M.Sc., MICROBIOLOGY

LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS – LOCF)

***(For the candidates admitted in the academic year* 2023-2024)**

SYLLABUS

PROGRAMME CODE: 2PSMIC

SENGAMALA THAYAAR EDUCATIONAL TRUST WOMEN'S COLLEGE

(AUTONOMOUS)

(Affiliated to Bharathidasan University, Tiruchirappalli)

Accredited by NAAC-An ISO 9001:2015 Certified Institution

SUNDARAKKOTTAI, MANNARGUDI – 614 016

TAMIL NADU, INDIA.

SENGAMALA THAYAAR EDUCATIONAL TRUST WOMEN'S COLLEGE
(AUTONOMOUS)

(Affiliated to Bharathidasan University, Tiruchirappalli)

Accredited by NAAC-An ISO 9001:2015 Certified Institution

SUNDARAKKOTTAI, MANNARGUDI–614016.

TAMILNADU, INDIA.

M.Sc., MICROBIOLOGY

CHOICE BASED CREDIT SYSTEM - LEARNINIG OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(For the candidates admitted in the academic year 2023-2024)

CHOICE BASED CREDIT SYSTEM

The credit based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. The choice based credit system provides a 'cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning. Our College has moved to CBCS and implemented the grading system.

OUTCOME-BASED EDUCATION (OBE)
LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK (LOCF)

The fundamental premise underlying the learning outcomes-based approach to curriculum planning and development is that higher education qualifications are awarded on the basis of demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and academic standards expected of graduates of a programme of study. Learning outcomes specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study. The expected learning outcomes are used as reference points that would help to formulate graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes which in turn will help in curriculum planning and development, and in the design, delivery and review of academic programmes. They provide general guidance for articulating the essential learnings associated with programmes of study and courses with in a programme, maintain national standards and international comparability of learning outcomes and academic standards to ensure global competitiveness, and to facilitate student/graduate mobility and provide higher education institutions an important point of reference for designing

teaching-learning strategies, assessing student learning levels, and periodic review of programmes and academic standards.

Some important aspects of the Outcome Based Education

Course: is defined as a theory, practical or theory cum practical subject studied in a semester.

Course Outcomes (COs): are statements that describe significant and essential learning that learners have achieved, and can reliably demonstrate at the end of a course. Generally three or more course outcomes may be specified for each course based on its weightage.

Programme: is defined as the specialization or discipline of a Degree.

Programme Outcomes (POs): Programme outcomes are narrower statements that describe what students are expected to be able to do by the time of graduation. POs are expected to be aligned closely with Graduate Attributes.

Programme Specific Outcomes (PSOs): PSOs are what the students should be able to do at the time of graduation with reference to a specific discipline.

Some important terminologies repeatedly used in LOCF.

Core Courses (CC): A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course. These are the courses which provide basic understanding of their main discipline. In order to maintain a requisite standard certain core courses must be included in an academic program. This helps in providing a universal recognition to the said academic program.

Discipline Specific Elective Courses (DSE): Elective course may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective (DSE). These courses offer the flexibility of selection of options from a pool of courses. These are considered specialized or advanced to that particular programme and provide extensive exposure in the area chosen; these are also more applied in nature.

Generic Elective Courses: An elective course chosen generally from an **unrelated discipline/subject,** with an intention to seek exposure is called a Generic Elective. Generic Elective courses are designed for the students of other disciplines. Thus, as per the CBCS policy, the students pursuing particular disciplines would have to opt Generic Elective courses offered by other disciplines, as per the basket of courses offered by the college. The scope of the Generic Elective (GE) Courses is positively related to the diversity of disciplines in which programmes are being offered by the college.

Non Major Elective (NME): A student shall choose at least two Non-major Elective Courses (NME) from outside his/her department.

Skill Enhancement Courses (SECs): These courses focus on developing skills or proficiencies in the student, and aim at providing hands-on training. Skill enhancement courses can be opted by the students of any other discipline, but are highly suitable for students pursuing their academic programme. These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge**.**

Field Study/Industrial Visit/Case Study: It has to be completed during the fifth semester of the degree programme. Credit for this course will be entered in the fifth semester's marks statement.

Internship: Students must complete internship during summer holidays after the fourth semester. They have to submit a report of internship training with the necessary documents and have to appear for a viva-voce examination during fifth semester. Credit for internship will be entered in the fifth semester's mark statement.

Extra Credit Courses: In order to facilitate the students, gaining knowledge/skills by attending online courses MOOC, credits are awarded as extra credits, the extra credit are at three semesters after verifying the course completion certificates. According to the guidelines of UGC, the students are encouraged to avail this option of enriching their knowledge by enrolling themselves in the Massive Open Online Courses (MOOC) provided by various portals such as SWAYAM, NPTELetc.

Postgraduate Programme:

Programme Pattern: The Post Graduate degree programme consists of **FIVE** vital components. They are as follows:

Part –A	:	Core Course (Theory, Practicals) Core Industry Module, Core Project
Part-B (i)	:	Elective courses
Part-B (ii)	:	Non Major Elective, Skill Enhancement course, Professional Competency course
Part-B (iii)	:	Internship
Part –C	:	Extension activity

EXAMINATION

Continuous Internal Assessment (CIA):

PG - Distribution of CIA Marks

Passing Minimum: 50 %

Assignments – 3 = 30%

Tests- 2 = 50%

Seminar=10 %

Attendance= 10 %

Question Paper Pattern
Part A: includes two subsections

Part A 1 (10X1=10 marks)
One word question/ Fill in/ Match the following/True or False/ Multiple Choice Questions
Two Questions from Each unit

Part A 2(5X2=10 marks)
Short Answers
One question from Each unit
Total Marks - 20

Part B: (5X5=25 marks)
Paragraph Answers
Either/ or type, One Question from each unit

Part C: (10X3=30)
Essay Type Answers
Answer 3 out of 5 Questions
One Question from each unit

Part A: K1 Level
Part B: K2, K3 and K4 Level
Part C: K5 and K6 Level

Knowledge levels for assessment of Outcomes based on Blooms Taxonomy

S.No.	Level	Parameter	Description
1	K1	Knowledge/Remembering	It is the ability to remember the previously learned
2	K2	Comprehension/ Understanding	The learner explains ideas or concepts
3	K3	Application/Applying	The learner uses information in a new way
4	K4	Analysis/Analysing	The learner distinguishes among different parts
5	K5	Evaluation/Evaluating	The learner justifies a stand or decision
6	K6	Synthesis/Creating	The learner creates a new product or point of view

WEIGHTAGE of K –LEVELS IN QUESTION PAPER

(Cognitive Level) K-LEVELS →	Lower Order Thinking			Higher Order Thinking			Total
	K1	K2	K3	K4	K5	K6	
END SEMESTER EXAMINATIONS (ESE)	20	25			30		**75**
Continuous Internal Assessment (CIA)	20	25			30		**75**

QUESTION PATTERN FOR END SEMESTER EXAMINATION/ Continuous Internal Assessment

PART		MARKS
PART –A I. (No choice ,One Mark) **TWO** questions from each unit **II.** (No choice, Two Mark) **ONE** question from each unit	(10x1=10) (5x2=10)	**20**
PART –B (Either/ or type,5-Marks) **ONE** question from each unit	(5x5=25)	**25**
PART –C (3 out of 5) (10Marks) **ONE** question from each unit	(3x10=30)	**30**
	Total	**75**

BLUE PRINT OF QUESTION PAPER FOR END SEMESTER EXAMINATION								
DURATION: 3.00 Hours.								**Max Mark :75**
K-LEVELS		**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**Total Marks**
PART								
PART –A	(One Mark, No choice) (10x1=10)	10						**10**
	(2-Marks,Nochoice) (10x2=20)	10						**10**
PART –B	(5-Marks)(Either/or type) (5x5=25)		5	10	10			**25**
PART –C	(10 Marks)(3 out of 5) (3x10=30) Courses having only **K5,K6** levels, K5 level- 3 Questions, K6 level- 2 Questions **(One K6 level question is compulsory)**					20	10	**30**
	Total	**20**	**05**	**10**	**10**	20	10	**75**

EVALUATION

GRADING SYSTEM

Once the marks of the CIA and the end-semester examination for each of the courses are available, they will be added and converted as final mark. The marks thus obtained will then be graded as per the scheme provided in Table-1.

