microbial identification using techniques like 16S rRNA gene sequencing or DNA fingerprinting methods.
5. Prepare simulated biological samples (e.g., blood, urine) spiked with common drugs or toxins.
6. Use techniques like High-Performance Liquid Chromatography (HPLC) or Gas Chromatography-Mass Spectrometry (GC-MS) to detect and quantify the substances present.

Suggested Reading

1. Butler, J. M. (2015). Forensic DNA typing: Biology, technology, and genetics of STR markers (2nd ed.). Academic Press.
2. Carracedo, A., & Schneider, P. M. (Eds.). (2009). Forensic DNA profiling protocols. Humana Press.
3. Budowle, B., Schutzer, S. E., Breeze, R. G., & Keim, P. (2005). Microbial forensics. Academic Press.
4. Goodwin, W., & Linacre, A. (2019). Forensic DNA analysis: A laboratory manual. Academic Press.
5. Houck, M. M., & Siegel, J. A. (Eds.). (2010). Fundamentals of forensic science (2nd ed.). Academic Press.
6. Primrose, S. B. (2001). Forensic science: An introduction to scientific and investigative techniques (2nd ed.). CRC Press.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO1	Demonstrate a comprehensive understanding of the principles and techniques used in forensic biotechnology.	U	PSO-1
CO2	Apply advanced molecular techniques for DNA analysis and interpretation of forensic evidence	R, U	PSO-1,3
CO3	Evaluate bioinformatics tools and databases for forensic DNA profiling and analysis.	U,Ap	PSO-3,4
CO4	Analyze and interpret forensic pathology findings in criminal investigations	U, An	PSO-3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Forensic biotechnology Credits: 2:1:2 (Lecture:Tutorial:Practical)

CO No.	CO	PO/ PSO	Cognitive Level	Knowledge Category	Lecture (L) /Tutorial (T)	Practical (P)

CO1	Demonstrate a comprehensive understanding of the principles and techniques used in forensic biotechnology.	PSO-1	U	F,	L	
CO2	Apply advanced molecular techniques for DNA analysis and interpretation of forensic evidence	PSO-1,3	R, U	P	L	
CO3	Evaluate bioinformatics tools and databases for forensic DNA profiling and analysis.	PSO-3,4	U,Ap	F	L	
	Analyze and interpret forensic pathology findings in criminal investigations	PSO-3,4	U, An	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	-	-	-	-	-						
CO 2	2	3	-	-	-	-						
CO 3	-	-	1	-	-	-						
CO 4	-	-	2	3	-	-						
CO 5	-	1	-	-	-	-						
CO 6	-	-	-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSEBIT329				
Course Title	CHEMICAL ECOLOGY				
Type of Course	DSE				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2	5
Pre-requisites	Undergraduate courses in biology, chemistry, and biochemistry. Basic knowledge of ecological principles.				
Course Summary	This course explores the interdisciplinary field of chemical ecology, focusing on the chemical interactions between organisms and their environment. Students will learn about the role of chemical signals in ecological processes and how these principles can be applied in biotechnology research and applications.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Chemical Ecology**	**9**
	1	Overview of chemical ecology: historical perspective and key concepts.	
	2	Chemical signaling in ecological interactions.	
	3	Chemical diversity in nature: secondary metabolites and their ecological roles.	
II		**Chemical Signaling Mechanisms**	**10**
	4	Communication through semiochemicals: pheromones, allelochemicals, and kairomones.	
	5	Molecular mechanisms of chemical signaling: receptors, signal transduction pathways.	
	6	Biosynthetic pathways of key signaling compounds Sensory mechanisms and receptors involved in chemical perception	
	7	Chemical signaling in symbiotic relationships (e.g., mutualistic symbiosis) Ecological roles of allelochemicals in shaping symbiotic interactions, Allelopathy and chemical competition among plants	
	8		
III		**Chemical Ecology in Microbial Systems**	**10**
	9	Microbial interactions in natural environments.	
	10	Quorum sensing and microbial communication. Molecular Mechanisms of Quorum Sensing Signal molecules and receptors Quorum sensing circuits: LuxI/LuxR, AHL, AI-2, etc. Quorum quenching and interference mechanisms Quorum sensing networks in bacterial pathogens Biofilm formation and quorum sensing	
	11	Biotechnological applications of microbial chemical signaling.	
IV		**Chemical Ecology in Plant-Organism Interactions**	**10**
		Plant secondary metabolites and their ecological functions.	

	12	Chemical defense mechanisms in plants. Chemical signaling in plant-microbe interactions Symbiotic relationships between plants and microbes Plant defense against pathogens and symbionts Chemical cues in plant-pollinator communication Harnessing microbial interactions for agricultural and environmental purposes	
	13	Herbivore-plant interactions and plant signalinghemical Ecology in Animal Behavior Chemical communication in animal behavior: pheromones and olfaction. Chemical defense mechanisms in animals. Applications in wildlife conservation and management.	
V	**Applied Chemical Ecology in Biotechnology**		**9**
	14	Analytical methods for identifying and quantifying chemical compounds Molecular techniques for studying chemical signaling pathways .	
	15	Drug discovery and natural products chemistry. Eco-friendly pest management strategies. Biotechnological approaches for sustainable agriculture	

Practical -30 hours. Essential Experiments-15 hours, Group/Individual works-15 hours

Essential Experiments

1. Isolation and Identification of Natural Products:
2. Extract natural products from plants, microorganisms, or insects known to have ecological significance.
3. Use techniques like Soxhlet extraction, maceration, or steam distillation.
4. Analyze the extracted compounds using chromatographic techniques such as TLC (Thin Layer Chromatography), GC-MS (Gas Chromatography-Mass Spectrometry), or HPLC (High-Performance Liquid Chromatography).
5. Identify the compounds based on their retention times, mass spectra, and comparison with known standards or databases.
6. Perform the following biological assays to determine the activity of isolated compounds.

