Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(Autonomous)

Two Year Degree Program in Microbiology (Faculty of Science & Technology)

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

M.Sc. Microbiology Part-I Semester -I

To be implemented from Academic Year 2023-2024

Title of the Programme: M.Sc. Microbiology

Credit distribution Structure
for M.Sc. I 2023-2024
(Microbiology)

Level	Sem	Major		Research Methodology (RM)	OJT/FP	RP	Cum. Cr.	Degree
		Mandatory	Elective					
6.0	Sem-I	MI-501-MJM: Instrumentation (Credit 04)	MI-511-MJE: A. Biochemistry B. Ecology C. Medical Microbiology (Credit 04)	MI-521-RM (Credit 04)	---	---	20	PG Diploma (after 3 year degree)
		MI-502-MJM: Microbial Technology (Credit 04)						
		MI-503-MJM: Practical course I (Credit 02)						
		MI-504-MJM: Practical Course II (Credit 02)						
	Sem-II	MI-551-MJM: Pharmaceutical Microbiology (Credit 04)	MI-561-MJE A. Virology B. Biophysical techniques C. Developmental Biology (Credit 04)	---	MI-581-OJT/FP Credit 04	---	20	
		MI-552-MJM: Industrial Waste Water treatment (Credit 04)						
		MI-553-MJM: Practical course III (Credit 02)						
		MI-554-MJM: Practical course IV (Credit 02)						
	Cum Cr.	24	8	4	4	---	40	

Anekant Education Society's
TuljaramChaturchand College of Arts, Science and Commerce, Baramati
(Autonomous)
Department of Microbiology

Course Structure for M.Sc. Microbiology Part I (2023 Pattern)

Semester	Course Type	Course Code	Title of Course	Theory/ Practical	No. of Credits
I	Major (Mandatory)	MI-501-MJM	Instrumentation	Theory	4
	Major (Mandatory)	MI-502-MJM	Microbial Technology	Theory	4
	Major (Mandatory)	MI-503-MJM	Practical Course I	Practical	2
	Major (Mandatory)	MI-504-MJM	Practical Course II	Practical	2
	Major (Elective)	MI-511-MJE(A)	Biochemistry	Theory	4
		MI-511-MJE(B)	Ecology		
		MI-511-MJE(C)	Medical Microbiology		
	RM	MI-521-RM	Research Methodology	Theory	4
	Total credits Semester I				20
II	Major (Mandatory)	MI-551-MJM	Pharmaceutical Microbiology	Theory	4
	Major (Mandatory)	MI-552-MJM	Industrial Waste water treatment	Theory	4
	Major (Mandatory)	MI-553-MJM	Practical Course III	Practical	2
	Major (Mandatory)	MI-554-MJM	Practical Course IV	Practical	2
	Major (Elective)	MI-561-MJE(A)	Virology	Theory	4
		MI-561-MJE(B)	Biophysical techniques		
		MI-561-MJE(C)	Developmental Biology		
	OJT/FP	MI-581-OJT/FP	On job training/Field projects	Training / Project	4
	Total credits Semester II				20
Cumulative Credits Semester I and II					40

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2023)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: II**
Course Type	**: Major Mandatory theory**
Course Name	**: Pharmaceutical Microbiology**
Course Code	**: MIB-551-MJM**
No. of Lectures	**: 60**
No. of Credits	**: 04**

Course Objective:

1. To enrich students' knowledge related to basic concepts in drug discovery and drug development.
2. To inculcate the knowledge regarding the drug designing, pharmacokinetics and pharmacodynamics
3. To aware students with the concepts of pharmaceuticals.
4. To understanding Drug Discovery Process
5. To Gain a comprehensive understanding of the drug discovery process, from target identification to clinical trials.
6. ToExplore the principles of rational drug design and computational methods for designing new drugs.
7. ToLearn the basics of drug toxicology and safety assessments.
8. Understand preclinical testing, including in vitro and in vivo models for assessing drug efficacy
9. Explore the regulatory requirements and processes involved in bringing a drug from discovery to market

Course Outcome:

CO1. Students will also understand the concepts of drug discovery
CO2. They will be able to know pharmacokinetics and pharmacodynamics.
CO3. Proficiency in various drug screening methods, including high-throughput screening, virtual screening, and biochemical assays.
CO4. They will be able to know medicinal chemistry principles to design and optimize drug candidates.
CO5. An understanding of the pharmacological aspects of drug development, including mechanisms of action, pharmacokinetics, and pharmacodynamics.
CO6. Knowledge of safety assessment procedures and understanding of potential toxicity issues associated with drug candidates.
CO7. Proficiency in developing drug formulations and delivery systems.
CO8. Awareness of the regulatory pathways for drug approval, as well as ethical considerations in drug development.

UNIT 1: Drug Discovery (15L)

- Conventional Process Bio-prospecting Hot and Cold Extraction, Purification and characterization of bioactive molecules from natural sources
- Modern Process: Rational Drug Design, Structure activity relationship (SAR),High throughput Screening, Combinatorial synthesis, Pharmaco-genomics

UNIT 2: Drug development (15L)

- Drug development: Preclinical development. Toxicity testing – acute, sub-acute, chronic.
- Clinical development: Clinical trials (aims, objectives and conduct). clinical trials I, II, III and IV
- Regulatory authorities and its role: FDA and Pharmacopeia (IP, UK, US)
- Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry.
- Concept of Quality assurance and quality control in pharmaceutical industry
- Safety profile of drugs: Pyrogenicity testing, Mutagenicity testing, Teratogenicity testing,
- Drug reaction: In vivo and in vitro drug interactions, Adverse Drug Reactions,

UNIT 3: Development of Anti-infectives (15L)

- Susceptibility Testing: Use of liquid and solid media(Therapeutic ratio,MIC and MBC)
- Factors affecting susceptibility testing,
- Diffusion methods –agar dilution technique, gradient plate techniques, E-test, Kirby Bauer, Stokes method
- Susceptibility testing for:
- Anti-mycobacterial agents,
- Anti-fungal agents (E test Turbidometric assay),
- Anti-protozoan agents (ELISA)
- Anti-viral agents (Plaque assay)