Grade Point Average (GPA) will be calculated from the first semester onwards for all semester. From the second semester onwards, the total performance within a semester and the continuous performance starting from the first semester are indicated by semester Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA) , respectively. These two are calculated by the following formulae:

$GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{I=1}^{n} C_i}$	$WAM(\text{Weighted Average Marks}) = \frac{\sum_{i=1}^{n} C_i M_i}{\sum_{I=1}^{n} C_i}$
Where, C_i is the Credit earned for the Course$i$ G_i is the Grade Point obtained by the student for the Course$i$ M_i is the marks obtained for the course$i$ and n is the number of Courses **Passed** in that semester.	

CGPA: Average GPA of all the Courses starting from the first semester to the current semester.

CLASSIFICATION OF FINAL RESULTS:

i. The classification of final results shall be based on the CGPA, as indicated in Table-2.

ii. For the purpose of Classification of Final Results, the candidates who earn the CGPA 9.00 and above shall be declared to have qualified for the Degree as 'Outstanding'. Similarly the candidates who earn the CGPA between 8.00 and 8.99, 7.00 and 7.99, 6.00 and 6.99 and 5.00 and 5.99 shall be declared to have qualified for their Degree in the respective programmes as 'Excellent', 'Very Good', 'Good', and 'Above Average' respectively.

iii. Absence from an examination shall not be taken an attempt.

Table- 1: Grading of the Courses

Marks Range	Grade Point	Corresponding Grade
90 and above	**10**	**O**
80 and above and below 90	**9**	A+
70 and above and below 80	**8**	**A**
60 and above and below 70	**7**	**B+**
50 and above and below 60	**6**	**B**
Below50	**NA**	**RA**

NA- Not Applicable, RA- Reappearance

The candidates performance in every current semester is indicated by **Semester Grade Point Average (SGPA)** and from the second semester onwards, the continuous performance including previous semester/s is indicated by **Cumulative Grade Point Average (CGPA)**

Table-2: Final Result

CGPA	Corresponding Grade	Classification of Final Result
9.00 and above	**O**	**Outstanding**
8.00 to 8.99	A+	**Excellent**
7.00 to 7.99	**A**	**Very Good**
6.00 to 6.99	**B+**	**Good**
5.00 to 5.99	**B**	**Above Average**

***** The candidates who have passed in the first appearance and within the prescribed duration of the PG Programme are eligible. If the candidate's Grade is O/A+ with more than one attempt, the performance is fixed as "Very Good"

VISION

Empowering the women students with quality education on utility of microbes, microbial processes, products, to make them academics and entrepreneurs to serve for the welfare of society.

MISSION

- To initiate, promote, develop, sustain quality and innovative research using sophisticated instruments in the field of Microbiology.
- To motivate the students so as to exploit the potentiality of microbes and microbial processes for the betterment of the society

PROGRAMME OUTCOMES FOR M.Sc.,DEGREE PROGRAMMES

PO.No	Programme Outcomes (*Upon completion of the M.Sc.,Degree Programme, the Post graduate will be able to)*
PO-1	**Disciplinary Knowledge**: demonstrate in-depth knowledge and understanding of theories, policies, and practices in one or more disciplines that form a part of a Post Graduate program of study in Master of Science.
PO-2	**Critical Thinking and Problem Solving**: apply analytic thought to a body of knowledge, analyse and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence, identify relevant assumptions or implications, formulate coherent arguments, critically evaluate practices, policies and theories by following scientific approach to knowledge development: solve problems and extrapolate the same to real life situation
PO-3	**Information/digital literacy and Communication Skills:** use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources, and use appropriate software for analysis of data: communicate thoughts and ideas analytically and effectively in writing and orally using appropriate media, and present complex information in a clear and concise manner to different groups.
PO-4	**Research-related skills:** conduct independent inquiry in a chosen scientific discipline, demonstrate sense of inquiry and capability for asking relevant/appropriate questions, problematising, synthesizing and articulating; recognize cause-and-effect relationships, define problems, formulate hypotheses, test hypotheses, analyse, interpret and draw conclusions from data, establish hypotheses, predict cause-and-effect relationships; plan, execute and report the results of an experiment or investigation.
PO-5	**Scientific reasoning and Reflective Thinking:** analyse, interpret and draw conclusions from quantitative/qualitative data and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective; critically and sensibly evaluate life experiences, with self awareness and reflexivity of both self and society.
PO-6	**Multidisciplinary Approach, Innovation and Entrepreneurship:** propose novel ideas of interdisciplinary approach in providing better solutions and new ideas for the sustainable developments; identify opportunities, entrepreneurship vision and use of innovative ideas to create value and wealth for the betterment of the individual and society.
PO-7	**Moral and ethical awareness/reasoning:** embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work, demonstrate the ability to identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, appreciate environmental and sustainability issues, and adopt objective, unbiased and truthful actions in all aspects of work.
PO-8	**Self directed Learning:** work independently, identify appropriate resources required for a project, and manage a project till completion.
PO-9	**Lifelong Learning:** engage in continuous learning for professional growth and development, acquire knowledge and skills, adapt to changing environment and to changing trades and demands of work place through knowledge/skill development/reskilling.
PO-10	**Multicultural Competence, Social Interaction and Effective Citizenship:** understand the values and beliefs of multiple cultures, global perspectives, engage and interact respectfully with diverse groups and elicit views of others, mediate disagreements and help reach conclusions in group settings, and demonstrate empathetic social concern and equity centred national development

PROGRAMME SPECIFIC OUTCOME (PSO) M.Sc.,DEGREE PROGRAMMES

PSO No.	Program Specific Outcomes **(M.Sc., Microbiology)**
PSO1	**Placement:** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.
PSO2	**Entrepreneur:** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations
PSO3	**Research and Development:** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.
PSO4	**Contribution to Business World:** To produce employable, ethical and innovative professionals to sustain in the dynamic business world.
PSO5	**Contribution to the Society:** To contribute to the development of the society by collaborating with stakeholders for mutual benefit

1.

SENGAMALA THAYAAR EDUCATIONAL TRUST WOMEN'S COLLEGE

(AUTONOMOUS)

(Affiliated to Bharathidasan University,Tiruchirappalli)

Accredited by NAAC-An ISO 9001:2015 Certified Institution

SUNDARAKKOTTAI- –614016, MANNARGUDI.

TAMILNADU, INDIA.

M.Sc., MICROBIOLOGY

CHOICE BASED CREDIT SYSTEM - LEARNINIG OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(Applicable to the candidates admitted form the academic year 2023-2024)

ELIGIBILITY: A candidate who is a graduate of this University or any recognized University in B.Sc., with Biotechnology/ Biochemistry/ Botany/ Zoology/ Microbiology/ Bioinformatics/ Biology/ Life sciences/ B.Sc., with Biological Sciences as one of the subjects (B.E / B.Tech in Biotechnology) B.Pharm / B.Sc., Agriculture/ B.Sc., Horticulture.

Sem	Part	Nature of the Course	Course Code	Title of the Paper	Ins. Hrs/ Week	L	T	P	S	Credit	Exam Hours	Marks		Total
												CIA	ESE	
I	Part A	Core Course -I	P23MB101	General Microbiology and Microbial Diversity	6	4	1	-	1	5	3	25	75	100
		Core Course- II	P23MB102	Immunology, Immunomics and Microbial Genetics	6	4	1	-	1	5	3	25	75	100
		Core Practical-I	P23MB103P	Practical Pertaining CCI and CCII	6	2	-	4	-	3	3	25	75	100
	Part B (i)	Elective Course – I	P23MBE11A/ P23MBE11B/ P23MBE11C	Forensic Science/ Health Hygiene/ Microalgal Technology (Among the three choices anyone can be chosen by the student)	5	4	1	-	-	3	3	25	75	100
		Elective Course – II	P23MBE12A/ P23MBE12B/ P23MBE13C	Bioinstrumentation/ Herbal Technology and Cosmetic Microbiology / Essentials of Laboratory Management and Biosafety (Among the three choices anyone can be chosen by the student)	5	4	1	-	-	3	3	25	75	100
	Part B (ii)	Non Major Elective - I	P23NMEMB11		2	2	-	-	-	2	3	25	75	100
	TOTAL				**30**	**20**	**4**	**4**	**2**	**21**	-	-	-	**600**
II	Part A	Core Course- III	P23MB204	Medical Bacteriology and Mycology	6	4	1	-	1	5	3	25	75	100
		Core Course -IV	P23MB205	Medical Virology and Parasitology	6	4	1	-	1	5	3	25	75	100
		Core Practical - II	P23MB206P	Practical Pertaining CCIII and CCIV	6	2	-	4	-	3	3	25	75	100