   1.antimicrobial activity, 2.antifeedant activity against herbivores, 3. allelopathic effects on plant growth.

7. Isolate and culture microorganisms from soil or other environments.

Test for interactions such as competition or cooperation using co-culturing techniques.

Suggested reading

1. Chemical Ecology" by Thomas Eisner, Jerrold Meinwald, and Eugene T. Schulz
2. "Chemical Ecology of Plants: Allelopathy in Aquatic and Terrestrial Ecosystems" by Wilfried E. Müller and Ulrich G. Müller
3. "Chemical Ecology: From Gene to Ecosystem" edited by Carde, Ring T., and Millar,
4. Chemical Ecology: The Chemistry of Biotic Interaction" by Thomas Eisner, Jerrold Meinwald, and Peter G. WaterhouseJocelyn G.
5. Ecological Biochemistry: Environmental and Interspecies Interactions" by G. W. Barrett and D. J. H. Griller

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the principles of chemical ecology and its significance in biotechnology	U	POS1
CO-2	Analyze chemical signaling mechanisms used by organisms in ecological interactions.	U,R	PSO3
CO3	To evaluate the ecological consequences of chemical signaling in various ecosystems.	U,E	PSO3
CO4	Explore applications of chemical ecology in biotechnology, including drug discovery, pest management, and sustainable agriculture.	U,Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Chemical ecology
Credits: 2:1:1 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the principles of chemical ecology and its significance in biotechnology	POS1	U	C	L	-
CO-2	Analyze chemical signaling mechanisms used by organisms in ecological interactions.	PSO3	U,R	C	L	P
CO3	1.	PSO3	U,E	P	L	P
CO4	To evaluate the ecological consequences of chemical signaling in various ecosystems.	PSO3,4	U,Ap	F	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	2	-	-	-	-	-						
CO 2	-	-	3	-	-	-						
CO 3	-	-	3	-	-	-						
CO 4	-	-	3	3	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓

CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4		✓		✓

Skill Enhancement Courses

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6SECBIT302				
Course Title	DATASCIENCE AND BIOTECHNOLOGY				
Type of Course	SEC				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3
Pre-requisites	Essentials of Biotechnology, Basic IT				

Course Summary	This graduate-level course provides an interdisciplinary exploration of the intersection between data science and biotechnology. It covers fundamental principles, techniques, and applications relevant to leveraging data analytics in the field of biotechnology. Students will gain a comprehensive understanding of how data science methodologies can be applied to biological data for insights, innovation, and problem-solving in various domains within biotechnology.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Data Science and Biotechnology.**	**9**
	1	Overview of data science and its applications in biotechnology	
	2	introduction to biotechnology and its subfields (e.g., genomics, proteomics, metabolomics. Biological Data Types and Sources	
	3	Basic concepts in statistics and probability relevant to data analysis in biotechnology.	
	4	Introduction to programming languages such as Python or R for data manipulation and analysis in biotechnology applications	
II		**Data Handling and Analysis in Biotechnology.**	**9**
	5	Biostatistics and Data Analysis -Descriptive statistics and data visualization techniques,Probability distributions and hypothesis testing, Regression analysis and correlation in biological data , Exploratory data analysis (EDA) for understanding the characteristics of biological datasets	
	6	Data acquisition and sources in biotechnology (e.g., next-generation sequencing data, microarray data, mass spectrometry data) Database management systems for biological data	
	7	- Data cleaning, preprocessing, and quality control techniques specific to biotechnological datasets.	
	8	Advanced data analysis techniques for omics data integration and interpretation.	
III		**Machine Learning and Predictive Modeling in Biotechnology.**	**9**
	9	Machine Learning and Deep Learning in Biomedical Data Analysis. Introduction to machine learning algorithms and their applications in biotechnology.	
	10	Supervised learning techniques for classification and regression tasks in biotechnological data analysis. Unsupervised learning methods for clustering and dimensionality reduction in biotechnology datasets	
	11	Feature selection and model evaluation techniques specific to biotechnological applications	
IV		**Advanced Topics in Data Science and Biotechnology.**	**9**
	12	Network analysis and systems biology approaches for understanding biological systems at the molecular level.	

	13	Genomics and Bioinformatics,Proteomics and Metabolomics Data Analysis, Applications of Data Science in Genomics- Genome sequencing technologies and data analysis,Variant calling, genome assembly, and annotation, Application of data science techniques in drug discovery, Pharmacogenomics and personalized medicine and Precision Biotechnology	
	14	Sequence alignment and similarity searching, Systems biology and network analysis	
	15	Structural bioinformatics: prediction of protein structures and molecular modelling,and prediction of functions using computational methods.	
	16	Overview ofchemical informatics, Drug target identification and validation Data Visualization and Interpretation in Biotechnology	
V		**Ethical considerations**	**9**
	17	Ethical considerations and challenges in the intersection of data science and biotechnology	