UNIT 4: Biopharmaceuticals (15L)

- Drugformulations-Carriersanddeliverysystems,targeteddrug delivery, sustained release
- Pharmacokinetic–ADME/Bioavailabilitystudies

Text/ReferenceBooks:

1. AgarwalS.S.andParidhaviM.,(2007),*HerbalDrugTechnology*,UniversitiesPress(India) Pvt.Ltd
2. Altreuter D., and D S. Clark, (1999), *Combinatorial Biocatalysis: Taking the Lead FromNature*,Curr.Opin.Biotechnol.10,130.
3. Bentley's Textbook of Pharmaceutics,Ed. E.A. Rawlins,8th Ed.(2002), BailliereTindall,London
4. BurnJ.H.(1957)*PrinciplesofTherapeutics*,BlackwellScientificPub.O.Ltd.Oxford.
5. Chatwal G. P. (2003) *Bio-pharmaceutics and Pharmacokinetics*, Himalaya PublishingHouse,Mumbai.
6. Paul W. Erhardt, (2006), *Medicinal Chemistry in the New Millennium: A Glance into theFuture,* Ed. ChorghadeMukund S. in Drug discovery and development Volume I: DrugDiscovery,Wiley-Interscience,JohnWileyandSonsInc. USA,17-102.
7. Committee for the Purpose of Control and Supervision on Experiments on Animals(CPCSEA),www.cpcsea.com
8. Dewick Paul M., (2002), *Medicinal natural products: A biosynthetic approach*, 2nd Ed.,JohnWileyandSons
9. Graly John O. and Pieter H. Joubert, (1997), *Handbook of Phase I / II clinical drug trials*,CRCPress

10. IyengarM.A.(1974)*PharmacologyofPowderedCrudeDrugs*,Manipal
11. MichelesP.S.,Y.L.Khmelnitsley,J.S.DordickandD.S.Clark,(1998),*CombinatorialBiocatalysis, ANaturalApproachtoDrugDiscovery*,TrendsinBiotechnol.16,197.
12. SatoskarR.S.&S.D.Bhandarkar(1991)*PharmacologyandPharmacotherapeutics*,12thEd.,Vol.1&2,Popular Prakashan,Mumbai.
13. VyasS.PandDixitV.R.(2002),*PharmaceuticalBiotechnology*,CBSPublishersandDistributors,NewDelhi
14. KokateC.K.,PurohitA.P.,GokhaleA.B.(2000)*Pharmacology*,4thEd.,NiraliPrakashan.
15. MannfredA.Holliger,(2008),*Introductiontopharmacology*,3rdEd.,CRCPress38
16. Sylvie E. Blondelle, Enrique Pe´Rez-Paya, And Richard A. Houghten, (1996), *SyntheticCombinatorial Libraries: Novel Discovery Strategy for Identification of AntimicrobialAgents*,AntimicrobialAgents andChemotherapy,1067–1071
17. WalshGary,(2003),*BiopharmaceuticalsBiochemistryAndBiotechnology*,2ndEd.,JohnWiley&SonsLtd, England
18. Franklin T. J. and Snow G. A., (1975), *Biochemistry of Antimicrobial Action*, ChapmanandHall,London,1-22and160-174
19. Gale E.F., Cundliffe E., ReynoldsP. E., RichmondM.H. and Waring M.J., (1972), *The molecular basis of antibiotic action*, John Wiley and Sons, London
20. GoldsteinA.,AronowL.,and KalmanS.M.(1969)*PrinciplesofDrugAction, TheBasisofPharmacology*,HarperinternationaleditionNewYork.

Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2		2	2	2				
CO2	2	2							
CO3									
CO4		2							
CO5	2								
CO6						2			
CO 7									
CO8									3

Justification for the mapping

1. **Disciplinary Knowledge:**

   CO1: Understanding drug discovery is essential for students pursuing careers in drug development, pharmacology, and healthcare
   Co2: understanding pharmacokinetics is justified in the field of pharmaceutical and medical sciences because it is a core component of disciplinary knowledge

   CO5: A strong grasp of pharmacokinetics is essential for optimizing drug dosing, ensuring therapeutic efficacy, and minimizing adverse effects.

2. **Critical Thinking and Problem solving:**

   CO 2: Pharmacokinetics involves the study of how the body absorbs, distributes, metabolizes, and eliminates drugs, which is essential for optimizing drug dosages, minimizing side effects, and ensuring their therapeutic efficacy.
   CO4: In the field of pharmacokinetics, students need to critically assess research papers, clinical trials, and data. Critical thinking enables them to discern the validity and relevance of various sources of information.

3. **Social competence:**

   CO 1: This knowledge is crucial for students to contribute to advancements in healthcare and the pharmaceutical industry.

4. **Research-related skills and Scientific temper:**

   CO 1: Drug Discovery is at forefront of Scientific Innovation And Research By grasping this concept student are better equipped to engage in innovative research project and potentially to break ground breaking discoveries

5. Trans-disciplinary knowledge

CO 1: Drug discovery involves multidisciplinary approach encompassing chemistry biology and pharmacology .teaching drug discovery

6. **Personal and professional competence:**

CO6: Understanding drug discovery is essential for students pursuing careers in drug development, pharmacology, and healthcare

9. Self-directed and Life-long learning: .

CO8: Healthcare professionals, researchers, and regulators need this knowledge to make informed decisions about drug administration and patient safety.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from 2023)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: II**
Course Type	**: Major Mandatory Theory**
Course Name	**: Industrial Wastewater Treatment**
Course Code	**: MIB-552-MJM**
No. of Lectures	**: 60**
No. of Credits	**: 04**

Course Objective:

1. Understand the importance of industrial wastewater treatment in environmental protection andpublic health.
2. Describe the sources and types of industrial wastewater.
3. Identify key pollutants commonly found in industrial wastewater.
4. Describe the design and operation of physical treatment units
5. Introduce the fundamentals of biological treatment, including aerobic and anaerobic processes.
6. Explain the role of microorganisms in biodegradation of organic matter.
7. Examine sustainability principles in wastewater treatment, including energy efficiency and minimizing the carbon footprint.