Sem	Part	Nature of the Course	Course Code	Title of the Paper	Ins. Hrs/ Week	L	T	P	S	Credit	Exam Hours	Marks		Total
												CIA	ESE	
	Part B (i)	Elective Course – III	P23MBE23A/ P23MBE23B/ P23MBE23C	Epidemiology/ Clinical Diagnostic Microbiology/ Bioremediation (Among the three choices anyone can be chosen by the student)	5	4	1	-	-	3	3	25	75	100
		Elective Course – IV	P23MBE24A/ P23MBE24B/ P23MBE24C	Bioinformatics/ Nanobiotechnology/ Clinical Research and Clinical Trials (Among the three choices anyone can be chosen by the student)	5	4	1	-	-	3	3	25	75	100
	Part B (ii)	Non Major Elective - II	P23NMEMB22		2	2	-	-	-	2	3	25	75	100
	Part B (iii)	Internship/Industrial Activity			-	-	-	-	-	-	-			-
	TOTAL				**30**	**20**	**4**	**4**	**2**	**21**	-	-	-	**600**
III	Part A	Core Course- V	P23MB307	Soil and Environmental Microbiology	6	4	1	-	1	5	3	25	75	100
		Core Course- VI	P23MB308	Recombinant DNA Technology	6	4	1	-	1	5	3	25	75	100
		Core Practical- III	P23MB309P	Practical Pertaining CC V and CCVI	6	2	-	4		3	3	25	75	100
		Core Industry Module	P23MBI31	Fermentation Technology and Pharmaceutical Microbiology	5	4	1	-	-	3	3	25	75	100
	Part B (i)	Elective Course – V	P23MBE35A/ P23MBE35B/ P23MBE35C	Biosafety, Bioethics and IPR/ Toxinology/ Water Conservation and Water Treatment (Among the three choices anyone can be chosen by the student)	5	4	1	-	-	3	3	25	75	100
	Part B (ii)	Skill Enhancement Course	P23SEMB31	Microbial Quality Control and Testing	2	2	-	-	-	2	3	25	75	100
	Part B (iii)	Internship/Industrial Activity				-	-	-	-	2		-	-	
	TOTAL				**30**	**20**	**4**	**4**	**2**	**23**	**-**	**-**	-	**600**
IV	Part A	Core Course- VII	P23MB410	Food and Dairy Microbiology	5	4	-	-	1	5	3	25	75	100
		Core Course- VIII	P23MB411	Research Methodology and Biostatistics	5	4	-	-	1	5	3	25	75	100
		Core Practical-IV	P23MB412P	Practical Pertaining CCVII and CCVIII	6	2	-	4		3	3	25	75	100
		Core Project	P23MBPW	Project with Viva Voce	8	-	2	6		7	-	25	75	100
	Part B (i)	Elective Course – VI (Industry /	P23MBE46A/ P23MBE46B/	Bioenergy/ Marine Microbiology/	4	4	-	-	-	3	3	25	75	100

Sem	Part	Nature of the Course	Course Code	Title of the Paper	Ins. Hrs/ Week	L	T	P	S	Credit	Exam Hours	Marks		Total
												CIA	ESE	
		Entrepreneurship)	P23MBE46C	Life Science for Competitive Examinations (Among the three choices anyone can be chosen by the student)										
	Part B (ii)	Professional Competency Course	P23PCMB41	Entrepreneurship in Biobusiness	2	2	-	-	-	2	3	25	75	100
	Part C			Extension Activity	-	-	-	-	-	1	-	-	-	-
	TOTAL				**30**	**16**	**2**	**10**	**2**	**26**	-	-	-	**600**
				GRAND TOTAL	**120**	**78**	**12**	**16**	**14**	**91**				**2400**
	Extra Credit			MOOC/SWAYAM/NPTEL		-	-	-	-	**2**	-	-	-	-
				Value added Courses (At least one per Year)		-	-	-	-	**2**	-	-	-	-

L-Lecture T-Tutorial P-Practical S-Seminar

NON MAJOR ELECTIVE OFFERED BY THE DEPARTMENT

Semester	Part	Course	Course Code	Title of the Course
I	IV	NME -I	P23NMEMB11	Vermitechnology
II		NME -II	P23NMEMB22	Organic Farming and Biofertilizer Technology

Credit Distribution for M.Sc., Microbiology

S.No	Course Details	Credit
Part A	Core Course [8 Courses X 5 Credits]	40
	Core Practical [4 Courses X 3 Credits]	12
	Project Work with Viva Voce	7
	Core Industry Module [1Course X 3 Credits]	3
Part B (i)	Elective Course [6 Courses X 3 Credits]	18
Part B (ii)	Non Major Elective [2 Courses X 2 Credits]	4
	Skill Enhancement Course [1 Course X 2 Credits]	2
	Professional Competency Course [1 Course X 2]	2
Part B (iii)	Internship	2
Part C	Extension Activity	1
	Total Credit	**91**

Part A component and Part B (i) will be taken into account for CGPA calculation for the postgraduate programme and the other components of Part B and Part C have to be completed during the duration of the programme as per the norms, to be eligible for obtaining the PG degree.

SEMESTER - III

Semester: III- CC-V: Soil and Environmental Microbiology

Ins. Hours / Week: 6 **Course Credit: 5** **Course Code:P23MB307**

UNIT-I: **(20 Hours)**

Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic and Inorganic Matter in Soil. Biological Nitrogen fixation- Chemistry and Genetics of BNF. Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), Pathogenesis Related (PR) Proteins, Plantibodies, Phenolics, Phytoalexins.

UNIT- II: **(20 Hours)**

Microbial Interactions - Mutualism, Commensalism, Amensalism, Synergism, Competition, Rhizosphere- Rhizosphere effect, Mycorrhizae – Types, Endophytes, PGPR- Plant Growth Promoting Bacteria– Symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non-Symbiotic (*Azospirillum, Azotobacter*, Mycorrhizae, MHBs, Phosphate Solubilizers, Algae), Novel combination of microbes as Biofertilizers, PGPRs. Biofertilizers and Biocontrol agents – Types, benefits and application. Advantages, Social and Environmental aspects - Bt crops, golden rice.

UNIT- III: **(15 Hours)**

Components of Environment: Hydrosphere, Lithosphere, Atmosphere and Biosphere – definitions with examples; Energy flow in the Ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of Microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space Microbiology - Microbiological research in space environment.

UNIT- IV: **(15 Hours)**

Waste management – Solid waste - Types - Management - Factors affecting solid waste generation rates. Domestic sewage water and Industrial effluent water treatment, Primary, Secondary, Tertiary and Advanced treatment techniques. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production. E waste management.

UNIT- V: **(20 Hours)**

Degradation of Organic matter - Lignin, Cellulose, Hemicellulose, Pectin, Common Pesticides- Herbicides (2,4-D) and Pesticides (DDT), Heavy metals. Biodegradation of Microplastic and Xenobiotics - Recalcitrant Halocarbons and TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather. Pollution Control Bodies (Central and State Government) and Environmental laws in India. Environmental Clearances (EC), Environmental impact assessment (EIA) guidelines, US Environment Protection Agency (EPA) norms.

Total Lecture Hours - 90

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Predict the role of microbes in biological nitrogen fixation.
2. Apply knowledge of microbial interactions, with beneficial application of biofertilizers
3. Identify the causes of water pollution and the methods for quality assessment of water
4. Recognize waste treatments and microbial decomposition and bio-remediation.
5. Evaluate environmental issues and Pollution control methods.

TEXT BOOKS

1. SubbaRao. N. S. (2017). Soil Microbiology. (5th Edition). Med Tech Publishers, New Delhi.
2. Daniel. C. J. (2006). Environmental Aspects of Microbiology. (2nd Edition). Bright Sun Publications, Jaipur.
3. Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd, New Delhi.
4. Sharma P. D. (2010). Microbiology and Plant pathology. (2nd Edition). Rastogi

Publications, Jattiwara, Meerut, UP.

5. Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd, New Delhi.

REFERENCE BOOKS

1. Pepper I. L., Gerba C. P. and Gentry T. J. (2014). Environmental Microbiology (1st Edition). Academic Press, Elsevier, Cambridge, Massachusetts.
2. Bitton, G. (2011). Wastewater Microbiology. (4th Edition). Wiley-Blackwell, Hoboken, New Jersey, US
3. Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington, D.C.
4. Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation, Daryaganj, New Delhi, Delhi, 110002
5. Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan, UK.