Suggested Reading

15. Biostatistics for Biomedical and Health Researchers" by Qian Liu
16. Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools" by Vince Buffalo.
17. Data Science for Biomedical Engineering and Bioinformatics" by Sébastien C. H. Bauget and Stefan W. Toth.
18. Biotechnology for Beginners" by Reinhard Renneberg, Arnold L. Demain, and Dieter Antranikian.
19. Introduction to Bioinformatics" by Arthur M. Lesk.
20. Machine Learning in Medicine – a Complete Overview" by Ton J. Cleophas and Aeilko H. Zwinderman.
21. Biological Data Analysis: A Practical Approach by C. Shamim Ahmed.
22. Python for Biologists: A complete programming course for beginners by Martin Jones
23. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids" by Richard
24. Durbin, Sean R. Eddy, Anders Krogh, and Graeme Mitchison.
25. Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking by Foster Provost and Tom Fawcett.
26. Introduction to Data Science" by Jeffrey Stanton
27. Bioinformatics Algorithms: An Active Learning Approach by Phillip Compeau and Pavel Pevzner
28. Machine Learning Yearning" by Andrew Ng

<u>Course Outcomes</u>

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand basic concepts in statistics, probability, and programming languages with applications in biotechnology.	U	PSO-1,3
CO-2	Learn data handling, cleaning, preprocessing, and advanced analysis techniques specific to biotechnological datasets	R, U	PSO-1,3,4
CO-3	Master supervised and unsupervised machine learning techniques for biotechnological data analysis	U	PSO3,4
CO-4	Apply data science techniques in network analysis, structural bioinformatics, drug discovery, and personalized medicine	L	PSO3,4
CO-5	Grasp ethical considerations and challenges in integrating data science with biotechnology for a responsible and fair practice.	U	PSO4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Datascience and biotechnology Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand basic concepts of statistics in biotechnology.	PSO-1,3	U	F, C	L	
CO-2	Learn data handling, cleaning, and processing	PSO-1,3,4	R, U	P	L	
CO-3	machine learning techniques for biotechnological data analysis	PSO3,4	U	F	L	

CO-4	Apply data science techniques in Biotechnology	PSO3,4	L	C	L	
CO-5	Grasp ethical considerations and challenges in integrating data science with biotechnology	PSO4,5	U	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	-	3	-	-	-						
CO 2	2	-	2	2	-	-						
CO 3	-	-	2	3	-	-						
CO 4	-	-	3	2	-	-						
CO 5	-	-	-	3	3	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6DSCBIT303				
Course Title	CLINICAL RESEARCH AND DATA MANAGEMENT				
Type of Course	SEC				
Semester	VI				
Academic Level	300 - 399.				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2	1		3
Pre-requisites	basics of Clinical Practices,fundamentals of Clinical Data Management				
Course Summary	This course provides an in-depth exploration of the principles and practices of clinical research and data management within the context of healthcare and pharmaceutical industries. It covers the essential components of planning,				

	conducting, and analyzing clinical trials, as well as the management of data generated throughout the research process. Students will gain practical skills in designing protocols, collecting and managing data, ensuring regulatory compliance, and interpreting results.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Clinical Research & Trials**	**9**
	1	An overview of clinical Research, clinical trials, study designs and phases of clinical trials, Introduction to biotechnology applications in clinical research	
	2	Clinical trial protocols, stake holders in clinical trial projects, Serious adverse events.	
	3	Ethics Committee role in reviewing research proposals and ensuring ethical conduct.	
II		**Good clinical Practices**	**9**
	4	Good Clinical Practices: Comprehending the principles of ICH GCP, including participant protection, data quality and ethical conduct.	
	5	ICMR guidelines for Biomedical Research on Human Subjects	
	6	Responsibility of Clinical Research Professionals: (Investigator, Project Manager, Regulatory Affairs Associate, Medical Writer, Clinical Research Associate, Clinical Research Coordinator and Safety Report Associate).	
III		**Clinical Research Regulations**	**9**
	7	Regulation in Clinical Research- Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities	
	8	Clinical Research Regulatory Submission & approval Process- DCGI submission procedure.	
	9	Other Regulatory authorities- EMEA, MHRA, PhRMA.	
	10	An overview of Drug development process and pharmacovigilance	
IV		**Clinical Data Management**	**9**
	11	Data Collection Methods and Instruments - Clinical Trial Design and Protocol Development- Phases of clinical trials, Study design: randomized controlled trials, observational studies, etc. Protocol development and study endpoints, Sample size determination and statistical considerations Clinical data management systems- Electronic data capture, System validation, Test procedures, change control, coding dictionaries, Migrating and archiving Legacy Data.	
	12	**Clinical Data Management process**- Data management Plan, CRF design considerations, Database design considerations, Study setup, Entering Data, Tracking CRF pages, cleaning data, Managing Lab Data, Identifying and Managing the discrepancies, Collecting	

		Adverse Event Data, Coding Reported terms, creating report and Transferring data, Closing study.	
V	**Biostatistics & Pharmacovigilance.**		**9**
	13	Regulatory Requirements and Ethical Considerations Data Management and Quality Assurance .Biostatistics in Clinical Studies and Data analysis.	
	14	Drug development phases, Quality control and quality assurance of clinical research procedures	
	15	Safety specification and risk management palan, Guidelines in Phamacovigilance.	

Suggested Readings

1.An introduction to clinical research by Piers Page, James Carr, OUP oxford Publication

2.Lawrence MF, Curt DF, David LD (2010) Fundamentals of clinical trials Tom Brody.

3. Clinical Research Principles Practices Perspectives by Mittal and Niti and Bikash Medhi, BSP Books

4. Clinical Trials by Alice Kuruvila, Paras Medical Publisher.

5. Textbook of Clinical Research by Vikas Dhikav AITBS Publishers.

6. Textbook On Clinical Research A Guide for Aspiring Professionals and Professionals by Guru Prasad Mohanta, Pharmamed Press.

Online Resources

Authentic web-based resources like NCBI, PubMed, e-pgpathshala, ScienceDirect etc.