Course Outcome:

CO1. Able to define the key terms and concepts related to industrial wastewater treatment.
CO2. Summarize the significance of industrial wastewater treatment for environmental protection.
CO3. Students be able to determine basic wastewater parameters, such as pH, turbidity, and suspended solids.
CO4. Interpret wastewater characterization data to assess pollution levels and develop treatment strategies.
CO5. Describe the operating principles of physical treatment processes.
CO6. Design a preliminary physical treatment system for a specific industrial wastewater.
CO7. Analyse and interpret data from a biological treatment system, including COD and BOD removal efficiency.

UNIT 1: Principles of Wastewater Treatment (15L)

- Concept of wastewater and Terms used in wastewater treatment
- Need for Wastewater Treatment
- Laws and regulations of wastewater treatment:
    a. Clean Water Act (CWA)
    b. Water (Prevention and Control of Pollution) Act, 1974
    c. National Water Policy, 2012.
- Characteristics of wastewater:
    a. Physical characteristics
    b. Chemical Characteristics

c. Biological characteristics

- Measuring pollution load of wastewaters & parameters used for determining treatment efficacy:
    a. Biochemical Oxygen Demand (BOD)
    b. Chemical Oxygen Demand (COD)
    c. Total Organic Carbon (TOC)
- Levels of wastewater treatment
    a. Preliminary wastewater treatment
    b. Primary wastewater treatment
    c. Secondary (Biological) wastewater treatment
    d. Tertiary wastewater treatment
    e. Advanced tertiary wastewater treatment
- Layout of typical wastewater treatment plants

UNIT 2: Pre-treatment & Primary treatment process (Unit operations) (15L)

- Flow equalization -
    a. Type of flow equalization – Inline Flow equalization & Offline Flow equalization
    b. Application of flow equalization
    c. Design consideration of flow equalization
- Screening –
    a. Characteristics of Screening
    b. Classification of screens
- Mixing & Flocculation –
    a. Types of mixers used in wastewater treatment
    b. Types of flocculation -Microflocculation&Macroflocculation
- Flotation –
  Types of flotation - Dissolved air flotation &Dispersed air flotation

UNIT 3: Secondary and Tertiary Treatment process (Unit Processes) (15L)

Secondary Treatment process

- Aerobic Biological Processes –
    1. Activated Sludge treatment
    2. Aerated lagoon system
    3. Trickling filter
    4. Rotating biological contactors
- Anaerobic Biological Processes –
    1. Anaerobic suspended growth processes
    2. Anaerobic sludge blanket process
    3. Upflow packed bed attached growth reactor
    4. Fluidized bed reactor

Tertiary Treatment process

1. Disinfection: Chlorination, ultraviolet (UV) irradiation, and ozonation.
2. Membrane Processes: Ultrafiltration and reverse osmosis

UNIT 4: Advanced wastewater treatment &current industrial wastewater treatment processes (15L)

- Submerged Aerobic Fixed Film reactors (SAFF): Process configuration, treatment process and basic design principal

- Membrane bioreactors (MBRs): Process configuration, treatment process and basic design principal
- Mixed Bed Bioreactors (MBBRs): Process configuration, treatment process and basic design principal

Current industrial wastewater treatment processes

- Dairyindustry
- Food processing industry
- Dyeing industry
- Paper manufacture industry

Reference Books:

1. Biotechnology for Water and Wastewater Treatment. Dr. SatyaPrakash. Navyug Publishers & Distributors, New Delhi. 2009.
2. Industrial Water Pollution Control. 3rd Edition. W. WesleyEckenfelder Jr. McGraw Hill. 2 000.
3. Standard Methods for the Examination of Water & Wastewater. 21st Edition. 2005 APHA.AWWA.WEF
4. Wastewater Engineering, Treatment, Disposal and Reuse. 3rd Ed., Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi Tchobanoglous G. and F. L. Burton. (1991).
5. Disposal and Reuse. 3rd Ed., Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi
6. Biological Wastewater Treatment. Vol. 5. Activated Sludge and Aerobic BiofilmReactors. Marcos von Sperling. IWA Publishing. London, New York. © 2007 IWA Publishing
7. Industrial Wastewater Treatment. A. D. Patwardhan. © Prentice –Hall of India Pvt. Ltd., New Delhi. 2008. ISBN 978-81-203-3350-5.

Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3						2		
CO2	3							2	
CO3	3		2		2	2			1
CO4	3	2		3	2	2		3	2
CO5	3	2	2	2	2	3	2		2
CO6	3	2	2	2		2			2
CO7	3	3	2			2		2	2

Justification for the mapping

PO1: Disciplinary Knowledge

Almost all the course outcomes CO1to CO7 imparts disciplinary knowledge by delving into the study of terms and concepts related to industrial wastewater treatment, significance of industrial wastewater treatment for environmental protection and basic wastewater parameters

PO2: Critical Thinking and Problem Solving

The CO4, CO5, CO6, CO7 cultivates critical thinking and problem-solving skills by requiring students to interpret wastewater characterization data to assess pollution levels and develop treatment strategies.

CO6 Designing a preliminary physical treatment system for a specific industrial wastewater and CO7 analysing and interpreting data from a biological treatment system, including COD and BOD removal efficiency these fosters the analytical and solution-oriented thinking.

PO3: Social competence

CO3, CO5, CO6, CO7 promotes social competence by involving interdisciplinary teams working to address environmental concerns. This experience fosters effective communication, teamwork, and cooperation, enabling students to engage with diverse stakeholders and contribute to solutions for water treatment issues in a socially responsible manner.

PO4: Research related skills and scientific temper

CO4, CO5, CO6 imparts research-related skills by exposing students to various sampling, isolation, and analysis preparing them for scientific research. It also fosters a scientific temper by emphasizing the critical evaluation of data from a biological treatment system, including COD and BOD removal efficiency

PO5: Trans-disciplinary knowledge

CO3, CO4, CO5 promotes trans-disciplinary knowledge by integrating principles from microbiology, environmental science, chemistry, and engineering to address complex environmental challenges. This cross-cutting approach equips students with a versatile skill set applicable across diverse scientific and engineering fields.