E-RESOURCES

1. https://academic.oup.com/femsec/article/93/5/fix044/3098413
2. http://www.fao.org/3/t0551e/t0551e05.htm
3. www.environmentshumail.blogspot.in/
4. https://www.frontiersin.org/articles/10.3389/fpls.2017.01617/full
5. https://serc.carleton.edu/microbelife/index.html

Semester: III- CC-VI: Recombinant DNA Technology

Ins. Hours / Week: 6 **Course Credit: 5** **Course Code:P23MB308**

UNIT-I: **(20Hours)**

Milestones in rDNA technology - Definition of gene manipulation - Major steps involved in gene cloning - Isolation and Purification of Chromosomal DNA, Plasmid DNA and RNA. Chemical Synthesis of DNA, Genomic Library and cDNA Library - applications. Applications of recombinant DNA technology

UNIT- II: **(20 Hours)**

. Restriction endonucleases: Discovery, Nomenclature, classification and Mode of action, Applications of type II restriction endonucleases, Helicase, Ligases, DNA polymerases, topoisomerases and DNA modifying enzymes.

UNIT- III: **(20 Hours)**

Cloning vectors: Definition and properties – Plasmid based vectors: Natural vectors (pSC101, pSF2124, pMB1), Artificial vectors (pBR322 and pUC), Phage based vectors- (Lamda phage vectors) and its derivatives - Hybrid Vectors- Phagemid, Cosmid, BAC and YAC – Expression systems – *E. coli*.

UNIT- IV: **(15 Hours)**

Gene/ DNA transfer techniques: Physical – Biolistic Method (Gene gun), Chemical- Calcium chloride and DEAE Methods, Biological *in vitro* packaging method in viruses, Selection and Screening of recombinants: Direct Method- Selection by Complementation, Marker inactivation methods. Indirect methods- Immunological and Genetic methods. PCR - basic steps in DNA amplification, RAPD, RFLP and their applications – DNA finger printing and Blotting (Southern, Western, Northern and North- eastern) techniques

UNIT- V: **(15 Hours)**

Microbial synthesis of commercial products - Insulin, Interferons, Human growth hormone, antibiotics, biopolymers. Transgenic Plants- Ti plasmid, insect resistant plant. Transgenic animal– mice. Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections - Human Gene Therapy – Germ line and Somatic Cell Therapy - Ex-vivo and In-vivo Gene Therapy.

Total Lecture Hours- 90

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Understand the steps involved in rDNA.
2. Analyze the applications of DNA modifying enzymes
3. Compare and classify the natural and artificial plasmid
4. Evaluate the Gene transfer techniques in rDNA Technology
5. Apply knowledge on rDNA Technology for Human welfare

REFERENCES

TEXT BOOKS

1. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
2. Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7th Edition). John Wiley and Sons, Inc, UK.
3. Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7th Edition). Blackwell Publishing Company, New Jersey, US.
4. Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing House Pvt. Ltd, New Delhi.
5. Shikha Jain (2023). A Text Book of Recombinant DNA Technology, John Wileys and Sons Ltd, UK.

REFERENCE BOOKS

1. Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7th Edition). John Wiley and Sons Ltd, UK.
2. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press, Washington, D.C.
3. Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Ed., London, England.
4. Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). Molecular Genetics of Bacteria. (4th Edition). ASM Press, Washington-D.C.
5. Dale J. W., Schantz M.V. and Nicholas Plant (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd, US.

E-RESOURCES

1. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/
2. https://geneticeducation.co.in/what-is-transcriptomics
3. https://www.molbiotools.com/usefullinks.html
4. https://geneticeducation.co.in/what-is-transcriptomics
5. https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/

Semester: III- CP-III: Soil and Environmental Microbiology and Recombinant DNA Technology

Ins. Hours / Week: 6 **Course Credit: 3** **Course Code:P23MB309P**

Soil and Environmental Microbiology

- Soil Analysis – pH, Chlorides, nitrate, calcium, magnesium and total phosphorous
- Isolation of microbes from Rhozspere soil sample
- Observation of VAM spores from plant root
- Isolation and identification of Rhizobium from Leguminous plant
- Quantification of microbes in air by - Settle plate method and Air sampler
- Examination of pot ability of drinking water by - Membrane filter technique, Standard Plate Count (SPC)method, Most Probable Number Test (MPN)
- Isolation and Counting of faecal bacteria from water
- Physico- chemical assessment of treated water by- TSS, TDSDO, COD and BOD

Recombinant DNA Technology

- Amplification of DNA by PCR techniques
- Blotting techniques-Western, Northern and Southern – Demonstration
- Restriction digestion of plasmid DNA by endonucleases
- Physical Mutation – Ultraviolet Radiation and Heat treatment
- Chemical Mutation- Ethidium Bromide induced mutaion

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Assess the microbial quality of water and air and relate the results to standards
2. Undertake novel research with techniques like PCR and blotting analysis.

3. Synthesize biofertilizers and vermicompost. Cultivate mushrooms using solid waste.
4. Acquire skills for extraction DNA from Bacteria
5. Utilize various molecular techniques for gene manipulation and detection of mutants

TEXT BOOKS

1. Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc, New Jersey.

6. Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition). ASM Press, Washington, D.C.

2. Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International.

3. James G Cappucino. and Natalie Sherman. (2016). Microbiology – A Laboratory manual. (5th Edition). The Benjamin publishing company. New York.

4. Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology, Washington, D.C.

REFERENCE BOOKS

1. Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press, Long Island, New York.

2. Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd.

3. Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd, US.

7. Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier, Washington, D.C.

4. Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4th Edition). Wiley, US.

E-RESOURCES

1. https://www.molbiotools.com/usefullinks.html

2. https://geneticgenie.org3

3. https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5.

4. https://vlab.amrita.edu/index.php?sub=3&brch=272

5. https://nptel.ac.in/courses/102105087

Semester: III– CC VII: Fermentation technology and Pharmaceutical Microbiology

Ins. Hours / Week: 5 **Course Credit: 3** **Course Code:P23MBI31**

UNIT- I **(12 Hours)**

Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter pre-culture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic.

UNIT-II: **(12 Hours)**

Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Entrepreneurial opportunities in Fermentation technology and its Economics.

UNIT-III: **(12 Hours)**

Downstream Processing - Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

UNIT-IV: **(12 Hours)**

Overview of Pharmaceutical Microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants.

UNIT-V: **(12 Hours)**

Production of pharmaceutical products and quality assurance – Vaccines, immunostimulants, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.

Total Lecture Hours – 60

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Develop microbial strains for fermentation process.
2. Design fermenters according to needs for various products.
3. Acquire skills for downstream processing
4. Gain knowledge on industrial production of valuable products
5. Evaluate therapeutic products extraction from microbes

TEXT BOOKS

1. Patel A. H. (2016). Industrial Microbiology. (2nd Edition). Laxmi Publications, New Delhi
2. Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers, Long Island, New York.
3. Sathyanarayana U. (2005). Biotechnology. (1st Edition). Books and Allied (P) Ltd, Beliaghata, Kolkata, WB-700010.
4. Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4th Edition). CBS Publishers and Distributors, Daryaganj, New Delhi.
5. Waites M. J., Morgan N. L., Rockey J. S. and Higton G. (2013). Industrial Microbiology: An Introduction. Wiley Blackwell Publishers, Hoboken, New Jersey.

REFERENCE BOOK(S)

1. Stanbury P. T. and Whitaker. (2016). Principles of Fermentation Technology. (3rd Edition). Pergamon Press. NY.
2. Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4th Edition). VallabhPrakashan Publishers, New Delhi.

3. Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12th Edition). Nirali Prakasham Publishers, Pune.
4. Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7th Edition). Blackwell Scientific Publication, Oxford.
5. Wallis, T.E. (2005). Text book of Pharmacognosy. (5th Edition). CBS publishers and distributors, New Delhi.

E-RESOURCES

1. https://ib.bioninja.com.au/options/untitled/b1-microbiology organisms/fermenters.html
2. https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicilli n.html
3. https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation
4. https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf
5. http://www.simbhq.org/

Semester: III - EC-V (Choice 1) -Biosafety, Bioethics and IPR

Ins. Hours / Week: 5 **Course Credit: 3** **Course Code:P23MBE35A**

UNIT-I: **(12 Hours)**

Intellectual Property Rights: Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology - Patents, Trademarks, Copyrights, Industrial designs, Geographical indications, Trade secrets, Non-disclosure agreements. Patent life and geographical boundaries. International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries.