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Summarize clinical research and phases of clinical trials	U	PSO4

CO-2	Outline the good clinical practices and explain the drug development process.	U, E	PSO4,5
CO-3	Categorize the responsibility of clinical research professionals.	A	PSO2
CO-4	Develop knowledge on basics of clinical data management process and clinical research regulations	A	PSO2

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Clinical research and data management **Credits: 2:1:0 (Lecture:Tutorial:)**

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Summarize clinical research and phases of clinical trials	PSO4	U	F, C	L	
CO-2	Outline the good clinical practices and explain the drug development process.	PSO4,5	U, E	P	L	
CO-3	Categorize the responsibility of clinical research professionals.	PSO2	A	F	L	
CO-4	Develop knowledge on basics of clinical data management process and clinical research regulations	PSO2	A	C	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6

CO 1	-	-	-	2	-	-						
CO 2	-	-	-	2	2	-						
CO 3	-	2	-	-	-	-						
CO 4	-	2	-	-	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY				
Course Code	UK6SECBIT304				
Course Title	BIOPOLYMER TECHNOLOGY				
Type of Course	SEC				
Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	2 hours	1	-	3
Pre-requisites	Fundamentals of Chemistry, Biochemistry, Microbiology				
Course Summary	This course provides an in-depth exploration of the principles, techniques, and applications of biopolymers in biotechnology. Students will gain				

	theoretical knowledge and practical skills essential for understanding and manipulating biopolymers for various industrial and biomedical purposes. Topics include biopolymer synthesis, characterization, modification, processing, and their diverse applications.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Biopolymers**	**9**
	1	Definition and classification of biopolymers Importance and applications of biopolymers in biotechnology Biodegradable biopolymers, Non-biodegradable Biopolymers	
	2	Comparison with synthetic polymers Environmental impact and sustainability of biopolymers	
	3	Biomedical applications, Food and beverage applications (e.g., edible packaging, encapsulation, Environmental applications (e.g., biodegradable plastics, wastewater treatment	
II		**Biopolymer Synthesis**	**9**
	4	Biopolymer Synthesis- Structure of Polymers, Polymer Synthesis, Copolymers ,Methods of Polymerization	
	5	Biosynthesis pathways of major biopolymers (polysaccharides, proteins, nucleic acids)	
	6	Enzymatic and microbial synthesis of biopolymers Genetic engineering approaches for biopolymer production	
	7	Biopolymer extraction from natural materials	
	8	Polymer processing techniques (e.g., extrusion, injection molding, compression molding) Biopolymer film formation and coating, Biopolymer-based composite materials	
III		**Sources of Biopolymers**	**9**
	9	Plant renewable polymers, starch and its derivatives, cellulose and its derivatives, lignin and its derivatives, hemicellulose and xylan derivatives, Natural rubber, Alginates,	
	10	Animal renewable polymers,- glycogen, chitin, chitosan, hyluronan, casein, whey proteins, albumin, keratin, leather, collagen, gelatin, silk, Microbial polymers,- Xantham, curdlan, pullulan, inulin, Biobased thermoplastics, thermosets, and elastomers, composites and blends	

	11	Biodegradable polymers from renewable sources and their importance in ecological, medical and material applications: agriculture and packaging, Food colloids, Conductive polymers	
IV		**Biopolymer Characterization**	**9**
	12	Analytical techniques for biopolymer characterization (e.g., spectroscopy, chromatography, microscopy) Structural analysis and molecular weight determination	
	13	Rheological properties of biopolymers, Tensile strength tester. Size and linkage analysis of polymers	
	14	Biopolymer Modification- Chemical and enzymatic modification techniques Functionalization and crosslinking of biopolymers Tailoring biopolymer properties for specific applications	
V		**Application of biopolymers -**	**9**
	15	Application of biopolymers - drug delivery, nonotechnologies, active packaging;	
	16	certification of products and progressive technologies. The ecological importance of biodegradable polymers and polymers from renewable resources, carbon footprint.	

Suggested reading

1. "Biopolymers: Biomedical and Environmental Applications" by Susheel Kalia and Luc Avérous
2. "Biopolymer Engineering in Food Processing" edited by A. K. Haghi and G. E. Zaikov
3. "Biopolymers: Processing and Products" edited by Michael Niaounakis
4. S. Ebnesajjad, ed., Handbook of biopolymers and biodegradable plastics – properties, processing and applications, Elsevier, 2013.
5. S. Kalia and L. Averous Biopolymers: Biomedical and environmental applications, Wiley-Scrivener, 2011.
6. D. Plackett, ed., Biopolymers - new materials for sustainable films and coatings, John Wiley and Sons Ltd., 2011.
7. H-J. Endres, A. Siebert-Raths, Engineering Biopolymers – Markets, Manufacturing, Properties and Applications, Hanser Publishers, 2011

Course Outcomes

No.	Upon completion of the course the graduate will be	Cognitive	PSO

	able to	Level	addressed
CO-1	Understand the fundamental principles of biopolymers and their significance in biotechnology.	U	POS1
CO-2	Analyze the various methods for the synthesis, modification, and characterization of biopolymers	U,An	PSO3,4
CO3	Apply theoretical knowledge to practical scenarios in biopolymer processing and production.	U,Ap	PSO4
CO4	Evaluate the applications of biopolymers in diverse fields such as medicine, agriculture, food, and environmental science.	U,E	PSO4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Biopolymer technology **Credits: 2:1:0 (Lecture:Tutorial:Practical)**