PO6: Personal and professional competence

The CO3, CO4, CO5, CO6, CO7enhances personal and professional competence by providing students with the knowledge and practical skills needed to in research, environmental monitoring, and water treatment careers. It also instills a sense of responsibility for environmental stewardship, preparing individuals to make a positive impact on society while fostering their professional development in various scientific and environmental fields.

PO7: Effective citizenship and ethics

The CO1, CO5 promotes effective citizenship and ethics by emphasizing the importance of responsible environmental stewardship and ethical conduct in research and water management practices. It equips students with the knowledge and values needed to make informed decisions regarding environmental conservation and sustainable water use, contributing to the well-being of communities and ecosystems.

PO8: Environment and sustainability

The CO2, CO4,CO7 addresses environmental and sustainability concerns by exploring the vital role of microorganisms in maintaining ecosystem balance and by investigating the impact of human activities on water quality. It equips students with the knowledge and tools to develop sustainable solutions for environmental challenges, such as pollution control, wastewater treatment, and the preservation of natural resources.

PO9: Self –directed and life –long learning

CO3, CO4, CO5, CO6, CO7 fosters self-directed and lifelong learning by encouraging students to explore cutting-edge research, adapt to evolving environmental challenges, and stay current with advancements in microbiological techniques and technology. It instills a sense of curiosity, adaptability, and the motivation to continuously expand their knowledge and expertise in order to address the dynamic and complex issues related to wastewater treatment.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2023)

Name of the Programme : M.Sc. Microbiology
Program Code : PSMI
Class : M.Sc. I
Semester : II
Course Type : Major Mandatory Practical
Course Name : Practical Course III
Course Code : MIB-553-MJM
No. of Lectures : 60
No. of Credits : 02

Course Objective:

1. Understanding the principles of sterility testing: Learning the theoretical foundations and principles behind sterility testing methods to ensure the absence of viable microorganisms.
2. Learn how to interpret susceptibility test results and use them to guide antibiotic therapy, including understanding clinical breakpoints.
3. Gain knowledge about the different mechanisms of antibiotic resistance in bacteria and how they affect treatment decisions.
4. Quality control in susceptibility testing: Implement quality control measures to ensure the accuracy and reliability of susceptibility testing results
5. Develop the skills to perform various susceptibility testing methods such as disc diffusion, broth microdilution, and automated systems for different types of microorganisms.

Course Outcome:

CO1. Understand the clinical significance of susceptibility results and how they influence patient treatment and management.
CO2. Implement quality control measures to ensure the accuracy and reliability of susceptibility testing results.
CO3. Gain knowledge about the different mechanisms of antibiotic resistance in bacteria and how they affect treatment decisions.
CO4. Learn how to interpret susceptibility test results and use them to guide antibiotic therapy, including understanding clinical breakpoints.
CO5. Mastering various sterility testing techniques, such as membrane filtration, direct inoculation, and isolator technology, as well as the associated procedures, aseptic techniques, and validation requirements

UNIT 1: Sterility testing of following pharmaceutical preparations as per IP by direct inoculation /membrane filtration techniques (15L)

1. Solid preparations: antibiotic tablets
2. Liquid preparation: water soluble vitamin or cough syrup or ophthalmic drops
3. Bulk preparation: (any two) Surgical Cotton rolls/ gauze/ surgical sutures/ disposable syringes.
4. Pyrogen testing (limulus amobeocyte lysate)

UNIT 2:Antibacterial susceptibility testing (15L)

1. Extraction of bioactive principles from plant part
2. Qualitative estimation of bioactive principles from plants part

3. Estimation of its antibacterial activity against different human pathogens using standard guidelines (CLSI)

UNIT 3: Antifungal susceptibility testing (15L)

1. Extraction of bioactive principles from plant part
2. Qualitative estimation of bioactive principles from plants part
3. Estimation of its antifungal activity against different human pathogens using standard guidelines (CLSI)

UNIT 4: susceptibility testing (15L)

1. Demonstration of E test
2. Isolation of antibiotic resistant mutant using gradient plate technique
3. Determination of MIC value of streptomycin against pseudomonas by tube dilution method
4. To test Susceptibility of *E.coli* and *Klebsiella* against different antibiotics by using Kirby Bauer method
5. To test Susceptibility of *E.coli* and *Klebsiella* against different antibiotics by using Stokes method

Text/ReferenceBooks:

1. AgarwalS.S.andParidhaviM.,(2007),*HerbalDrugTechnology*,UniversitiesPress(India) Pvt.Ltd
2. Altreuter D., and D S. Clark, (1999), *Combinatorial Biocatalysis: Taking the Lead FromNature*,Curr.Opin.Biotechnol.10,130.
3. Bentley's Textbook of Pharmaceutics,Ed. E.A. Rawlins,8th Ed.(2002), BailliereTindall,London
4. BurnJ.H.(1957)*PrinciplesofTherapeutics*,BlackwellScientificPub.O.Ltd.Oxford.
5. Chatwal G. P. (2003) *Bio-pharmaceutics and Pharmacokinetics*, Himalaya PublishingHouse,Mumbai.
6. Paul W. Erhardt, (2006), *Medicinal Chemistry in the New Millennium: A Glance into theFuture,* Ed. ChorghadeMukund S. in Drug discovery and development Volume I: DrugDiscovery,Wiley-Interscience,JohnWileyandSonsInc. USA,17-102.
7. Committee for the Purpose of Control and Supervision on Experiments on Animals(CPCSEA),www.cpcsea.com
8. Dewick Paul M., (2002), *Medicinal natural products: A biosynthetic approach*, 2nd Ed.,JohnWileyandSons
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10. IyengarM.A.(1974)*PharmacologyofPowderedCrudeDrugs*,Manipal
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16. Sylvie E. Blondelle, Enrique Pe´Rez-Paya, And Richard A. Houghten, (1996), *SyntheticCombinatorial Libraries: Novel Discovery Strategy for Identification of AntimicrobialAgents,*AntimicrobialAgents andChemotherapy,1067–1071
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18. Franklin T. J. and Snow G. A., (1975), *Biochemistry of Antimicrobial Action,* ChapmanandHall,London,1-22and160-174
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20. Goldstein A., Aronow L., and Kalman S.M. (1969) *Principles of Drug Action, The Basis of Pharmacology,* Harper international edition New York.

Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10
CO1			2	2				3		
CO2										
CO3					2		2			
CO4				2						
CO5									2	

Justificationforthemapping

3. Social competence:

CO 1: The results of susceptibility testing guide clinicians in selecting the most effective antibiotics or antimicrobial agents for treating infections.

4. Research-related skills and Scientific temper:

CO 1: It's relevant for researchers and pharmaceutical companies working on the development of new antibiotics and antimicrobial agents.

CO3: Students pursuing laboratory or research careers need to learn techniques for detecting and studying antibiotic resistance

CO 4: Teaching about antibiotic resistance can inspire students to engage in research and innovation, seeking new treatments, diagnostic tools, and prevention strategies.

5. Trans-disciplinary knowledge:

CO3: Antibiotic resistance is a multidisciplinary issue, involving microbiology, pharmacology, epidemiology, and more. Understanding it requires an interdisciplinary approach, which is beneficial for students.

7. Effective Citizenship and Ethics:

CO3: Students who grasp the significance of antibiotic resistance can become advocates for policy changes and initiatives to combat this problem at local, national, and international levels.

9. Self-directed and Life-long learning:

CO1: For students pursuing careers in laboratory medicine, microbiology, or research, susceptibility testing is a fundamental skill.

CO 5: It equips them with the knowledge and expertise needed for conducting these tests accurately.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2023)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: II**
Course Type	**: Major Mandatory Practical**
Course Name	**: Practical Course IV**
Course Code	**: MIB-554-MJM**
No. of Lectures	**: 60**
No. of Credits	**: 02**

Course Objective:

1. Understand the importance of industrial wastewater treatment in environmental protection and public health.
2. Describe the sources and types of industrial wastewater.
3. Students be able to determine basic wastewater parameters, such as pH, turbidity, and suspended solids.
4. Identify key pollutants commonly found in industrial wastewater.
5. Explain the role of microorganisms in biodegradation of organic matter
6. Examine sustainability principles in wastewater treatment.
7. Acquire the skills for analysis of wastewater.

Course Outcome:

CO1. Able to define the key terms and concepts related to industrial wastewater treatment.
CO2. Summarize the significance of industrial wastewater treatment for environmental protection.
CO3. Students be able to determine basic wastewater parameters, such as pH, turbidity, and suspended solids.
CO4. Interpret wastewater characterization data to assess pollution levels and develop treatment strategies.
CO5. Understand biological treatment system
CO6. Analyze and interpret data from a biological treatment system, including COD and BOD removal efficiency.
CO7. Students can examine sustainability principles in wastewater treatment, including energy efficiency and minimizing the carbon footprint.

UNIT 1: Analysis of physical characteristics of wastewater sample (10L)

1.Sampling of wastewater
2. Analysis of physical characteristics of wastewater sample
    1. Solids
        - Total solids (TS)
        - Total Dissolved solids
        - Total suspended solids (TSS) or Mixed liquor solids (MLSS)
        - Total volatile solids
    2. Turbidity
    3. Colour
    4. Absorption/ Transmittance

5. Temperature

UNIT 2: Analysis of inorganic & organic constituents in wastewater sample (24L)

Analysis of inorganic constituents in wastewater sample

1. pH
2. Chlorides (Titration Method)
3. Alkalinity (Titration Method)
4. Nitrogen (Titration Method)
5. Phosphorus (Spectroscopic Method)
6. Gases (Chemical Method)

Analysis of organic constituents in wastewater sample

1. Biochemical Oxygen Demand (BOD)
2. Chemical Oxygen Demand (COD)
3. Total Organic Carbon (TOC)
4. Interrelationship between BOD, COD & TOC

UNIT 3: Analysis of biological characteristics of wastewater sample (12L)

1. Isolation of bacteria from wastewater sample
2. Enumeration of microbial load present in wastewater sample

UNIT 4: Industrial Waste water treatment (14L)

1. Estimation of pollution load of natural sample (e.g. River water / Industrial Wastewater)
2. Setting up laboratory experiments to assess degradability of synthetic wastewater.

References

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Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2=moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2								
CO2	2					2			
CO3	2	3	3	2	3				
CO4	2	3	2		2	2	3	3	3
CO5	2	2		3	2			3	2
CO6	2	3	3	2	2	2		3	
CO7	2	2		3		2	3	3	3

Justification for the mapping

PO1: Disciplinary Knowledge

Almost all the course outcomes CO1 to CO7 imparts disciplinary knowledge by delving into the study of wastewater characteristics. It provides insights into biological principles of industrial wastewater treatment for environmental protection.

PO2: Critical Thinking and Problem Solving

The CO3 ,CO4, CO 5, CO6, CO7 cultivates critical thinking and problem-solving skills by requiring students to data interpretation, students develop the ability to address real-world challenges, such as water quality management and the spread of airborne pathogens, fostering analytical and solution-oriented thinking.

PO3: Social competence

CO3, CO4, CO6 promotes social competence by encouraging collaborative work that involve interdisciplinary teams working to address environmental concerns. This experience fosters effective communication, teamwork, and cooperation, enabling students to engage with diverse stakeholders and contribute to solutions for wastewater treatment issues in a socially responsible manner.

PO4: Research related skills and scientific temper

The CO3 , CO 5, CO6, CO7 imparts research-related skills by exposing students to various sampling, isolation, and analysis techniques, preparing them for scientific research. It also fosters a scientific temper by emphasizing the critical evaluation of environmental data and the application of the scientific method, nurturing a mindset of evidence-based inquiry and a commitment to understanding and protecting our natural surroundings.

PO5: Trans-disciplinary knowledge

CO3 ,CO4, CO 5, CO6 promotes transdisciplinary knowledge by integrating principles from microbiology, environmental science, chemistry, and engineering to address complex

environmental challenges. This cross-cutting approach equips students with a versatile skill set applicable across diverse scientific and engineering fields, allowing them to contribute to the holistic understanding and sustainable management of air and water ecosystems.