UNIT-II: **(12 Hours)**

Process involved in Patenting. Patent Search - Procedural steps in patenting, process of filing, PCT application, Pre-grant and Post-grant opposition, PCT and patent harmonization including Sui-generis system, Patent search methods, Patent databases and libraries, online tools, Country-wise patent searches (USPTO, EPO, India etc.), Patent mapping.

UNIT-III: **(12 Hours)**

Patentability of biotechnology inventions - Patentability of biotechnology inventions in India, statutory provisions regarding biotechnological inventions under the current Patent Act 1970 (as Amended 2005). Biotechnological inventions as patentable subject matter, Territorial nature of patents - from territorial to global patent regime, interpreting trips in the light of biotechnology inventions, feasibility of a uniform global patent system, merits and demerits of uniform patent law, relevance of the existing international patent, tentative harmonisation efforts, implications of setting up a uniform world patent system.

UNIT-IV: **(12 Hours)**

Introduction to Bioethics - Need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity - conserving natural biodiversity, convention on protecting biodiversity, protocols in exchanging biological material across borders. Bioethics and GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the gene-pool.

UNIT-V: **(12 Hours)**

Bioethics in medicine - Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning - permissions and procedures in animal cloning, human cloning, risks and hopes. Bioethics in research: stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races. The Nuremberg code.

Total Lecture Hours - 60

COURSE OUTCOME

On completion of this course, students will,

1. Understand the IPR, Patent, Trademarks and its importance.
2. Develop patent procedure, patent filling and its mapping.
3. Comprehend patent laws and world patent system
4. Apply bioethics in GMO, food crops and its biodiversity.
5. Analyze the importance of bioethics in research.

TEXT BOOKS

1. Usharani B., Anbazhagi S. and Vidya C. K. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN-101645878856, Chennai, India.
2. Satheesh M. K. (2009). Bioethics and Biosafety. (1st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703
3. Goel D. and Parashar S. (2013). IPR, Biosaftey and Bioethics. (1st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700
4. Raj Mohan Joshi. Biosafety and Bioethics. Wiley Publications, Hoboken, New Jersey
5. Sibi. G. Intellectual, Property Rights, Bioethics, Biosafety and Entreepreneurship in biotechnology. (2021). Wiley Publications, Hoboken, New Jersey.

REFERENCE BOOK(S)

1. Nithyananda K. V. (2019). Intellectual Property Rights: Protection and Management, India, IN: Cengage Learning India Private Limited.
2. Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights, India, IN: PHI learning Private Limited, New Delhi.
3. Ahuja, V K. (2017). Law relating to Intellectual Property Rights, India, IN: Lexis Nexis
4. Tony Hope (2004). Medical Ethics: A very Short introduction, Oxford Publication, England.
5. Goel Parashar. IPR, Biosafety and Bioethics (2013). Pearson Publications, Chennai.

E-RESOURCES

1. http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf.
2. https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub _489.pdf.
3. https://www.cdc.gov/training/quicklearns/biosafety/
4. https://bioethics.msu.edu/what-is-bioethics
5. https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm

Semester: III- EC-V(Choice 2)- Toxinology

Ins. Hours / Week: 5 **Course Credit: 3** **Course Code:P23MBE35B**

UNIT-I: **(12 Hours)**

General Introduction - Definition of toxins, Different categories of toxins and Venoms, recent trends in Venom and toxin research.

UNIT-II: **(12 Hours)**

Bacterial toxins - Bacterial toxinogenesis, endotoxins, exotoxins, bacterial protein toxins with special reference to Cholera, Diphtheria and Tetanus toxins, molecular mechanism of action of Endotoxins, Exotoxins, Enterotoxins, Neurotoxins and Mycotoxins.

UNIT-III: **(12 Hours)**

Plant toxins & Toxins from snake venom - Natural toxins in plants, Plant toxic proteins, impact of plant toxin on human, natural toxins in food, plants, allelopathy. Toxins from snake venom Snakes and Biological significance of their venoms, composition of snake venom, evolution of venom, 3D structure of some important venom constituents and their mechanism of action (Phospholipase A2, Cardiotoxin, Neurotoxin) three-finger toxins, anti-venom and medicinal plants in treatment of snakebite patients.

UNIT-IV: **(12 Hours)**

Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis), toxin mass fingerprinting, N-terminal peptide sequencing, analysis of protein data by using proteomics software.

UNIT-V: **(12 Hours)**

Medicinal and industrial applications of venoms and toxins. Use of toxin in neurobiology and muscular research, anticancer drug, diagnosis of haemostatic disorders, antibacterial agents, bioinsecticides and other industrial applications.

Total Lecture Hours - 60

COURSE OUTCOME

On completion of this course, students will;

1. Perceive the adverse effects of toxin and its potential role in research.
2. Assess the toxicity, properties and mode of actions of microbial toxins.

3. Analyze the mode of actions and their biological significance of plant toxins
4. Evaluate the toxicity level with the help of advanced techniques.
5. Elucidate the various natures of application of toxic substances.

TEXT BOOKS

1. Holst O. (2008). Bacterial Toxin –Methods & Protocols. Humana Press. ISBN 9781592590520, Totowa, New Jersey.
2. Shier W. T. (1990). Handbook of Toxinology. CRC Press. ISBN 9780824783747, Boca Raton, Florida.
3. Wilson K. and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. (7thEdition). Cambridge University Press India Pvt.Ltd. ISBN 1-4051-3544-1.
4. Pholtan Rajeev S.R. (2021Pictorial hand book for toxinology. Rudra Publications, New Delhi.
5. Cora Lancester. (2015). Molecular Toxinology Handbook. Callisto Reference

REFERENCE BOOK(S)

1. Reilly M. J. (2018). Bioinstrumentation. CBS Publishers and Distributors Pvt Ltd. ISBN 13 978-8123928395.
2. Greenberg M., Hamilton R., Phillips S. and McCluskey G. J. (2003). Occupational, Industrial and Environmental Toxicology. St Louis: C.V. Mosby.
3. Wiley-Vch. (2005).Ullmann's Industrial Toxicology. New York: John Wiley and Sons.
4. Winder C. and Stacey N.H. and Boca Raton F. L. (2004). Occupational Toxicology. (2nd Edition). CRC Press, Boca Raton, Florida.
5. Gopalakrishnakone(2015). Biological Toxins and Bioterrorism. Springer, New Delhi.

E-RESOURCES

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869414/
2. https://www.reseachgate.net/publication/269037373_TOXIN_AS_A_MEDICINE
3. https://www.toxinology.org/
4. https://www.mdpi.com/journal/toxins/special_issues/snakebite_clinical_toxinology
5. https://pubmed.ncbi.nlm.nih.gov/12807310

Semester: III - EC-IV (Choice 3) Water Conservation and Water treatment Technologies

Ins. Hours / Week: 5 **Course Credit: 3** **Course Code: P23MBE35C**

UNIT-I: **(12 Hours)**

Water Scarcity; Major Causes of Water Scarcity, Types of Water Scarcity, Water Footprint-Effects of Water Scarcity Across the Globe-, Water Scarcity in India; Effects of Water Scarcity in India - Social and Political Effects and Economic Risks of Water Scarcity in India.

UNIT-II: **(12 Hours)**

Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging, Water reuse and ETP, STP, WTP and Zero-Liquid Discharge (ZLD) Technology, Coastal Reservoir, Desalination Plants-Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal Bhujal Yojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting. Utilization of ETP, STP, WTP and ZLD treated water.

.**UNIT-III:** **(12 Hours)**

Water Quality and Pollution; Impurities in the water, Characteristics of different water sources Vulnerability of the water sources to contamination, Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater, Water quality standards, Microbiological quality of drinking Water, Chemical quality of drinking water.

UNIT-IV: **(12 Hours)**

Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration, Water disinfection, Activated carbon filtration, Pressurized sand filtration, Household Water Treatment and Safe Storage (HWTS). Methods for household water treatment, Safe water storage and safe storage decision tree, assessing the impact of HWTS, Government policies for HWTS.

UNIT-V: **(12 Hours)**

New and Emerging Drinking Water Treatment Technologies; Nanotechnology, Acoustic nanotube technology, Photocatalytic water purification technology, Automatic Variable Filtration (AVF) technology, Sun Spring System.