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO-1	Understand the fundamental principles of biopolymers	POS1	U	C	L	-
CO-2	Analyze the various methods for the synthesis of biopolymers	PSO3,4	U,An	C	L	P
CO3	Apply theoretical knowledge in biopolymer processing and production.	PSO4	U,Ap	P	L	P
CO4	Evaluate the applications of biopolymers in diverse fields	PSO4	U,E	F	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						
CO 2	-	-	2	2	-	-						
CO 3	-	-	-	3	-	-						
CO 4	-	-	-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments

- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4		✓		✓

University of Kerala

<table>
<tr><td>Discipline</td><td colspan="5">BIOTECHNOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="5">UK6SECBIT306</td></tr>
<tr><td>Course Title</td><td colspan="5">INDUSTRIAL REGULATORY AFFAIRS</td></tr>
<tr><td>Type of Course</td><td colspan="5">SEC</td></tr>
<tr><td>Semester</td><td colspan="5">VI</td></tr>
<tr><td>Academic Level</td><td colspan="5">300 - 399.</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours/Week</td></tr>
<tr><td>3</td><td>2 hours</td><td>1</td><td>-</td><td>3</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Fundamentals of biotechnology</td></tr>
</table>

Course Summary	Designing a graduate-level course for regulatory affairs in biotechnology would entail covering various aspects critical to navigating the complex regulatory landscape.

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to regulatory affairs**	**9**
	1	Introduction to Regulatory Affairs in Biotechnology Overview of regulatory bodies (FDA, EMA, etc.) Importance of regulatory compliance in biotechnology	
	2	Regulatory Frameworks and Guidelines Understanding regulatory pathways (e.g., 510(k), PMA, BLA) International regulatory harmonization efforts Key regulations governing biotechnology products	
II		**Preclinical processes**	**9**
	3	Preclinical Development and Good Laboratory Practice (GLP) Animal studies and toxicology testing GLP standards and compliance	
	4	Quality Systems and Good Manufacturing Practice (GMP) Manufacturing processes for biotech products Quality control and assurance GMP regulations and inspections	
	5	Regulatory Submissions and Documentation Preparation of Investigational New Drug (IND) applications New Drug Application (NDA) and Biologics License Application (BLA) Regulatory documentation requirements	
III		**Special Topics in Regulatory Affairs**	**9**
	6	Biosimilars and generics Advanced therapies (gene therapy, cell therapy) Emerging regulatory trends and challenges Regulatory Requirements for Biopharmaceuticals and medical devices,Regulatory Requirements for Agricultural Biotechnology Products	
	7	Regulatory Affairs in a Global Context Regulatory requirements in different regions Strategies for global market access	
	8	Regulatory Strategies for Product Development and Approval	
	9	Post Market Surveillance and Pharmacovigilance-Post-Market Regulatory Compliance Pharmacovigilance and adverse event reporting Post-market surveillance and monitoring Labeling and promotional material regulations	
		Case Studies and Regulatory Strategy	**9**

	10	Analyzing real-world regulatory challenges Developing regulatory strategies for product development	
	11	Ethical, Legal, and Social Implications (ELSI) Ethical considerations in biotechnology regulation Legal aspects and intellectual property rights	
V		**Practical Training**	**9**
	12	Hands-on experience with regulatory submissions Internship opportunities in regulatory affairs departments	

Suggested reading

6. `"Regulatory Affairs for Biopharmaceuticals" by Marilyn Morris
7. "FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics" by Douglas J. Pisano
8. "Regulatory Affairs Professionals Society (RAPS) Online Courses"
9. "Biotechnology Regulation and GMOs: Law, Technology and Public Contestations in Europe" by Fern Wickson and Telemaco Talbot
10. "Regulation of Agricultural Biotechnology: The United States and Canada" by Robert Wager and Stuart J. Smy

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Understand the regulatory framework governing biotechnological products worldwide	U	PSO-3,4
CO-2	Analyze the regulatory requirements for different categories of biotechnological products, including pharmaceuticals, medical devices, and agricultural biotechnology.	R, U	PSO4
CO3	Evaluate the impact of regulatory compliance on the development, manufacturing, and marketing of biotechnological products.	U,An	PSO4
CO4	Develop regulatory strategies for the successful approval and commercialization of biotechnological products.	U,Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Industrial regulatory affairs Credits: 2:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the regulatory frameworks in biotechnology	PSO-3,4	U	F, C	L	
CO-2	Analyze the regulatory requirement	PSO4	R, U	P	L	
CO3	Evaluate the impact of regulatory compliance on the development,	PSO4	U,An	F	L	
CO4	Develop regulatory strategies for the successful approval	PSO3,4	U,Ap	P	L	P

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	2	3	-	-						
CO 2	-	-	-	3	-	-						
CO 3	-	-	-	3	-	-						
CO 4	-	-	2	3	-	-						
CO 5			-	-	-	-						
CO 6			-	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar/Midterm Exam
- Programming Assignments /Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓	✓	
CO 5		✓		
CO 6			✓	