PO6: Personal and professional competence

CO2, CO4, CO6, CO7enhances personal and professional competence by providing students with the knowledge and practical skills needed to excel in research, environmental monitoring, and water treatment careers. It also instills a sense of responsibility for environmental stewardship, preparing individuals to make a positive impact on society while fostering their professional development in various scientific and environmental fields.

PO7: Effective citizenship and ethics

The CO4, CO7 promotes effective citizenship and ethics by emphasizing the importance of responsible environmental stewardship and ethical conduct in research and water management practices. It equips students with the knowledge and values needed to make informed decisions regarding environmental conservation and sustainable water use, contributing to the well-being of communities and ecosystems.

PO8: Environment and sustainability

CO3 ,CO4, CO 5, CO6, CO7 addresses environmental and sustainability concerns by exploring the vital role of microorganisms in maintaining ecosystem balance and by investigating the impact of human activities on air and water quality. It equips students with the knowledge and tools to develop sustainable solutions for environmental challenges, such as pollution control, wastewater treatment, and the preservation of natural resources.

PO9: Self –directed and life –long learning

CO4, CO5, CO7 fosters self-directed and lifelong learning by encouraging students to explore cutting-edge research, adapt to evolving environmental challenges, and stay current with advancements in microbiological techniques and technology. It instills a sense of curiosity, adaptability, and the motivation to continuously expand their knowledge and expertise in order to address the dynamic and complex issues related to wastewater treatment.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2023)

Name of the Programme : M.Sc. Microbiology
Program Code : PSMI
Class : M.Sc. I
Semester : II
Course Type : Major Elective Theory
Course Name : Virology
Course Code : MIB-561-MJE(A)
No. of Lectures : 60
No. of Credits : 04

Course Objective:

1. To enrich student's Knowledge about basic chemistry belongs to microbiology
2. To describe and review the elements of the viral life cycle
3. Explain vaccine strategies and mechanism of antiviral drug
4. To help student's build-up a progressive and successful career
5. Discuss and identify the different viral detection methods
6. Describe the different cultivation methods of viruses
7. To describe the mechanism of action of antiviral and antiretroviral drugs

Course Outcome:

CO1. Understand basic structures of viruses
CO2. Student will understand principles of virus pathogenesis
CO3. Understand basic knowledge of virus cultivation and detection methods
CO4. Overall understanding about bacteriophages therapy for control bacterial diseases
CO5. Students will understand viral replication strategies and compare replication mechanism used by viruses
CO6. Understand different types of vaccines and antiviral agents
CO7. To comprehend and appreciate the major and varied laboratory techniques and researchapproaches employed in the field of virology

UNIT1: Structure and Replication of viruses (15L)

- Enveloped and non-enveloped viruses
- Capsid symmetries–Icosahedral, Helical, Simple and Complex Capsid
- Structural components of virus–Protein–Envelope proteins (Glycoprotein), Matrix proteins and Lipoproteins, Genome– dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense and antisense), linear, circular, segmented
- Virus related structures–Viroids and Prions

Replicationofviruses:

- Mechanism of virus attachment
- Entry into host cell
- Uncoating of viral genome
- Transcription strategies for RNA genome &DNA genome
- Genome replication-RNA replication, DNA replication
- Reverse Transcription
- Post transcriptional processing
- Translation of viral proteins
- Protein nucleic acid inter actions and genome packaging

- Assembly, exit and maturation of progeny virions

UNIT2: Cultivation and Detection methods for viruses (15L)

Cultivation of viruses:

- In ovo: using embryonated chicken eggs
- In vivo: using experimental animals
- Ex vivo/ Invitro: using various cell cultures–primary and secondary cell lines, suspensioncellcultures and monolayer cell culture

Diagnostic and detection methods for viruses:

- Direct methods of detection–Light microscopy (inclusion bodies), Electron microscopy and Fluorescence microscopy
- Immnuodiagnosis, Hemagglutination and Hemagglutination inhibition tests, Complement fixation, Neutralization, Westernblot, Radio-active Immuno Precipitation Assay (RIPA), Flow Cytometry and Immunohistochemistry
- Nucleic acid-based diagnosis: Nucleic acid hybridization, polymerase Chain Reaction(PCR), Microarray and Nucleotide sequencing, LINE probe assay

Infectivity assay for animal and bacterial viruses:

- Plaque method
- Pock counting
- Endpointmethods,LD50, ID50, EID50, TCID50

Infectivity assays of plant viruses.

UNIT3: Bacteriophages (15L)

Bacteriophage ecology

Morphology, Genome organization and Lifecycles of

- T phages (odd and even)
- Lambda phage
- M13phage
- PhiX174phage

Bacteriophage therapy for control of any two bacterial diseases

UNIT4: Viral Therapeutics (15L)

Vaccines:

- Conventionalvaccines:Killedandattenuated
- Modernvaccines:Conceptsandexamples(DNAvaccines,RecombinantDNA, Recombinantproteinvaccines,Subunitvaccines,Peptidevaccines,Anti-idiotype vaccines,Ediblevaccines,mRNAvaccine,Vaccineformulationsanddelivery:Adjuvants,immunomodulators,cytokines)

Antiviral agents:

- Designingandscreening
- Mechanism of action (e.g: Nucleoside analogues, Nucleotide analogues, Antisense, Topical immunemodulator, neuraminidase inhibitors, Ion channel function inhibitors of M2 proteins, Pyrimidines)

Anti-retroviral agents (any two):

- Mechanism of action
- Mechanism of resistance
- Modern approaches of virus control- Small interfering RNA(siRNA), Ribozymes

Text/Reference Books:

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Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3				2				2
CO2		3			3			2	3
CO3		2		3	3	3			3
CO4	3	2		2		2		3	3
CO5	3	3							3
CO6	2	1		3	2	2		3	
CO7	3	3		3	3	3			3