Total Lecture Hours - 60

COURSE OUTCOME

On completion of this course, students will;

1. Appraise issues of water scarcity, stress, and conflict on global population.
2. Apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation.
3. Relate the connection between water quality and public health.
4. Design and execute standard strategy for successful HWTS implementation.
5. Understand the purpose, principles, operation, and limitation of various modern water treatment technologies.

TEXT BOOKS

1. Vasileios A., Tzanakakis N. Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3-03943-3070.
2. Pannirselvam M., ShuLi.,Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3.
3. Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781.
4. Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1st edn. Bright Sun Publications, Europe.
5. Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2nd edn. Academic Press, Washington, DC.

REFERENCE BOOKS

1. Fujita K. and Mizushima T. (2021). Sustainable Development in India -Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976.

2. Gupta R. (2008). Water Crisis in India. Atlantic Publishers. ISBN: 9788126909582, 9788126909582.
3. Ahuja S. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955.
4. Saeid Eslamian, Faezeh Eslamian ., (2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications, Hoboken, New Jerse.
5. Buckley RG. (2016) Environmental Microbiology 1st edn. CBS Publishing, Daryaganj, New Delhi.

E-RESOURCES

1. https://link.springer.com/book/10.1007/978-1-59745-278-6
2. https://apps.who.int/iris/handle/10665/206916?show=full
3. https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html
4. https://www.toftigers.org/best-practice/water-conservation-and-treatment/
5. https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss

Semester: III- SEC-I: Microbial Quality Control and Testing

Ins. Hours / Week: 2 **Course Credit: 2** **Course Code: P23SEMB31**

UNIT-I: **(6 Hours)**

Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay.

UNIT- II: **(6 Hours)**

Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies

UNIT- III: **(6 Hours)**

Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens - Precipitation, chemical disinfection, filtration, high temperature, UV light

UNIT- IV: **(6 Hours)**

Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration.

UNIT- V: **(6 Hours)**

Quality control in food - Food X ray inspection, PPE Equipment, IoT sensors, preventive quality control and reality quality control. Quality control of pharma products. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.

Total Lecture Hours - 30

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Apply knowledge in quality analysis techniques suitable for industries.
2. Perform water managements, water harvesting and treat sewage, water pollutions and remedies.
3. Detect portability of water. Test water quality.
4. Impart knowledge on bioaerosols, impact and prevention
5. Apply quality control techniques for food and pharma products

TEXT BOOKS

1. Aneja R. P., Mathur B.N., Chandan R. C. and Banerjee, A. K. (2002). Experiments in Microbiology.

2. Adams M. R. and Moss M. O. (2006). Food Microbiology. (2nd Edition). Royal Society of Chemistry.

3. Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.
4. Cappuccimo, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi.
5. Rosamund M. Baird., Norman A. (2019). Handbook of Microbiologicalquality control in Pharmaceuticals and Medical Devices. CRC Press.

REFERENCE BOOK(S)

1. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). -Taylor &Francis.
2. Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals, cosmetics & Toiletries. by Sally F. Bloomfield
3. Amitava Mitra. Fundamentals of Quality control and Improvement. (3rd Edition). Wiley

Publications

4. Sundararaj T. (2003). Microbiology Laboratory Manual. (2nd Edition). Published by A. Sundararaj
5. David Roesti, Marcel Goverde (2019). Pharmaceutical Microbiological Quality Assurance and control: Practical guide for non- sterile Manufacturing. Wiley Publishers.

E-RESOURCES

1. https://www.researchgate.net › publication › 320730681
2. https://www.fssai.gov.in
3. https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc
4. https://www.who.int/news-room/fact-sheets/detail/food-safety
5. https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

SEMESTER - IV

Semester: IV- CC-VII: Food and Dairy Microbiology

Ins. Hours / Week: 5 **Course Credit: 5** **Course Code:P23MB410**

UNIT- I **(18 Hours)**

Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food – Vegetables, Fruits, Poultry, Fish, Eggs, Meat, Meat Products and Canned Foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.

UNIT-II: **(18 Hours)**

Food microbiology and public health.Food hazards.Food infections -*Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli, Salmonella, Shigella, Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus

UNIT-III: **(18 Hours)**

Quality assurance of food - International aspects of Quality and safety assessment of foods.Microbiological quality standards for food.Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014.Food adulteration and common food additives.

UNIT-IV: **(18 Hours)**

Introduction to Dairy microbiology – Milk production and hygiene. Microorganisms associated with milk. Microbial metabolites and their role in spoilages- souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour. Antimicrobial systems in raw milk.Microbiological grading of raw milk.Milk borne diseases and their control. Bacteriological aspects of milk processing – Thermization, Pasteurization, Boiling, Sterilization, UHT, bactofugation and membrane filtration.

UNIT-V: **(18 Hours)**

Composition and chemistry of Cream, Butter, Ghee, Ice-Cream, Cheese, Kefir, Koumiss, Rennin, condensed and dried milks, infant food. Spoilage of ghee and use of antioxidants.

Chemistry of milk fermentation. Chemistry of rennin coagulation of milk and changes occurring during ripening of cheese, physico-chemical changes in the manufacture and storage of milk powder, lactose, crystallization and its significance. Dairy plant hygiene and sanitation.Disposal of dairy waste.Microbiological standards for Milk and Milk products- PFA BIS, Codex/ ISO standards.

Total Lecture Hours – 90

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Utilize the knowledge on process of food contamination and spoilage to preserve food.
2. Acquire knowledge on food borne disease to protect public health.
3. Familiarize various national and international aspects of food safety and quality assurance.
4. Prepare dairy products and perform quality checks.
5. Apply microbiological standards to milk and milk products.

TEXT BOOKS

1. Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.
2. Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education, New York, US.
3. Jay J.M., Loessner M.J. and Golden D.A. (2006). Modern Food Microbiology. (7th Edition). Springer, New York, US.
4. Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4th Edition). American Society for Microbiology Press, Washington, DC
5. Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press, Boca Raton, Florida.

REFERENCE BOOK(S)

1. Robinson R. K. (2000). Dairy Microbiology3rdedn, Elsevier Applied Science, London.
2. Adams M.R, and Moss M.D, (2005). Food Microbiology 4thedn, New Age International Pvt. Ltd., Publishers. First edition, Darya Ganj.
3. Banwarst. G.J. (2003). Basic Food Microbiology 2ndedn, CBS Publishers and

distributors, New Delhi.

4. Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7th edn. Edward Arnold: London.
5. Vijaya R K, (2004). Food Microbiology 1st edn. MJP Publishers, Chennai.

E-RESOURCES

1. https://www.fssai.gov.in
2. https://www.who.int/news-room/fact-sheets/detail/food-safety
3. https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Semester: IV- CC-VIII: Research Methodology and Biostatistics

Ins. Hours / Week: 5 **Course Credit: 5** **Course Code:P23MB411**

UNIT-I: **(20 Hours)**

Introduction to Research Methodology - Meaning and importance. Statement, Constraints. Review of literature - Review and synopsis presentation. Types of research, Research tools. Methods and techniques of data collection - Types of Data, methods of Primary Data collection (observation/ experimentation/ questionnaire/ interviewing/ case/pilot study, methods), methods of secondary data collection.

UNIT- II: **(20 Hours)**

Sampling and sampling distributions. Sampling frame, importance of Probability Sampling, sampling - simple random, systematic, stratified random and cluster. Variables - nominal, ordinal, discontinuous, continuous, derived. Research process, Designs and Report writing - types of research reports, guidelines for writing an article and report, report format, appendices, Ethical issues related to publishing, Plagiarism and Self-Plagiarism.

UNIT- III: **(15 Hours)**

Introduction to Biostatistics - Basic concepts, Measurement and measurement scales, Sampling and data collection, Data presentation. Measures of central tendency: Mean, Median, Mode. Measures of variability - Standard deviation, Standard error, Range, Mean deviation and coefficient of variation. Frequency table of single discrete variable, Bubble spot, computation of mean, variance and standard Deviations, t test, correlation coefficient.

UNIT- IV: **(20 Hours)**

Correlation and regression - Positive, negative, calculation of Karl-Pearsons co-efficient of correlation. Linear regression and Multiple linear regression, ANOVA, One and Two way classification. Calculation of an unknown Variable using regression equation. Tests of significance - Tests of significance: Small sample test (Chi-square t test, F test), Large sample test (Z test) and standard error.

UNIT- V: **(15 Hours)**

Probability and distributions - Introduction to probability theory and distributions, (concept without deviation) Binomial, Poison and Normal (only definitions and problems) Computer oriented statistical techniques. RSM: methods for process optimization set up CCD, Box Behnken, optimal RSM design, regression models FDS curves, surface contours, multi linear constraints and categoric factors to optimal design.