SEMESTER 7

Discipline Specific Core Level 400-499-A12(P),A13(P) capstone

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK7DSCBIT400
Course Title	STEM CELL TECHNOLOGY AND REGENERATIVE MEDICINE
Type of Course	DSC
Semester	VII
Academic Level	400-499.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	1	2	5
Pre-requisites	Basic knowledge in Cell biology, Animal Cell Physiology				
Course Summary	This graduate-level course offers an in-depth exploration of Stem Cell Technology and Regenerative Medicine, providing students with a comprehensive understanding of the principles, techniques, and applications within this rapidly evolving field. Through a combination of lectures, discussions, laboratory exercises, and case studies, students will delve into the foundational concepts, current advancements, ethical considerations, and future prospects associated with stem cell research and its therapeutic potential.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**stem cell origin and types**	**12**
	1	Stem cells: Properties, Importance in development, tissue regeneration and repair	
	2	Types of stem cells: Embryonic stem cells (ESCs), Adult Stem Cells (ASCs), Cord blood stem cells	
	3	Induced Pluripotent Stem cells (IPSCs), Cancer stem cells	
	4	Stem cell potential: totipotent, pluripotent, multi potent, oligopotent and unipotent stem cells	
II		**stem cell niche and stem cell differentiation**	**12**
	5	Stem cell niche: The concept of stem cell niche; HSC niche	
	6	Components of stem cell niche: Stromal cells, Extracellular Matrix (ECM) and signalling molecules and its role	
	7	Self-renewal/proliferation and differentiation of stem cells	
	8	Stem cell differentiation – molecular pathways	
		Stem cell niche in disease and aging: Malignant stem cell niche, stem cell niche in aging	
III		**stem cell isolation, culture and characterization**	**12**
	9	Isolation of ESCs: Isolation from inner cell mass of blastocyst	
	10	Isolation of ASC: isolation of HSCs and MSCs	
	11	Stem cell culture: Feeder layer and feeder free system	
	12	Use of defined medium and differentiation medium for stem cells in culture: importance of growth factors and other signalling molecules	
	13	Induced Pluripotent stem cells – somatic cell reprogramming, techniques – viral and non-viral methods of gene transfer	
	14	Stem cell characterization – use of stem cell markers – FACS and MACS for stem cell characterization and sorting	
	15	Microfluidic stem cell isolation	
IV		**stem cells: bench to bedside**	**12**
	16	Stem cells and regenerative medicine	
	17	Stem cell transplantation – Bone marrow transplantation	

	18	Stem cells and tissue engineering	
	19	Stem cells and personalized medicine- use of iPSCs	
	20	Stem Cell Banking	
V		**challenges and limitations of stem cell**	**12**
	21	Fundamental Ethical Principles	
	22	Ethical and regulatory considerations of stem cell research and applications	
	23	Committees and organizations controlling stem cell research and clinical applications	

Practicals(30 hours)

(Essential Experiments -15 hours, Group/Individual work -15 Hours)

Virtual lab/Advanced Lab visit

1.Isolation and Culture of Stem Cell from various sources such as bone marrow, adipose tissue, or umbilical cord blood.

2.Evaluate appropriate media and conditions

3.Estimate the growth and characteristics of cells

4. Research lab visit and report preparation

Suggested readings

1. Essentials of stem cell biology, 3rd Edition (2014) – Robert Lanza, Anthony Atala, Elsevier,
2. Stem Cell Biology (2001) – Daniel Marshak, Richard L Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press
3. Stem cell biology and Gene therapy, 1st Edition (1998) – Peter J. Quesenberry, Gary S. Stein, Bernard Forget, and Sherman Weissman, Wiley-Liss
4. Frontiers in Pluripotent stem cell research and therapeutic potentials Bench to Bedside (2012)- Kuldip S Sidhu, Benthambooks
5. Stem cell Now: A brief introduction to the coming medical revolution (2006) - Christopher Thomas Scott, Plume Publishers
6. Stem Cell Technology (2009) - P C Trivedi, Meghna Razdan,Pointer Publishers
7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6142731/
8. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4969512/

Course Outcomes

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	Explain different types of stem cells, its properties and importance in development, repair and disease like cancer	U	PSO1
CO-2	Correlate the components of stem cell niche to its role in development, aging and diseases	AN	PSO-1
CO-3	Discuss stem cell culture and characterization techniques	U	PSO-1
CO-4	Describe various clinical applications of stem cells	U	PSO-2
CO-5	Comment and argue on the suitability of different types of stem cells for clinical applications	E	PSO-2
CO-6	Prepare a case study report of clinical application of stem cells	C	PSO-3

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Stem cell technology and regenerative medicine Credits: 3:1:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Explain different types of stem cells, its properties and importance in development, repair and disease like cancer	PSO-1 PO-1	U	F, C	L	-
CO-2	Correlate the components of stem cell niche to its role in development, aging and disease	PSO-1 PO-1	An	F, C, M	L	-

CO-3	Discuss stem cell culture and characterization techniques	PSO-1 PO-1	U	F, C	L	-
CO-4	Describe various clinical applications of stem cells	PSO-2 PO-2	U	F, C	L	-
CO-5	Comment and argue on the suitability of different types of stem cells for clinical applications	PSO-2 PO-2	E	F, C, M	L	-
CO-6	Prepare a case study report of clinical application of stem cells	PSO-3 PO-6	C	F, C, M	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	3	-	-	-	-	-	2					
CO 2	3	-			-	-	3					
CO 3	2				-	-	2					
CO 4	-	2	-	-		-		2				
CO5		2						2				
CO6			2									1

Correlation Levels:

Level	**Correlation**
-	Nil

1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK7DSCBIT401
Course Title	INTRODUCTION TO METABOLIC ENGINEERING
Type of Course	**DSC**
Semester	VIII
Academic Level	400 - 499.