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Student get basic knowledge of viruses
CO4: Acquired knowledge regarding bacteriophages therapy to control bacterial diseases
CO5: Students will understand strategies and mechanism of viruses replication.
CO6: Student get knowledge of different types of vaccines and antiviral agents
CO7: Students get familiar to different laboratory techniques and research approaches employed in the field of virology

PO2: Critical Thinking and Problem Solving

CO2: Students will apply learned knowledge to understand virus pathogenesis.
CO3: Students get basic knowledge of virus cultivation and detection methods
CO4: Overall understanding about bacteriophages therapy for control bacterial diseases
CO5: Students will apply learned knowledge to compare replication mechanism used by viruses.
CO6: Students understand the mode of action of vaccines and antiviral agents
CO7: To comprehend techniques and research approaches employed in the field of virology

PO4: Research related skill and Scientific temper.
CO3: Understand basic knowledge of virus cultivation and detection methods
CO4: Students acquired knowledge to use bacteriophages therapy to control bacterial diseases
CO6: Student able to apply and analyze the inference of effect of different types of vaccines and antiviral agents
CO7: To comprehend and appreciate the major and varied laboratory techniques and research approaches employed in the field of virology

PO5: Trans-disciplinary Knowledge

CO1: Understand basic structures of viruses
CO2: Student will aware about different virus infections.
CO3: Understand basic knowledge of virus cultivation and detection methods
CO6: Understand different types of vaccines and antiviral agents
CO7: Students explore and employed the knowledge in the field of virology

PO6: Personal and Professional Competence

CO3: Understand virus cultivation
CO4: Student shall use bacteriophages therapy for control bacterial diseases
CO6: Understand different types of vaccines and antiviral agents
CO7: To comprehend and appreciate the major and varied laboratory techniques and research
approaches employed in the field of virology

PO8: Environment and Sustainability

CO2: Student will aware to virus pathogenesis
CO4: Overall understanding about bacteriophages therapy for control bacterial diseases
CO6: Student will aware about the action of vaccines and antiviral agents

PO9: Self-directed and Life-long Learning

Students will understand over all knowledge related to virology subject

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2023)

Name of the Programme : M.Sc. Microbiology
Program Code : PSMI
Class : M.Sc. I
Semester : II
Course Type : Major Elective Theory
Course Name : Biophysical Techniques
Course Code : MIB-561-MJE(B)
No. of Lectures : 60
No. of Credits : 04

Course Objectives:

1. To learn different techniques of biophysics.
2. To learn different techniques of molecular structure determination.
3. To learn principle and working of biophysical techniques.
4. To learn the different ionization methods
5. To learn the chromatography as well as spectroscopy techniques.
6. To determines the physical and chemical properties of atoms or molecules.
7. To enables the study of physiochemical, electronic and structural properties of molecules.

Course Outcome:

CO1. Students will be able to learn molecular structure determination.
CO2. Student will able to understand core concept of Biology, Chemistry and physics and how they are interconnecting with biophysical system.
CO3. Students will function successfully in the laboratory and use safe laboratory practices.
CO4. Students will critically evaluate primary literature in the discipline.
CO5. Students will use databases, computational tools and other online resources effectively.
CO6. Students will use demonstrate awareness of issues in the practice of science.
CO7. Demonstrates excellent understanding of the biophysical concepts.

UNIT 1: Mass spectroscopy (15L)

- Principles of operation, Components of Mass Spectrometer
- Ionization and Ion fragmentation- Electron Impact Ionization, Chemical Ionization, Electrospray Ionization, Matrix-Assisted Laser Desorption Ionization (MALDI)
- Mass Analysers- Quadrupole, Ion Trap, Magnetic sector, Time-of- Flight (TOF) Mass analyser
- Detectors- Electron Multiplier and Conversion Dynode
- GC-MS (Gas Chromatography Mass Spectrometry)
- MALDI-TOF

UNIT 2: X-ray crystallography (15L)

- Crystallization of proteins.
- Instrumentation, acquisition of the diffraction pattern
- Basic principles of X-ray diffraction
- Crystal Structures (Bravais Lattices)

- Crystal planes and Miller Indices
- Fourier Transform and Inverse Fourier
- Direct Lattice and Reciprocal lattice
- Ewald sphere
- Electron density Maps
- Phase determination, Phase Refinement, Validation.

UNIT 3: NMR spectroscopy (15L)

- Basic Principles of NMR
- Chemical shift, Intensity, Line width, Relaxation parameters
- Spin coupling
- Nuclear Overhauser Effect Spectroscopy
- Correlation Spectroscopy
- Approach to structure determination by 2D-NMR

UNIT 4: Tools of Bioinformatics (15L)

- Introduction to bioinformatics- (Definition, Application, Goals, Overview of bioinformatics)
- General Introduction of Biological Databases. (Primary database, Secondary database)
- Databases (GENBANK, PDB, OMIM)
- Introduction to Sequences.
- Sequence alignment-
    A. Local and global alignment.
    B. Pair wise sequence alignment- (Dot Matrix method, Dynamic programming method, Word / K- tupple method)
    C. Multiple sequence alignment.
- Homology Modelling, 3-D protein Model
- Examples of related tools (FASTA, BLAST, BLAT)
- Software (RASMOL)

Text / Reference Books:

1. Wilson Keith and Walker John (2005) Principles and Techniques of Biochemistry and Molecular Biology, 6th Ed. Cambridge University Press, New York.
2. Pattabhi, V. and Gautham, N. (2002) Biophysics. Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
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9. Mount, D. W. (2001) Bioinformatics: sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.

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11. Narayanan, P. (2000) Essentials of Biophysics. New Age International Publication, New Delhi.

Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1									3
CO2	3				3	2			
CO3		2							3
CO4	3	2							
CO5					2				
CO6									

Justification for the mapping

PO1: Disciplinary Knowledge

CO2: Students will able to understand core concept of Biology, Chemistry, and physics and how they are interconnecting with biophysical system microscopy, spectroscopy, electrophysiology, single-molecule methods and molecular modelling.
CO4: Students will demonstrate awareness of issuues in the practice of science it is bridge between biology and molecules to cells, organisms, and environment.