Total Lecture Hours - 90

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Collect and present data suitable to the research design.
2. Describe research manuscripts and articles for journals.
3. Utilize biostatistical tools for analysis of biological data.
4. Analyze and test the hypothesis for a particular research.
5. Recognize the software tools for interpretation of biological data.

TEXT BOOKS

1. Sharma K. R. (2002) Research methodology. National Publishing House, New Delhi.
2. Daniel W.W. (2005). Biostatistics; A foundation for analysis in the health sciences. (7^{th} Edition). Jhon Wiley and sons Inc, New York.
3. Rao P. S. S. and Richard J. (2006). Introduction to Biostatistics and Research methods. Prentice-Hall, New Delhi.
4. Veerakumari L. (2015) Bioinstrumentation 1^{st}edn. MJP Publishers, Chennai.
5. Ahuja V.K. (2017) Laws Relating to Intellectual Property Rights. Lexis Nexis.

REFERENCE BOOK(S)

1. Zar J. H. (2006). Biostatistical Analysis. (4^{th} Edition). Pearson Education Inc. New Jersey.
2. Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics. Pearson Education Inc. New Jersey.
3. Adams K. A. and Lawrence E. M. K. (2014). Research Methods, Statistics, and Applications. SAGE Publications, Inc., New Delhi.
4. Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4^{th}edn. Wiley India Private Limited, Bengaluru, Karnataka.

5. Kothari C.R. and Garg G (2004) Research Methodology: Methods and Techniques. 2nd Edition. New Age International Publishers, New Delhi.

E-RESOURCES

1. https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093
2. https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library
3. https://testbook.com/learn/maths-mean-median-mode/
4. https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%20Correlation%20and%20Regression.pdf
5. https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf

Semester: IV- CP-IV: Practical Pertaining CC-VII and CC-VIII

Ins. Hours / Week: 6 **Course Credit: 3** **Course Code:P23MB412P**

CC-VII- Food and Dairy Microbiology

- Assessment of milk quality by Methylene Blue Reduction Test
- Performance of phosphatase test for pasteurized milk
- Isolation of bacteria from food by Standard Plate Count method
- Isolation of Yeast from grapes
- Wet mount preparation of spoiled Bread, Tomato, Grapes, Potato
- Observation of food samples to study *Leuconsostoc*, *Lactobacillus, Streptococcus lactis* and *Saccharomyces*
- Preparation of fermented food- Yoghurt and Cheese (Demonstration)
- Production of wine from grapes
- Production of alcohol for agricultural waste (Sugarcane molasses and beetroot)

CC-VIII- Research Methodology and Biostatistics

- Collection of data, sampling designs, Tabulation and Graphic representation using Biological materials.
- Representation of statistical data by Histograms, Ogive curve and Pie diagrams
- SPSS (Statistical Package for the Social Sciences)
- Determination of statistical averages / central tendencies - Arithmetic Mean, Median and Mode
- Determination of measures of dispersion – Mean deviation and Standard deviation
- Tests of significance't' test, 'chi' square, standard error and standard deviation.

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Assess food quality in dairy and food industry
2. Construct suitable methods for alcoholic fermentation
3. Develop methods for production of milk and milk product
4. Collect and present data suitable to the research design.
5. Describe research manuscripts and articles for journals.
6. Recognize the software tools for interpretation of biological data.

TEXT BOOKS

1. Sharma K. R. (2002) Research methodology. National Publishing House, New Delhi.
2. Daniel W.W. (2005). Biostatistics; A foundation for analysis in the health sciences. (7^{th} Edition). Jhon Wiley and sons Inc, New York.
3. Rao P. S. S. and Richard J. (2006). Introduction to Biostatistics and Research methods. Prentice-Hall, New Delhi.
4. Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4^{th} Edition). American Society for Microbiology Press, Washington, DC.
5. Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5^{th} Edition). CRC Press, New York.

REFERENCE BOOK(S)

1. Zar J. H. (2006). Biostatistical Analysis. (4^{th} Edition). Pearson Education Inc. New Jersey.
2. Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics. Pearson Education Inc. New Jersey.
3. Adams K. A. and Lawrence E. M. K. (2014). Research Methods, Statistics, and Applications. SAGE Publications, Inc., New Delhi.
4. Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7^{th}edn. Edward Arnold: London.
5. Vijaya R K, (2004). Food Microbiology 1^{st}edn. MJP Publishers, Chennai.

E-RESOURCES

1. https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093
2. https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library
3. https://testbook.com/learn/maths-mean-median-mode/

Semester: IV- EC-VI (Choice – 1)-Bioenergy

Ins. Hours / Week: 4 **Course Credit: 3** **Course Code:P23MBE46A**

UNIT- I: (12 Hours)

Bioenergy– Biomass Energy Resources.Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, Fungi, Yeast and Microalgae) -Bioprospecting of microbial strains for biofuel production.

UNIT-II: (12 Hours)

Biodiesel − Microbes and Biodiesel.Production and feed stock.Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment.Strategies of genetic engineering of organisms for biodiesel production.Biodiesel production from single cell organisms (*Cryptococcus, Cunninghamella, Mortierella*).

UNIT-III: (12 Hours)

Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production.Distillation and Quantification of ethanol.Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.

UNIT-IV: (12 Hours)

Biogas - Microbes and Biogas production, Biogas plants – Types – Design – Construction– Biogas Bottling Technology and Development in India, Biogas appliances – Burner, Luminaries and power generation – effect on engine performance. Application of Biogas slurry in agriculture**.**

UNIT-V: (12 Hours)

Biohydrogen– Production from bacteria and algae. Commercialized microalgae (*Spirulina, Dunaliella, Hematococcus*and *Chlorella*) and their production. Economics of microalgae production. Cultivation of seaweeds and Microbial fuel cells.

Total Lecture Hours - 60

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Evaluate the various aspects of biomass production and their implementation.
2. Design and construct a biodiesel plant.
3. Carry out the process of fermentation for bio – alcohol fuels.
4. Identify the nature of biogas as a biofuel and their technologies and applications.
5. Design, execute and extract biohydrogen from algae.

TEXT BOOKS

1. Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1st Edition). Academic Press Editor, Cambridge.
2. Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1st Edition). Wiley Blackwell Publishing, Hoboken, New Jershey.
3. Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1st Edition). Springer Cham.
4. Caye M. Drapcho, Tery H. Walker (Biofuels Engineering Process Technology. McGraw Hill, New York.
5. Teri. Bio energy Powering the Future. Pearson Longman Publications, New York.

REFERENCE BOOKS

1. Konur O. (2018). Bioenergy and Biofuels. (1st Edition). CRC Press, Boca Raton, Florida.
2. Leej.W.(2012). Advanced Biofuels and Bioproducts. (13th Edition), Springer, New York city.
3. Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8th Edition). Wiley-Blackwell Publishing, New Jershey.
4. Pradeep Chaturvedi. (1995). Bioenergy Resources. Concept Publishing Company, New Delhi.
5. Lee S. (2018).Biofuel and Bioenergy. Taylor and Francis, New York.

E-RESOURCES

1. https://www.elsevier.com Biofuels and Bioenergy
2. https://www.sciencedirect.com › book › bioenergy
3. https://www.un.org/en/climatechange/what-is-renewableenergy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE
4. https://www.energy.gov/eere/bioenergy/bioenergy-basics
5. https://www.iea.org/fuels-and-technologies/bioenergy

Semester: IV- EC-VI (Choice –2)-Marine Microbiology

Ins. Hours / Week: 4 **Course Credit: 3** **Course Code:P23MBE46B**

UNIT- I: **(12 Hours)**

Marine microbial environment - Benthic and littoral zone, Salt pan, Mangroves and Estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts.

UNIT-II: **(12 Hours)**

Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials.

UNIT-III: **(12 Hours)**

Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic, hyperthermophilic and halophilic microorganisms – Importance in biotechnology.

UNIT-IV: **(12 Hours)**

Marine Microbial Diseases: Aqua culture pathogens and Water borne pathogens -*Aeromonas, Vibrio, Salmonella, Pseudomonas, Leptospira, Corynebacteria* and viral diseases. Rapid diagnosis of contamination in sea foods and aquaculture products.

UNIT-V: **(12 Hours)**

Applications of Marine Microbiology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture.