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	1	2 hours	5
Pre-requisites	Undergraduate coursework in biology, biochemistry, genetics, and engineering Basic understanding of molecular biology techniques and genetic manipulation				
Course Summary	This course provides an in-depth examination of metabolic engineering principles, techniques, and applications. Students will explore the manipulation of cellular metabolism for the production of biofuels, pharmaceuticals, and other valuable compounds through genetic and metabolic interventions.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Metabolic Engineering**	**6**
	1	Overview of cellular metabolism and metabolic pathways	
	2	Principles of metabolic flux analysis by isotope labelling and pathway optimization,	
		concepts of stoichiometry, kinetics, and thermodynamics of metabolic pathways Overview of Metabolic Pathway Synthesis	
	3	Historical perspective and key milestones in metabolic engineering	
II		**Tools and Techniques in Metabolic Engineering**	**10**
	4	**Tools and Techniques in Metabolic Engineering** Genome editing technologies (CRISPR/Cas9, TALENs, zinc finger nucleases) methods for identifying key enzymes in metabolic networks, metabolic regulation at the gene, enzyme, operon, and cell levels	
	5	Synthetic biology approaches for pathway construction and optimization	
	6	High-throughput screening and metabolic engineering software tools	
III		**Application of Metabolic Engineering**	**10**
	7	**Metabolic Engineering for Biofuel Production** Genome architecture of E. coli , fate of pyruvate in metabolic reactions ,Engineering microbes for the production of bioethanol, biodiesel, and advanced biofuels **Engineering Cellulases(CS)**	

	8	Optimization of metabolic pathways for improved substrate utilization and product yield	
	9	Challenges and opportunities in scaling up biofuel production processes	
IV	**Metabolic Engineering for Bioremediation and Environmental Applications**		
	10	Biodegradation of environmental pollutants using engineered microbes Molecular Farming Approach Towards Bioactive Compounds Biosynthesis of biodegradable plastics and other environmentally friendly materials	
	11	Implications of metabolic engineering for sustainability and ecosystem health	
V	**Case Studies and Applications**		**9**
	12	Analysis of successful metabolic engineering projects in industry and academia- metabolic engineering of escherichia coli for the production of aromatic compounds ,biodegradable plastics Guest lectures from experts in the field highlighting real-world applications and challenges Group discussions and presentations on current topics and trends in metabolic engineering	
	13	Research proposals or project reports outlining metabolic engineering strategies for specific applications Case study analyses of successful and unsuccessful metabolic engineering projects	
	14	Familiarise the mathematical tools of Metabolic Engineering (MFA, MCA)	

Practicals(30 hours)- (Essential Experiments -15 hours, Group/Individual work -15 Hours)

Essential Experiments –Virtual Lab

1. Formulate research questions or objectives related to metabolic pathway manipulation.

Design experimental strategies to achieve the desired outcomes.

2. Inoculate starter cultures of the microbial host strain(s).

3. Perform genetic mutations by Applying UV irradiation

3. Perform Plasmid Isolation, and Transform into host cells using appropriate methods (e.g., electroporation, heat shock).

4. Transfer transformed cells onto selective growth media.

5. Incubate cultures under optimized conditions for growth and selection.

6. Monitor growth kinetics by measuring optical density (OD) using a spectrophotometer.

7. Analyze metabolite production using analytical techniques such as HPLC or GC-MS.

8.Apply bioinformatics tools in metabolic pathway studues

Recommended Resources:

Metabolic Engineering for Bioactive Compounds

Strategies and Processes, • Vipin Chandra Kalia, • Adesh Kumar Saini.

2. Metabolic Engineering: Concepts and Applications

Sang Yup Lee (Editor), Jens Nielsen (Editor), Gregory Stephanopoulos (Editor). Wiley

3. Metabolic Engineering: Principles and Methodologies

By George Stephanopoulos, Aristos A. Aristidou, Jens Nielsen

4. Metabolic Engineering . Sang Yup Lee, E. Terry Papoutsakis,Taylor And Francis

5.Metabolic Engineering: Methodologies and Applications .Michael J. Volk, Vinh G. Tran, Shih-I Tan, Shekhar Mishra, Zia Fatma, Aashutosh Boob, Hongxiang Li, Pu Xue, Teresa A. Martin, and Huimin Zhao* ACS Publications

Scientific journals (e.g., Metabolic Engineering, Biotechnology and Bioengineering, Nature Biotechnology)

Online resources such as metabolic pathway databases and bioinformatics tools

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO1	Understand the fundamental principles of cellular metabolism and metabolic pathways.	U	PSO-1,3
CO-2	Explore the tools and techniques used in metabolic engineering, including genome editing and synthetic biology.	R, U	PSO3,4
CO3	Analyze case studies of successful metabolic engineering projects in various industries.	U,E	PSO3,4

CO4	Evaluate the challenges and ethical considerations associated with metabolic engineering applications. Design and propose metabolic engineering strategies for specific biotechnological applications.	U,E,A	PSO3,4,5

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Introduction to metabolic engineering **Credits: 3:1:0 (Lecture:Tutorial:Practical)**

CO No.	**CO**	**PO/PSO**	**Cognitive Level**	**Knowledge Category**	**Lecture (L)/Tutorial (T)**	**Practical (P)**
CO1	Understand the fundamentals of metabolic pathways.	PSO-1,3	U	F, C	L	
CO-2	Explore the tools and techniques used in metabolic engineering,	PSO3,4	R, U	P	L	P
CO3	Analyze case studies	PSO3,4	U,E	F	L	
CO4	Evaluate the challenges and ethical considerations and propose metabolic engineering strategies	PSO3,4,5	U,E,A	F	L	

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**

CO 1	1	-	-	-	-	-						
CO 2	2	3	-	-	-	-						
CO 3	-	-	1	-	-	-						
CO 4	-	-	2	3	-	-						

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓

University of Kerala

Discipline	BIOTECHNOLOGY
Course Code	UK6DSEBIT329
Course Title	CHEMICAL ECOLOGY
Type of Course	DSE

Semester	VI				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3
Pre-requisites	Undergraduate courses in biology, chemistry, and biochemistry. Basic knowledge of ecological principles.				
Course Summary	This course explores the interdisciplinary field of chemical ecology, focusing on the chemical interactions between organisms and their environment. Students will learn about the role of chemical signals in ecological processes and how these principles can be applied in biotechnology research and applications.				