PO2: Critical Thinking and Problem Solving

CO3: Students will understanding the mechanics of how the molecules of life are made, how different parts of cell move and function and how complex systems in our bodies the brain, circulation, immune system, and others.
CO4:Students will critically evaluate primary literature in the dicipline develop and use computer modelling methods to see and manipulate the shapes and structures, crucial information needed to develop new drug targets, or understand how proteins mutate and cause tumors to grow.

PO5: Trans-disciplinary Knowledge

CO2: Students will apply different concepts such as databases, Homology modelling, 3D protein model These concepts are used in many different disciplines, such as Biology, Chemistry and physics and how they are interconnecting with biophysical system and knowledge that applies the principles of physics and chemistry.
CO5: Modern biology is the perspective that biological processes can be understood from the interactions between and within the constituent molecules

PO6: Personal and Professional Competence

CO2: Students will demonstrate the ability to apply different techniques of molecular structure determination such as structure determination by 2D- NMR .This ability is essential for success inmany different careers.

PO9: Self-directed and Life-long Learning

CO1: Students will demonstrate the ability to apply concepts of molecular structure determination and techniques in practical contexts. This ability will enable them to continue learning and developing their skills throughout their careers.
CO3: Students will able to understand the principle and working of biophysical techniques the methods of mathematical analysis and computer modeling to biophysical systems, with the ultimate goal of understanding at fundamental level the structure, dynamics, interactions.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2023)

Name of the Programme : M.Sc. Microbiology
Program Code : PSMI
Class : M.Sc. I
Semester : II
Course Type : Major Elective Theory
Course Name : Developmental Biology
Course Code : MIB-561-MJE(C)
No. of Lectures : 60
No. of Credits : 04

Course Objective:

1. To introduce students to the molecular and cellular mechanisms that underlies the early development of organisms.
2. Understanding of Developmental mechanisms and processes in genetic model organisms such as the fruit fly (*D. melanogaster*), the worm (*C. elegans*), vertebrates such as the frog as well as in plants.

Course Outcome: Students who successfully complete the course will be able to

CO1. Name, describe and order the main stages of development common to most multicellular organisms.
CO2. Describe the main anatomical changes that occur during development.
CO3. Identify the cellular behaviours that lead to morphological change during development.
CO4. Describe the hierarchy of gene activation that occurs in early *Drosophila* development.
CO5. Understand how gene activation plays a role in differentiation and development.

UNIT 1: Fundamentals of Developmental Biology: (15L)

- **Definition and scope**
- **Concepts in Developmental Biology**: Growth, Potency, Commitment, Specification, Induction, Competence, Determination, Differentiation, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and the cytoplasmic determinants, Imprinting, Mutants, Transgenics in analysis of development
- **Theories of Developmental Biology:** Preformation, Pangenesis, Epigenesis, Axial gradient, Germplasm.
- **Model organisms in study of developmental biology:** frog, chick, mouse, Drosophila, Sea urchin, Zebra Fish, *Caenorhabditis elegans*

UNIT 2: Reproduction and Development: (15L)

- Basics of gametogenesis: Oogenesis, spermatogenesis and spermiogenesis
- Detailed structure of gametes
- Fertilization process in sea urchin and mammals
- cleavage: Types of eggs, types and patterns of cleavage
- Blastula formation
- Morphogenetic movements
- Gastrulation: Formation of germ layers in animals
- Embryogenesis

UNIT 3: Morphogenesis and organogenesis in animals: (15 L)

- Cell aggregation and differentiation in *Dictyostelium*
- Axes and pattern formation in: *Drosophila*, Amphibia, Chick
- Organogenesis: Vulva formation in *Caenorhabditis elegans*, Eye lens induction, Limb development, Regeneration in vertebrates
- Differentiation of neurons
- Post embryonic development: Larval formation, Metamorphosis, Environmental regulation of normal development
- Sex determination

UNIT 4: Morphogenesis and organogenesis in plants: (15 L)

- Organization of shoot and root apical meristem
- Shoot and root development
- Leaf development and phyllotaxy
- Transition to flowering
- Floral meristems
- Floral development: Arabidopsis, Antirrhinum.

References:

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2. Principles of Development, 4th edition (2010), Wolpert L and Tickle C, Publisher: Oxford University Press, USA.
3. Bhojwani S.S. and Bhatnagar S.P. (2009) – Embryology of Angiosperms (VikasPubl House, New Delhi).
4. Burgess J. (1985) An Introduction to Plant Cell Development (Cambridge Univ Press, UK).
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6. Sharma HP (2009) – Plant embryology: Classical and experimental (alpha sci).
7. Steeves TA & Sussex IM (2004) – Patterns in plant development. (Cambridge Univ Press, Cambridge, New York).
8. The molecular life of plants by Jones et al Wiley.
9. Biochemistry and Molecular Biology of Plants, 2nd Edition - Bob Buchanan et al Wiley.
10. Plant Physiology, Taiz and Zeiger Sixth edition Sinaeur

Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate orpartial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10
CO1	2			4	2					
CO2			2							
CO3	2									
CO4		2								
CO5										

Justificationforthemapping

1. Disciplinary Knowledge:

CO 1:Knowledge of these stages allow for the design of effective educational Strategies tailored to students cognitive abilities and needs

CO 3: Drosophila melanogaster, which has been instrumental in advancing our understanding of genetics, developmental biology, and evolution. It enables students to grasp fundamental principles of organism development.

2. Critical Thinking and Problem solving:

CO 4: Analyzing and interpreting data from Drosophila experiments can enhance critical thinking skills. Students learn to formulate hypotheses, design experiments, and draw conclusions from their findings, which are key skills in scientific research.

3. Social competence:

CO2: anthropology benefit from an understanding of development to examine cultural and societal influences on individuals at various life stages.

4. Research-related skills and Scientific temper:

CO 1: For students interested in pursuing a career in biology or research, a Drosophila development course can serve as a stepping stone. It may lead to opportunities for independent research projects and exposure to scientific research environments.

5. Trans-disciplinary knowledge:

CO1: Drosophila research often involves a combination of genetics, molecular biology, and developmental biology, encouraging interdisciplinary learning and a holistic understanding of biological processes.