Total Lecture Hours - 60

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Apply the knowledge on marine microbial communities and their interactions.
2. Illustrate the role of marine microorganisms in biogeochemical cycles.
3. Carry out the process of fermentation for bio – alcohol fuels.
4. Identify the diseases affecting marine organisms and its diagnosis.
5. Evaluate the marine microorganisms as a resource for novel microbial products.

TEXT BOOKS

1. Munn C. B. (2019). Marine Microbiology: Ecology and Applications. (3rd Edition). CRC Press. ISBN:9780367183561.
2. Bhakuni, D.S. and Rawat D.S. (2005). Bioactive Marine Natural Products. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5.
3. Brock T. D. (2011). Thermophilic Microorganisms and Life at High Temperatures. Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860.
4. Nybakken, J.W. (2001). Marine Biology. (5th Edition). Benjamin Cummings. ISBN:0321030761 9780321030764.
5. Veena. (Understanding marine biology. Discovery Publishing.

REFERENCE BOOKS

1. Maier R.M., Pepper I.L. and Gerba C.P. (2006). Environmental Microbiology. (2nd Edition). Academic Press.US. ISBN:978-0-12-370519-8.

2. Belkin S. and Colwell R.R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN:978-0-387-23708-4, New York.

3. Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540-69357-4, New York.

4. Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the Oceans. (3rd Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7, New Jershy.

5. Kim S. K. (2019). Essentials of Marine Biotechnology. Springer, New York.

E-RESOURCES

1. https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1
2. https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products
3. http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf
4. https://link.springer.com/book/10.1007/b102184
5. https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187

Semester: IV- EC-VI (Choice – 3)-Life Sciences for Competitive Examinations

Ins. Hours / Week: 3 **Course Credit: 3** **Course Code:P23MBE46C**

UNIT- I: (12 Hours)

Composition, structure and function of biomolecules (Carbohydrates, Lipids, Proteins, Nucleic Acids and Vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, Nucleotides and Vitamins. Structure of Atoms, Molecules and Chemical bonds. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.) Bioenergetics.

UNIT-II: (12 Hours)

Cellular Organisation, Cell division and cell cycle, Membrane structure and function, Organization of genes and chromosomes, Structural organization and function of intracellular organelles, DNA replication, Repair and Recombination, Protein synthesis and Processing.

UNIT-III: (12 Hours)

Inheritance Biology, Mendelian principles- Dominance, Segregation, Independent assortment, Linkage and Gene mapping, Karyotyping, Extrachromosomal inheritance - Inheritance of Mitochondrial and Chloroplast genes, maternal inheritance. Human genetics- Pedigree analysis, lod score for linkage testing, Karyotypes, Genetic Disorders.

UNIT-IV: (12 Hours)

Ecology-Habitat and Niche, Biotic and Abiotic interactions, Biome- biogeographical zones of India. Ecological Succession, Population Ecology- Characteristics of a population; Population growth curves, Environmental pollution-global environmental change, Biodiversity: Status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves).

UNIT-V: **(12 Hours)**

Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration and Parental care. Molecular Evolution **-** Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny.

Total Lecture Hours - 60

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Assess the structure, biological functions and interactions of Biomolecules.
2. Acquire knowledge on collective and progressive notions of cellular organization.
3. Describe the importance of inheritance biology.
4. Understand the ecology & Biodiversity in a broader sense.
5. Recognize the processes of evolution, relate with natural selection, adaptation and speciation.

TEXT BOOKS

1. Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5th Edition). W.H. Freeman and Company, New York.
2. Chapman J.L. (1998). Ecology: Principles and Applications. (2nd Edition). Cambridge University Press, UK.
3. Krishnamurthy V.K. (2003). Textbook of Biodiversity. Science Publishers, New York.
4. Rogers A.L. (2011). Evidence of Evolution. University of Chicago Press. Chicago.
5. StitesD.P., AbbaI.Terr, Parslow T.G.(1997). Medical Immunology. 9thEdn, Prentice-Hall Inc, New Jersy

REFERENCE BOOKS

1. Pontarotti P. (2018). Origin and Evolution of biodiversity. (1st Edition). Springer, New York.
2. Verma P.S. and Agarwal V.K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication, New Delhi.
3. Lewin R. and Foley R. (2004). Principles of Human Evolution. (2nd Edition). Black well Publishing Company, UK.

4. Boyer R.F. (2002) Modern Experimental Biochemistry 3rd Edition. Pearson Education, London.

5. Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edition. Cambridge University Press, UK.

E-RESOURCES

1. https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_
2. https://www.livescience.com/474-controversy-evolution-works.html.
3. https://www.examrace.com/Study-Material/Life-Sciences/
4. https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts
5. https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html

Semester: IV- Professional Competency Course: Entrepreneurship in Bio business

Ins. Hours / Week: 2 **Course Credit: 2** **Course Code:P23PCMB41**

UNIT- I **(6 Hours)**

Bio Entrepreneurship - Introduction to bio-business, SWOT analysis of bio-business. Ownership. Development of Entrepreneurship. Stages in entrepreneurial process. Government schemes and Funding. Small, Medium and Large scale industries - Definition, Characteristics, Need and Rationale.

UNIT-II **(6 Hours)**

Entrepreneurship opportunity in agricultural biotechnology - Business opportunity, Essential requirement, Marketing, Strategies, Schemes, Challenges and scope. Case study on Plant cell and tissue culture technique, Poly house culture. Herbal bulk drug production, nutraceuticals, value added herbal products. Bioethanol production using agricultural waste, Algal source. Integration of system biology for agricultural applications. Biosensor development in agrimanagement.

UNIT-III **(6 Hours)**

Entrepreneurship opportunity in industrial biotechnology **-**Business opportunity, Essential requirement, marketing strategies, schemes, challenges and scope. Pollution monitoring and Bioremediation for Industrial pollutants. Integrated compost production- microbe enriched compost. Bio pesticide/ insecticide production. Biofertilizers. Single Cell Protein.

UNIT-IV **(6 Hours)**

Therapeutic and Fermented products - Stem Cell Production, Stem Cell Bank, production of Monoclonal/Polyclonal antibodies, Secondary metabolite production – Antibiotics, Probiotic and Prebiotics.

UNIT-V: **(6 Hours)**

Project Management, Technology Management and Startup Schemes - Building Biotech business challenges in Indian context-biotech partners (BIRAC, DBT, Incubation centers. etc.,), operational biotech parks in India. Indian Company act for Biobusiness-schemes and subsidies. Project proposal preparation, Successful start-ups-case study.

Total Lecture Hours - 30

COURSE OUTCOME

After the completion of the course, students should be able to,

1. Describe entrepreneurial ideas and business theories in practical framework.
2. Analyse the business environment in order to identify business opportunities.
3. Express the mass production of microbial inoculants used as Biofertilizers.
4. Analyze the application and commercial production of Monoclonal antibodies and Cytokines.
5. Understand regulation of biotechnology industries.

TEXT BOOKS

1. Shimasaki C. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies- Academic Press. New York. ISBN: 978-0-12-404730-3.
2. Acton A. Q. (2021). Biological Pigments - Advances in Research and Application-(Scholarly Editions). Atlanta, Georgia. ISBN: 978-1-481-68574-0
3. Stanbury P. F. and Whitekar. A. Principles of Fermentation Technology, (3rd Edition). Butterworth-Heinemann, London. ISBN 10: 0080999530.
4. Anil Kumar (2020). Small Business and Entrepreneurship, Willey Distributions, Dream Tech Press, New York.
5. AngiRedy (2015). An Unfinished Agenda. ISBN 139780670087808.

REFERENCE BOOKS

1. Crueger, W, and Crueger. A. (2017). Biotechnology: A Text Book of Industrial Microbiology. (2nd Edition). Medtech. ISBN-10 : 9385998633

2. Teng P. S.(2008). Bioscience Entrepreneurship in Asia. World Scientific Publishing Company. 2008.

3. Agarwal S., Kumari S. and Khan S. (2021). Bioentrepreneurship and Transferring Technology into Product Development. Business Science Reference. ISBN-10 : 1799874125
4. Krishnamurthy A.G. Dirubai Ambani Against All Odds. McGraw Hills. New York.
5. Peter F. Drucker. Innovation and Entrepreneurship (1985).

E-RESOURCES

1. https://www.profitableventure.com/biotech-business-ideas/
2. https://www.bio-rad.com/webroot/web/pdf/lse/literature/Biobusiness.pdf
3. https://www.nature.com/articles/s41587-021-01110-3
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3003900/
5. https://springhouse.in/government-schemes-every-entrepreneur/