Detailed Syllabus:

Module	Unit	Content	Hrs
I		**Introduction to Chemical Ecology**	9
	1	Overview of chemical ecology: historical perspective and key concepts.	
	2	Chemical signaling in ecological interactions.	
	3	Chemical diversity in nature: secondary metabolites and their ecological roles.	
II		**Chemical Signaling Mechanisms**	9
	4	Communication through semiochemicals: pheromones, allelochemicals, and kairomones.	
	5	Molecular mechanisms of chemical signaling: receptors, signal transduction pathways.	
	6	Biosynthetic pathways of key signaling compounds Sensory mechanisms and receptors involved in chemical perception	
	7	Chemical signaling in symbiotic relationships (e.g., mutualistic symbiosis) Ecological roles of allelochemicals in shaping symbiotic interactions, Allelopathy and chemical competition among plants	
	8		
III		**Chemical Ecology in Microbial Systems**	9
	9	Microbial interactions in natural environments.	

	10	Quorum sensing and microbial communication. Molecular Mechanisms of Quorum Sensing Signal molecules and receptors Quorum sensing circuits: LuxI/LuxR, AHL, AI-2, etc. Quorum quenching and interference mechanisms Quorum sensing networks in bacterial pathogens Biofilm formation and quorum sensing	
	11	Biotechnological applications of microbial chemical signaling.	
IV		**Chemical Ecology in Plant-Organism Interactions**	**9**
		Plant secondary metabolites and their ecological functions.	
		Chemical defense mechanisms in plants. Chemical signaling in plant-microbe interactions Symbiotic relationships between plants and microbes Plant defense against pathogens and symbionts Chemical cues in plant-pollinator communication Harnessing microbial interactions for agricultural and environmental purposes	
		Herbivore-plant interactions and plant signalinghemical Ecology in Animal Behavior Chemical communication in animal behavior: pheromones and olfaction. Chemical defense mechanisms in animals. Applications in wildlife conservation and management.	
V		**Applied Chemical Ecology in Biotechnology**	**9**
	15	Analytical methods for identifying and quantifying chemical compounds Molecular techniques for studying chemical signaling pathways .	
	16	Drug discovery and natural products chemistry. Eco-friendly pest management strategies. Biotechnological approaches for sustainable agriculture	

Practical -30 hours. Essential Experiments-15 hours, Group/Individual works-15 hours

Essential Experiments

7. Isolation and Identification of Natural Products:
8. Extract natural products from plants, microorganisms, or insects known to have ecological significance.
9. Use techniques like Soxhlet extraction, maceration, or steam distillation.

10. Analyze the extracted compounds using chromatographic techniques such as TLC (Thin Layer Chromatography), GC-MS (Gas Chromatography-Mass Spectrometry), or HPLC (High-Performance Liquid Chromatography).

11. Identify the compounds based on their retention times, mass spectra, and comparison with known standards or databases.

12. Perform the following biological assays to determine the activity of isolated compounds.

    1.antimicrobial activity, 2.antifeedant activity against herbivores, 3. allelopathic effects on plant growth.

7. Isolate and culture microorganisms from soil or other environments.

   Test for interactions such as competition or cooperation using co-culturing techniques.

Suggested reading

6. Chemical Ecology" by Thomas Eisner, Jerrold Meinwald, and Eugene T. Schulz

7. "Chemical Ecology of Plants: Allelopathy in Aquatic and Terrestrial Ecosystems" by Wilfried E. Müller and Ulrich G. Müller

8. "Chemical Ecology: From Gene to Ecosystem" edited by Carde, Ring T., and Millar,

9. Chemical Ecology: The Chemistry of Biotic Interaction" by Thomas Eisner, Jerrold Meinwald, and Peter G. WaterhouseJocelyn G.

10. Ecological Biochemistry: Environmental and Interspecies Interactions" by G. W. Barrett and D. J. H. Griller

Course Outcomes

No.	**Upon completion of the course the graduate will be able to**	**Cognitive Level**	**PSO addressed**
CO-1	Understand the principles of chemical ecology and its significance in biotechnology	U	POS1
CO-2	Analyze chemical signaling mechanisms used by organisms in ecological interactions.	U,R	PSO3

CO3	To evaluate the ecological consequences of chemical signaling in various ecosystems.	U,E	PSO3
CO4	Explore applications of chemical ecology in biotechnology, including drug discovery, pest management, and sustainable agriculture.	U,Ap	PSO3,4

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Note: 1 or 2 COs/module

Name of the Course: Credits: 4:0:0 (Lecture:Tutorial:Practical)

CO No.	CO	PO/PSO	Cognitive Level	Knowledge Category	Lecture (L)/Tutorial (T)	Practical (P)
CO-1	Understand the principles of chemical ecology and its significance in biotechnology	POS1	U	C	L	-
CO-2	Analyze chemical signaling mechanisms used by organisms in ecological interactions.	PSO3	U,R	C	L	P
CO3	1.	PSO3	U,E	P	L	P
CO4	To evaluate the ecological consequences of chemical signaling in various ecosystems.	PSO3,4	U,Ap	F	L	-

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	-	-	-	-						
CO 2	-	-	3	-	-	-						
CO 3	-	-	3	-	-	-						
CO 4	-	-	3	3	-	-						

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments

- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4		✓		✓